EFFECT OF HEAT ABSORBING MEDIA ON THERMAL PERFORMANCE OF AIR-TYPE SOLAR COLLECTORS

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by
Kamil AYDIN

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İZMİR

We approve the thesis of **Kamil AYDIN**

Date of Signature

…………………………………………….. 20 July 2005

Prof. Dr. Zafer İLKEN
Supervisor
Department of Mechanical Engineering
İzmir Institute of Technology

…………………………………………….. 20 July 2005

Asst. Prof. Dr. Hüseyin GÜNERHAN
Department of Mechanical Engineering
Ege University

…………………………………………….. 20 July 2005

Assoc. Prof. Dr. Barış ÖZERDEM
Department of Mechanical Engineering
İzmir Institute of Technology

…………………………………………….. 20 July 2005

Assoc. Prof. Dr. Barış ÖZERDEM
Head of Department
İzmir Institute of Technology

………………………………………………………

Assoc. Prof. Dr. Semahat ÖZDEMİR
Head of Graduate School

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ABSTRACT

In this study, effect of heat absorbing media on the thermal performance of air-type solar collector is studied experimentally. Experimental setup was built and tested by using the ASHRAE 93-1986 standard named “Methods of testing to determine the thermal performance of solar collectors”. Polyurethane foam is used as heat absorbing media with a porosity of 85%. In the analysis three air speeds 3 m/s, 3,5 m/s and 4 m/s are used. Data for similar days are compared with each other. Increment of the efficiency related to the polyurethane foam is presented and performance curves of our air-type solar collector are indicated. Factors, affect the performance of collector, are discussed. Using heat absorbing media enhances heat transfer surface area and this increases efficiency, but pressure drop should be taken into consideration to prevent extra pumping power. In conclusion, efficiency values about 55% for 3m/s for ambient temperatures between 35 and 38^{o}C, 60% for 4 m/s and 48% for 3,5 m/s for ambient temperature between 28 and 32^{o}C with polyurethane foam are obtained. On the other hand, pressure drops increase from 0,015 kPa to 0,215 kPa for 3 m/s, from 0,01 kPa to 0,32 kPa for 3,5 m/s and from 0,01 kPa to 0,385 kPa for 4 m/s.

ÖZET

Bu çalışmada hava yutma ortamının hava tipi güneş kolektörlerinin termal performansına etkisi deneysel olarak çalışıldı. ASHRAE 93-1986 "Güneş kolektörlerinin termal performanslarını belirlemek için test yöntemleri" kullanılarak deney düzeneği yapıldı ve test edildi. Hava yutma ortamı olarak %85 gözenekli poliüretan köpük kullanıldı. Analizlerde 3, 3,5 ve 4 m/s olmak üzere üç hava hızı kullanıldı. Benzer günler için olan datalar birbirleriyle karşılaştırıldı. Verimin poliüretana bağlı olan artışı sunuldu ve hava tipi güneş kolektörümüzün performans eğrileri gösterildi. Kolektör performansına etki eden faktörler tartışıldı. Hava yutma ortamının kullanılışı ısı transferi yüzey alanını arttırır ve bu da verimi arttırır, fakat, ekstra pompalama gücüne maruz kalmamak için basınç düşümü de göz önünde bulundurulmalıdır. Sonuç olarak, 35 ve 38^{o}C arası ortam sıcaklıklarında 3 m/s için yaklaşık %55, 28 ve 32^{o}C arası ortam sıcaklıklarında 4 m/s için yaklaşık %60 ve 3,5 m/s için yaklaşık %48 verim değerleri elde edildi. Diğer taraftan, basınç düşümleri 3 m/s için 0,015 kPa dan 0,215 kPa ya, 3,5 m/s için 0,01 kPa dan 0,32 kPa ya ve 4 m/s için 0,01 kPa dan 0,385 kPa ya yükseldi.

TABLE OF CONTENTS

LIST OF TABLES viii

LIST OF FIGURES x

LIST OF SYMBOLS xii

CHAPTER 1. INTRODUCTION 1

1.1. Solar Collectors 1

1.1.1. Flat-Plate Collectors 2

1.1.2. Concentrating Collectors 3

1.2. Air-Type Solar Collectors 4

1.2.1. Types of Air-Type Solar Collectors 5

1.2.1.1. Bare-Plate Air-Type Solar Collectors 5

1.2.1.2. Covered-Plate Air-Type Solar Collectors 6

1.2.1.2.1. Front-Pass Covered-Plate Air-Type Solar Collectors 6

1.2.1.2.2. Back-Pass Covered-Plate Air-Type Solar Collectors 7

1.2.1.2.3. Suspended-Plate Covered-Plate Air-Type Solar Collectors 7

1.2.1.2.4. Perforated-Plate Covered-Plate Air-Type Solar Collectors 8

1.2.2. Collector Thermal Efficiency 9

1.2.3. Applications to Increase Efficiency of Air-Type Solar Collectors .10

1.2.3.1. Absorber Plate with Fins 11

1.2.3.2. Metal Filling Material Inside the Air Duct 12

1.2.3.3. Corrugated Absorber Plate 12

1.2.3.4. Air Flow on Both Side of the Absorber Plate 12

CHAPTER 2. EXPERIMENTAL SETUP ……………………………………………23
2.1. Parts of Experimental Setup …………………………………………23
2.1.1. Air-Type Solar Collector …………………………………………23
2.1.2. Radial Fan ………………………………………………………...25
2.1.3. Air Ducts ………………………………………………………....25
2.2. Measuring Instruments ………………………………………………26
2.2.1. Data Logger ………………………………………………………26
2.2.2. Anemometer ………………………………………………………27
2.2.3. Pitot Tube …………………………………………………………27
2.2.4. Weather Station Package …………………………………………28

CHAPTER 3. RESULTS AND DISCUSSION ………………………………………29

CHAPTER 4. CONCLUSIONS AND RECOMMENDATIONS ...…………………...35

REFERENCES ………………………………………………………………………...38

APPENDICES
APPENDIX A. TECHNICAL DRAWING OF AIR-TYPE SOLAR COLLECTOR …40
APPENDIX B. CALCULATIONS …………………………………………………42
B.1. Mass Flow Rate and Specific Heat …………………………………42
B.2. Total Solar Radiation on the Tilted Surface ……………….………43
B.3. Useful Heat and Total Heat …………………………………………...44
B.4. Efficiency …………………………………………………………...45
APPENDIX C. DAILY DATA ………………………………………………………..46

LIST OF TABLES

Table **Page**

Table 1.1. Properties of some selective coatings ……………………………………11
Table C.1. Daily data for 05.04.2005 ……………………..……………...………....46
Table C.2. Daily data for 06.04.2005 …………………………………………………47
Table C.3. Daily data for 11.04.2005 …………………………………………………48
Table C.4. Daily data for 19.04.2005 …………………………………………………49
Table C.5. Daily data for 20.04.2005 …………………………………………………50
Table C.6. Daily data for 25.04.2005 …………………………………………………51
Table C.7. Daily data for 26.04.2005 …………………………………………………52
Table C.8. Daily data for 28.04.2005 …………………………………………………53
Table C.9. Daily data for 02.05.2005 …………………………………………………54
Table C.10. Daily data for 03.05.2005 ………………………………………………...55
Table C.11. Daily data for 05.05.2005 ………………………………………………...56
Table C.12. Daily data for 09.05.2005 ………………………………………………...57
Table C.13. Daily data for 11.05.2005 ………………………………………………...58
Table C.14. Daily data for 12.05.2005 ………………………………………………...59
Table C.15. Daily data for 16.05.2005 ………………………………………………...60
Table C.16. Daily data for 17.05.2005 ………………………………………………...61
Table C.17. Daily data for 23.05.2005 ………………………………………………...62
Table C.18. Daily data for 24.05.2005 ………………………………………………...63
Table C.19. Daily data for 06.06.2005 ………………………………………………...64
Table C.20. Daily data for 07.06.2005 ………………………………………………...65
Table C.21. Daily data for 13.06.2005 ………………………………………………...66
Table C.22. Daily data for 15.06.2005 ………………………………………………...67
Table C.23. Daily data for 22.07.2005 ………………………………………………...68
Table C.24. Daily data for 25.07.2005 ………………………………………………...69
Table C.25. Daily data for 26.07.2005 ………………………………………………...70
Table C.26. Daily data for 27.07.2005 ………………………………………………...71
Table C.27. Daily data for 28.07.2005 ………………………………………………...72
Table C.28. Daily data for 29.07.2005 ………………………………………………...73

Table C.29. Daily data for 01.08.2005 ………………………………………………...74
Table C.30. Daily data for 02.08.2005 ………………………………………………...75
Table C.31. Daily data for 03.08.2005 ………………………………………………...76
Table C.32. Daily data for 04.08.2005 ………………………………………………...77

LIST OF FIGURES

Figure **Page**

Figure 1.1. Flat-plate type and concentrating type solar collectors ……………………1
Figure 1.2. Cross section of a basic flat-plate solar collector …………………………..2
Figure 1.3. Basic concentrating type solar collector ……………………………………3
Figure 1.4. Bare-plate air-type solar collector …………………………………………..5
Figure 1.5. Front-pass covered-plate air-type solar collector …………………………...6
Figure 1.6. Back-pass covered-plate air-type solar collector …………………………...7
Figure 1.7. Parallel-pass suspended-plate covered-plate air-type solar collector ………8
Figure 1.8. Double-pass suspended-plate covered-plate air-type solar collector ……….8
Figure 1.9. Perforated-plate covered-plate air-type solar collector ……………………..8
Figure 1.10. Absorber plate with fins …………………………………………………11
Figure 1.11. Metal filling material inside the air duct …………………………………12
Figure 1.12. Corrugated absorber plate ………………………………………………..12
Figure 1.13. Air flow on both side of the absorber plate ………………………………13
Figure 1.14. Counter-flow solar air heater with porous matrix ………………………..13
Figure 1.15. Dismantled collector with finned system on the back side ………………14
Figure 1.16. Offset plate fin absorber-plate ……………………………………………15
Figure 1.17. Functional diagram of the solar air collector with metal matrix absorber ……………………………………………………………………..15
Figure 1.18. The schematic of a double-pass thermal solar collector with porous media in the second channel ..……………………………………………16
Figure 1.19. Upward type solar air heater with fins …………………………………...17
Figure 1.20. Fins with attached baffles ………………………………………………...17
Figure 1.21. Complete drying system for drying apricots ……………………………..18
Figure 1.22. The perspective appearance of the air solar collector ……………………18
Figure 1.23. Schematic diagram of a SPDDSAH …………………………………...…19
Figure 1.24. Experimental device for drying grapes …………………………………..19
Figure 1.25. Solar air flat plate collector supplied with obstacles ……………………..20
Figure 1.26. Presentation of the typical obstacles (a) WDL1 (b) TL …………………20
Figure 1.27. Schematic diagram of the air solar collector with an absorber plate made of recyclable aluminium cans .....…………………………………20

Figure 1.28. Multi-tray crop dryer with inclined multi-pass air heater with in-built thermal storage ……………………………..…..………...21
Figure 2.1. General aspect of experimental setup ……………………………….23
Figure 2.2. Parts of air-type solar collector …………………………………….....24
Figure 2.3. Polyurethane foam ………………………………..……………….24
Figure 2.4. Radial fan (a) front side (b) rear Side ……………………………......25
Figure 2.5. Air ducts (a) inlet (b) outlet ………………………………………………25
Figure 2.6. ALMEMO 2290-8 Data logger 26
Figure 2.7. NiCr-Ni Thermo-couples ………………………………………….……26
Figure 2.8. Anemometer ……………………………………………………………27
Figure 2.9. Manometer and pitot tube ……………………………………………27
Figure 2.10. Weather station and Davis Vantage Pro console ………………...28
Figure 3.1. Thermal efficiency variation as a function of ambient temperature for air speed 3 m/s ..………………………………………………..…30
Figure 3.2. Thermal efficiency variation as a function of ambient temperature for air speeds 3,5 and 4 m/s ..…………………………………………….30
Figure 3.3. Thermal efficiency variation as a function of ambient temperature for air speeds 3,5 and 4 m/s …………………………………….………31
Figure 3.4. Thermal efficiency variation related to temperature difference between inlet and outlet of air-type solar collector for air speeds 3,5 and 4 m/s ...…31
Figure 3.5. Efficiency variation related to wind speed ……………………………...32
Figure 3.6. Characteristic curves for air speed 3 m/s ……………………………....33
Figure 3.7. Characteristic curves for air speeds 3,5 and 4 m/s ...………………………33
Figure 3.8. Pressure drop related to polyurethane foam for air speeds 3, 3,5 and 4 m/s …..……………………………………………………...34
Figure A.1. Technical drawing of experimental setup ………………………...40
Figure A.2. Experimental setup ………………………………………………..41

LIST OF SYMBOLS

Symbol	
a	width of the collector (m)
A	cross-section area of air duct (m^2)
A_c	collector area (m^2)
A_g	gross collector area (m^2)
b	depth of the collector (m)
c_p	specific heat of the heat transfer fluid (J/kg.^oC)
I_o	total solar radiation per unit area (W/m^2)
I_β	total solar radiation on the tilted surface per unit area (W/m^2)
k	thermal conductivity (W/m.^oC)
L	collector length (m)
L_{loc}	longitude, degrees west
L_{st}	standard meridian for local time zone, degrees west
m	mass flow rate of fluid (kg/s)
m_{in}	inlet mass flow rate (kg/s)
$m_{leakage}$	leakage mass flow rate (kg/s)
m_{out}	outlet mass flow rate (kg/s)
n	day number of the year
$T_{amb.}$	ambient temperature (^oC)
T_{in}	temperature of the fluid entering the collector (^oC)
T_{out}	temperature of the fluid leaving the collector (^oC)
ΔT	temperature difference between outlet and inlet (^oC)
P_{in}	pressure of the fluid entering the collector (kPa)
P_{out}	pressure of the fluid leaving the collector (kPa)
Q	total heat (W)
Q_{useful}	useful heat collected (W)
V_{av}	average speed of fluid (m/s)
V_{in}	speed of the fluid entering the collector (m/s)
V_{out}	speed of the fluid leaving the collector (m/s)

Greek symbols

α	absorptance of the collector absorber surface for solar radiation, dimensionless
β	slope, the angle between the plane of the surface and the horizontal, degrees
δ	declination angle, degrees
Φ	latitude, degrees
γ	surface azimuth angle, degrees
μ	viscosity (Pa.s)
η	efficiency (%)
η_g	collector efficiency based on gross collector area (%)
ρ	density (kg/m^3)
θ	angle of incidence, degrees
θ_z	zenith angle, degrees
τ	transmittance of the solar collector cover plate, dimensionless
w	hour angle, degrees

CHAPTER 1

INTRODUCTION

Solar energy is the most considerable energy source in the world. Sun, which is $1.495x10^{11}$ (m) far from the world and has a diameter of $1.39x10^{9}$ (m), would emit approximately 1353 (W/m^2) on to a surface perpendicular to rays if there was no atmospheric layer. The world receives 170 trillion (kW) solar energy and %30 of this energy is reflected back to the space, %47 is transformed to low temperature heat energy, %23 is used for evaporation/rainfall cycle in the Biosphere and less than %0.5 is used in the kinetic energy of the wind, waves and photosynthesis of plants (Duffie and Beckman 1991, Kalogirou 2004).

Solar energy systems consist of many parts. The most important part of these systems is the solar collector where the heat transfer from sun to absorber and absorber to fluid occurs. In order to affect the performance of these systems, generally modifications on solar collectors are performed.

1.1. Solar Collectors

A solar collector is a special kind of heat exchanger which converts solar radiation energy to heat energy by using usually air, water or oil. There are basically two types of solar collectors. They are the flat-plate collectors and the concentrating collectors (Figure 1.1).

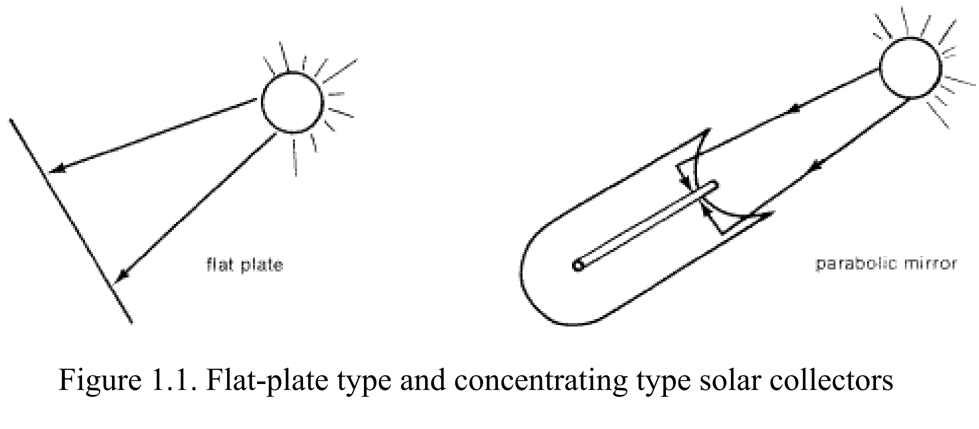


Figure 1.1. Flat-plate type and concentrating type solar collectors

The flat-plate collector absorbs energy directly from the sun as well as indirect or diffuse radiation reflected off nearby buildings, ground or clouds. On the other hand the concentrating collector focuses the direct rays of the sun which are incident on a reflector onto a smaller absorbing area. Concentrating collectors can heat the absorber to much higher temperatures than flat-plate collectors, because of the focusing effect. Concentrating collectors must continually track or follow the sun across the sky because of the use of only direct rays.

Flat-plate collectors may remain stationary, because they do not require direct radiation to operate. They are capable of providing the moderate temperatures required for space heating or cooling up to 70 to 100 ^{o}C and mechanically simpler than concentrating collectors. Because of these reasons, the flat-plate collector is the logical choice for agricultural and space heating applications.

1.1.1. Flat-Plate Collectors

A typical liquid heating flat-plate collector basically consists of black absorber plate which absorbs solar energy and transfers it to a fluid, cover plate which minimizes upward heat losses, back insulation which reduces conduction losses and fluid tube where the fluid flows and transfers heat (Figure 1.2). Air heaters are fundamentally the same except fluid tubes. Air ducts where air flows and transfer heat to air stream are replaced by fluid tubes (Duffie and Beckman 1991).

There are many different designs of flat-plate collectors, but they have two main characteristic in common. A flat-plate collector increases the temperature of plate which absorbs the sun's radiant energy and picks up the heat absorbed by the plate and transfers it to a point of use or storage by circulating fluid such as air or water.

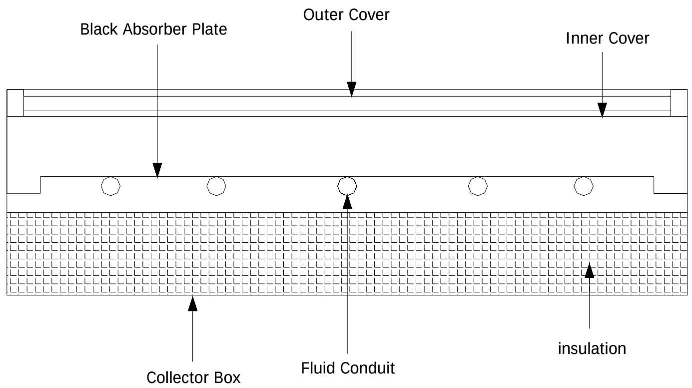


Figure 1.2. Cross section of a basic flat-plate solar collector

1.1.2. Concentrating Collectors

For many applications higher temperatures that obtained from flat-plate collectors are desirable to deliver energy. Energy delivery temperatures can be increased by decreasing the area from which heat losses occur. This is done by interposing an optical device between the source of radiation and the energy absorbing surface. The small absorber has smaller heat losses compared to a flat-plate collector at the same absorber temperature. Because of this reason, concentrating collectors which generally collect the sun's rays from a relatively large area and focus them on a point by using parabolic mirrors are used (Figure 1.3).

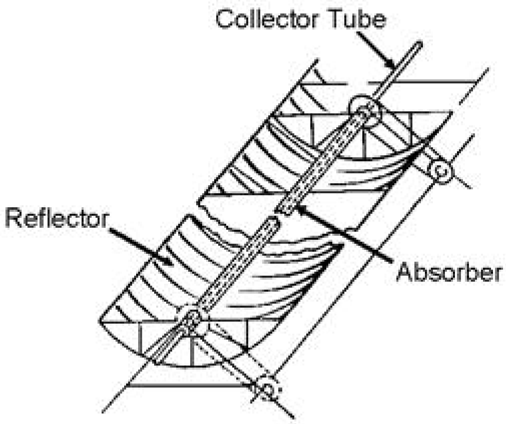


Figure 1.3. Basic concentrating type solar collector

There are many different designs of concentrating collectors. Concentrators can be reflectors or refractors, can be cylindrical or surfaces of revolution and can be continuous or segmented. Receivers can be convex, flat or concave and can be covered with glazing or uncovered. Concentration ratios can vary over several orders of magnitude, from as low as unity to high values of the order of 10 000. Increased ratios mean increased temperatures at which energy can be delivered but consequently these collectors have increased requirements for precision in optical quality and positioning of the optical system (Kalogirou 2004).

Concentrators are treated in two groups, because it is difficult to develop general analyses applicable to all concentrators. They are non-imaging collectors with low concentration ratio and linear imaging collectors with intermediate concentration ratio.

We also note some basic consideration of three-dimensional concentrators that can operate at the high end of the concentrating scale.

There are some advantages of concentrating collectors. Firstly, the working fluid can achieve higher temperatures in a concentrator system when compared to a flat-plate system of the same solar energy collecting surface. This means that a higher thermodynamic efficiency can be achieved. Another advantage for concentrating collectors is that, it is possible with a concentrator system, to achieve a thermodynamic match between temperature level and task. The task may be to operate thermionic, thermodynamic, or other higher temperature devices. Additionally, the thermal efficiency is greater because of the small heat loss area relative to receiver area. Reflecting surfaces require less material and are structurally simpler than flat-plate collector. For a concentrating collector the cost per unit area of the solar collecting surface is therefore less than that of a flat-plate collector. The last advantage for concentrating collector is that, owing to the relatively small area of receiver per unit of collected solar energy, selective surface treatment and vacuum insulation to reduce heat losses and improve the collector efficiency are economically viable.

On the other hand, these collectors have some disadvantages. Firstly, concentrator systems collect little diffuse radiation depending on the concentration ratio. Other disadvantage for concentrating collectors is that, some form of tracking system is required so as to enable the collector to follow the sun. The last disadvantage is that, solar reflecting surfaces may loose their reflectance with time and may require periodic cleaning and refurbishing.

1.2. Air-Type Solar Collectors

Air-type solar collector is a specific type of heat exchanger which transfers heat energy, which is obtained from absorbing solar radiation, to air. There are many differences between an air-type solar collector and a heat exchanger. Basically, in heat exchanger heat transfer from fluid to fluid occurs by conduction and convection. On the other hand, in air-type solar collector heat transfer occurs from an energy source which spreads radiation to air.

Basically, an air-type solar collector consists of an absorber plate which absorbs heat and behaves as a black matter, cover material, generally glass, to protect the absorber plate against cooling and other external effects and insulation to minimize heat losses. All the parts of the collector except glazing must be thermally well insulated to minimize heat losses. Glazing minimizes convective and radiative losses to atmosphere and obtains solar rays to stay between absorber plate and glazing, and to be absorbed by black matter. Heat transferred to air by an air duct between glazing and absorber plate.

In many fields air-type solar collectors are applicable. They generally used in food industry to dry agricultural products, textile industry to dry fabrics and space heating. Drying grains (wheat, barley, maize etc.), fruits (grape, fig, apricot etc.), vegetables, tea are examples for food industry. Greenhouse heating and hospital heating to obtain fresh air are examples of space heating. These examples show that increasing efficiency of air-type solar collectors is significant for commercial acceptance (Ilken and Değirmencioğlu 2003).

1.2.1. Types of Air-Type Solar Collectors

Air-type solar collectors can be classified as two types:

- Bare-plate air-type solar collectors
- Covered-plate air type solar collectors

These types are detailed in the next sections.

1.2.1.1. Bare-Plate Air-Type Solar Collectors

Bare-plate air-type solar collectors consist of an air duct and an uppermost surface as an absorber plate. In these types of collectors heat transfer to the air stream is through the rear side of the absorber (Figure 1.4).

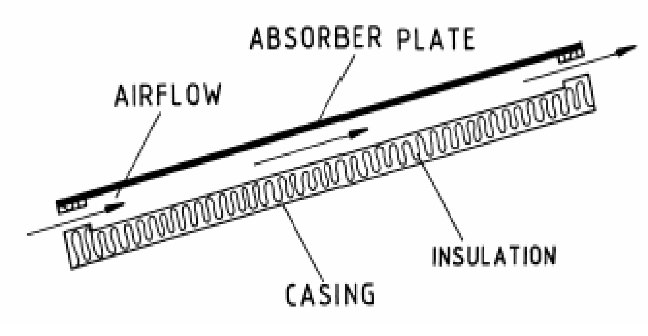


Figure 1.4. Bare-plate air-type solar collector

Corrugated iron sheet roofs of buildings are being adapted frequently as bare-plate collectors for heating the air space within the building.

1.2.1.2. Covered-Plate Air-Type Solar Collectors

Covered-plate air-type solar collectors use one or more cover plates of glass, plastic or fiberglass to minimize upward heat losses. Cover plate is placed above and usually parallel to the absorber plate. This cover plate protects the absorber plate against cooling and other external effects (rain, wind etc.). There are four main types of cover-plate air-type solar collectors. They are front-pass covered-plate air-type solar collector, back-pass covered-plate air-type solar collector, suspended-plate covered-plate air-type solar collector and perforated-plate covered-plate air-type solar collector.

1.2.1.2.1. Front-Pass Covered-Plate Air-Type Solar Collector

In front-pass covered-plate air-type solar collector, air passes through the duct between the cover plate and the absorber plate (Figure 1.5).

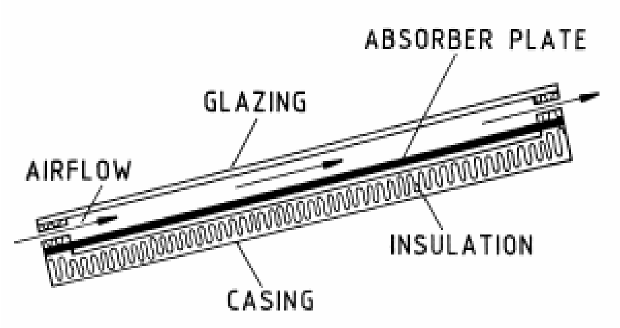


Figure 1.5. Front-pass covered-plate air-type solar collector

In this type of collector, heat transfer to the air stream is through the front side of the absorber plate. They are simple to build; on the other hand, only one surface of the absorber is used as effective heat transfer area.

1.2.1.2.2. Back-Pass Covered-Plate Air-Type Solar Collector

In back-pass covered-plate air-type solar collector, the absorber plate is placed behind the cover plate with a layer of static air. Air flows between the rear side of the absorber plate and the insulation layer (Figure 1.6).

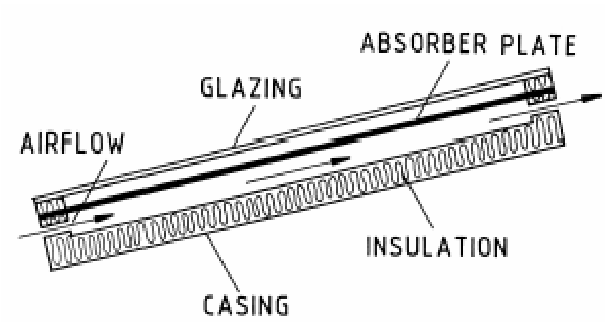


Figure 1.6. Back-pass covered-plate air-type solar collector

In this type of collector, heat transfer to the air stream is through the rear side of the absorber plate. Air in the gap between absorber and glazing operates as insulation. As a disadvantage, only one surface of the absorber is used as effective heat transfer area.

1.2.1.2.3. Suspended-Plate Covered-Plate Air-Type Solar Collector

In suspended-plate covered-plate air-type solar collector, the absorber plate is between the cover plate and insulation layer. Air flows both side of the absorber plate. There are two main types of suspended-plate covered-plate air-type solar collector. They are parallel-pass suspended-plate covered-plate air-type solar collector (Figure 1.7) and double-pass suspended-plate covered-plate air-type solar collector (Figure 1.8).

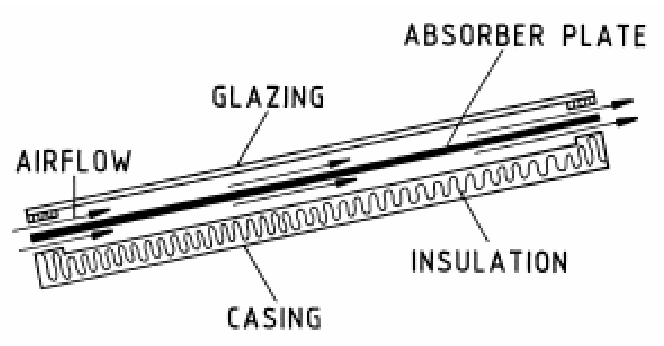


Figure 1.7. Parallel-pass suspended-plate covered-plate air-type solar collector

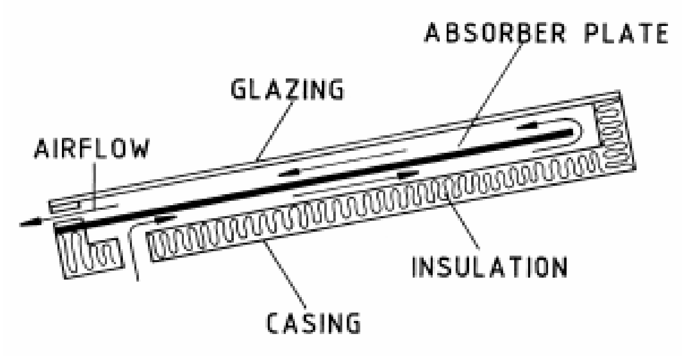


Figure 1.8. Double-pass suspended-plate covered-plate air-type solar collector

In these types of collectors, double effective heat transfer area is an advantage but, increase of the heat losses at high differences between absorber and ambient temperature due to the hot air directly under the cover is a disadvantage.

1.2.1.2.4. Perforated-Plate Covered-Plate Air-Type Solar Collector

Perforated-plate covered-plate air-type solar collector is a modified form of suspended-plate air-type solar collector, also known as matrix solar heater. This type of collector is made of a porous high surface area absorber, such as blackened gauze (Figure 1.9).

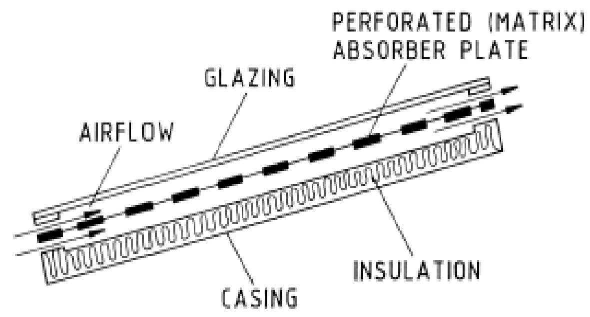


Figure 1.9. Perforated-plate covered-plate air-type solar collector

This type of collector is more efficient than the others, because of the increased heat transfer coefficient and surface area. On the other hand, high pressure drop and the absorber under a high technical stress, because of the ambient air conditions (dust, pollution etc.), are the disadvantages of this type of collector.

1.2.2. Collector Thermal Efficiency

The efficiency of a solar collector is defined as the ratio of the amount of useful heat collected to the total amount of solar radiation striking the collector surface during any period of time.

$$\eta = \frac{\text{Solar Energy Collected}}{\text{Total Solar Striking Collector Surface}} = \frac{Q_{\text{Useful}}}{I_O . A_c} \qquad (1.1)$$

Useful heat collected for an air-type solar collector can be expressed as:

$$Q_u = \dot{m} C_p (T_{out} - T_{in}) \qquad (1.2)$$

So, collector thermal efficiency becomes,

$$\eta = \dot{m} C_p \frac{(T_{out} - T_{in})}{I_o A_c} \qquad (1.3)$$

The thermal performance of a solar collector depends on many parameters. These parameters can be listed as:

- Ambient conditions : Ambient temperature, wind speed, solar radiation
- Geometry of collector (L, a, b)
- Characteristics of working fluid (c_p, k, ρ, μ)
- Inlet temperature of fluid (T_{in})
- Flow rate ($\dot{m}$)
- Choice of the absorber material
- Location of the construction : Inclination angle, direction

1.2.3. Applications to Increase Efficiency of Air-Type Solar Collectors

Air-type solar collectors directly use air as working fluid. As a result of this, they are simple, because of the fewer components then the other collectors. This feature enhances the importance of air-type solar collectors in solar heating systems. In spite of common usage area, they have disadvantages. The main disadvantage is necessity of using excessive air at low thermal capacity as the transfer fluid.

Factors that affect the efficiency of the air-type solar collectors can be easily arranged in order. Increasing the collector absorbing area enhances the heat amount transferred to air, so that efficiency increases. Increasing the flow rate of air under same conditions and constant collector length also increases the efficiency. Using more than one transparent cover decreases the upward heat losses from the collector and obtains an increase on the efficiency. Another factor effect the efficiency is the material of absorber plate. Absorber plate with high solar absorptance and low thermal emittance increases the efficiency of collector. This type of absorber plates called as selective solar absorber plates.

Selective solar absorber plates play an important role, especially when the temperature difference between absorber and ambient is high. Collector durability indicates the quality of the absorber surface. Selective solar absorber surfaces generally obtain by coating. Coating which will not optically degrade significantly during the life time of the collector and also withstand stagnation temperature and humidity is needed (Tesfamichael 2000, Choudhury 2003).

The selective surface or coating should have the following physical properties.

1. High absorptance for solar spectrum range 0,3 – 2,5 μm and low emittance for spectrum greater than 2,0 μm.
2. Spectral transition between the region of high absorptance and low emittance be as sharp as possible.
3. The opto-physical properties of the coating must remain stable under long term operation at elevated temperatures, repeated thermal cycling, air exposure, ultra-violet radiation, etc.
4. Adherence of coating to substrate must be good.
5. Coating should be easily applicable and economical.

Properties of some important selective coatings are given on table 1.1.

Table 1.1. Properties of some selective coatings
(Source: Choudhury 2003)

Coating	Substrate	Absorptivity	Emissivity
CuO	Cu	0.90	0.11
CuO	Al	0.93	0.11
CuO / ZnO	Zn / Al	0.88	0.20
CuO	Fe	0.90	0.16
Black nickel on bright nickel	Fe, Cu	0.96	0.07
Black nickel	Zn / Fe	0.94	0.09
Black chrome on bright nickel	Fe, Cu	0.95	0.09
	Zn / Al Ni / Al Zn / Fe	0.95 0.95 0.95	0.12 0.5 0.16
Co_2O	Zn / Fe Ni	0.93 0.92	0.08 0.08

The most important factor that affects efficiency is the large absorber plate and the large heat transfer area. The aim of enlargement is minimizing the disadvantages that happen from the thermal capacity of air. There are four main studies to increase the absorber plate area and the heat transfer area.

1.2.3.1. Absorber Plate with Fins

A method to increase the thermal performance of air-type solar collector is adding fins on to the absorber plate (Figure 1.10). This process gives a positive effect to the performance of the collector because of the increased heat transfer surface area.

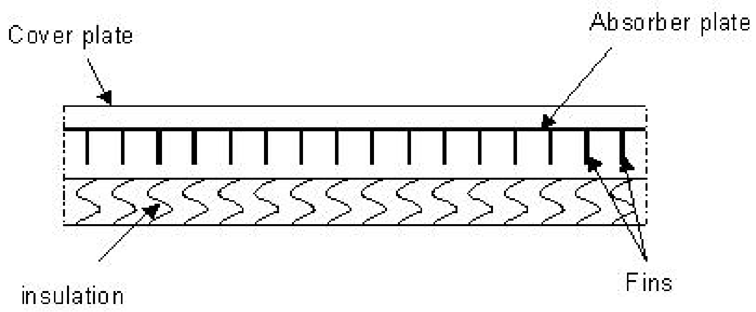


Figure 1.10. Absorber plate with fins

1.2.3.2. Metal Filling Material inside the Air Duct

Filling air duct with metal filling material increases the performance of collector, but pressure drop should be taken into consideration for this type collectors (Figure 1.11).

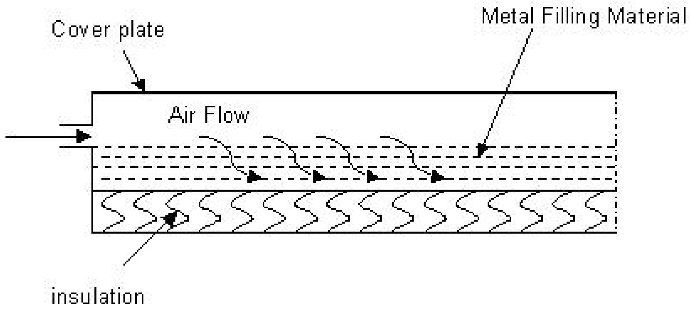


Figure 1.11. Metal filling material inside the air duct

1.2.3.3. Corrugated Absorber Plate

In literature, corrugated absorber plate is the first application applied to increase the heat absorber surface area (Figure 1.12). This is a basic application used in the countryside for heating sheep-fold.

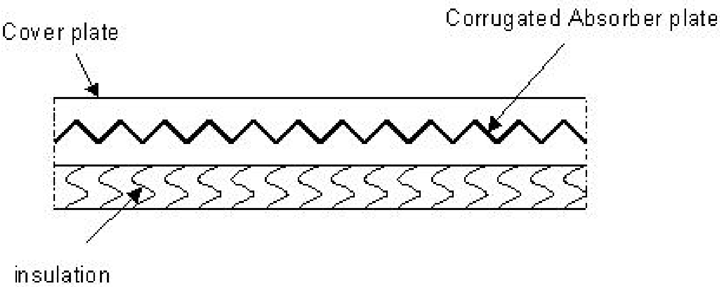


Figure 1.12. Corrugated absorber plate

1.2.3.4. Air Flow on Both Side of the Absorber Plate

There are many absorber plate layers consist of normal and black glass. Black glass absorbs the radiation and normal glass infects radiation the black glass under itself (Figure 1.13).

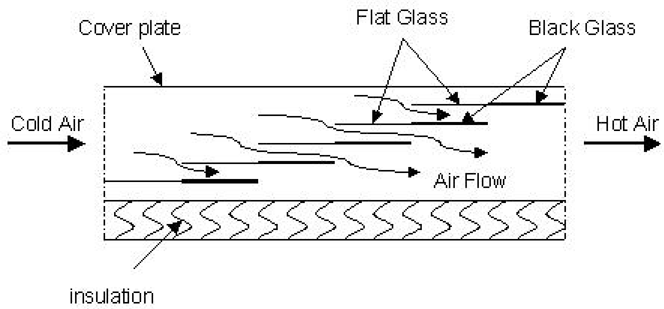


Figure 1.13. Air flow on both side of the absorber plate

In literature, there are many studies to increase the performance of air-type solar collector. Article named “High efficiency solar heater” presents an analysis for a novel type of solar air heater (Mohamad 1996). Air is forced to flow over the front glass cover (preheat the air) before passing through the absorber to minimize heat losses from the front cover and maximize heat extraction. Porous media is used to enhance heat transfer from the absorber to the air stream, because of high volumetric heat transfer coefficient (Figure 1.14). This collector combines double air passage and porous media and in the design of this type of collector care should be taken to minimize pressure drop. The thermal efficiency of this type of collector is higher than the thermal efficiency of conventional air collectors. If high porous medium is used and U-return section is carefully designed, the pressure drop is not so significant. Performance of the suggested counter-flow solar air heater is studied for different value of the flow rate of air varied from 0.005 to 0.2 kg/(ms) and compared with the performance of single and double glazing conventional solar air heaters.

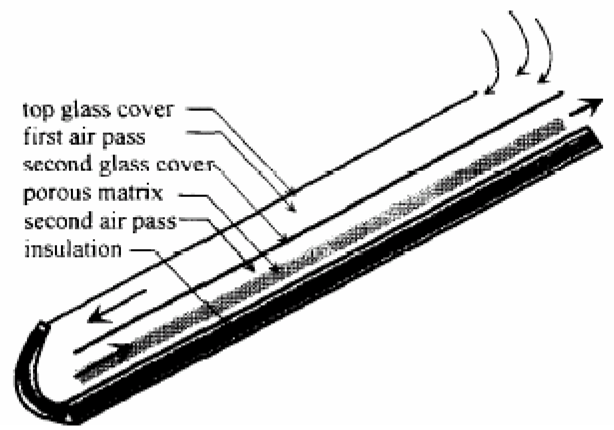


Figure 1.14. Counter-flow Solar Air Heater with Porous Matrix
(Source: Mohamad 1996)

Consequently, the thermal efficiency of counter-flow without porous media is between 18 and 25% higher than that for a conventional air heater. The thermal efficiency of counter-flow with porous media is above 75% for normal operating range and exceeding 80% for high flow rates.

Another article named "Technical Note – Comparative study on the thermal performance of solar air heater collectors with selective and nonselective absorber-plate" presents the effect of selective and non-selective absorber plates on the thermal performance of solar air heater (Hachemi 1998). Selective absorbers in solar collectors obtain the lowering of the forward heat loss by radiation to the environment. Unlike high cost price of the installation, selective absorbers improve the thermal heat performance of collectors. Reducing not only the absorber temperature, but also the forward heat loss is significant to increase performance. A fully developed turbulent flow by using finned system is created to increase performance (Figure 1.15). That cools the absorber and increases the air temperature. The use of any black-painted plate, as a nonselective absorber, obtains high thermal efficiencies with low cost.

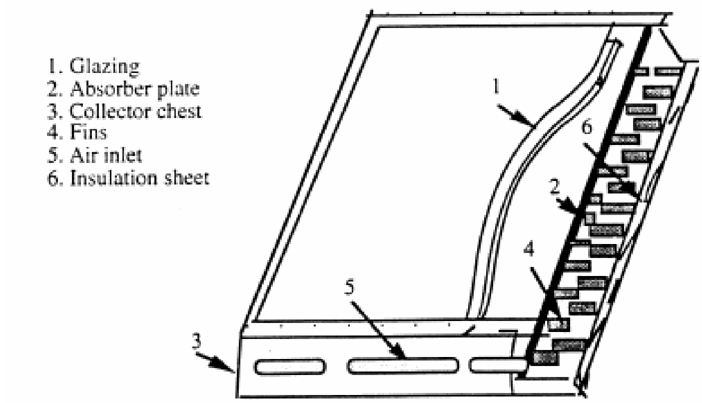


Figure 1.15. Dismantled collector with finned system on the back side
(Source: Hachemi 1998)

Another study named "Experimental study of thermal performance of offset rectangular plate fin absorber-plates" presents developed offset rectangular plate fin absorber plates to enhance the heat transfer more than with fully developed turbulent flow (Hachemi 1998). Offset rectangular plate fins are commonly used in heat exchangers. In this type of collector the fluid homogenization depends on the length of interruption which is alternated periodically. Velocity and thermal boundary layers are developed where offset fin is located downstream of interruption. This technique causes higher heat transfer than in fully developed turbulent flow.

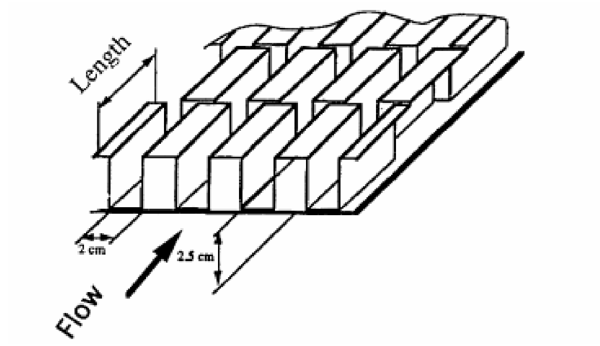


Figure 1.16. Offset plate fin absorber-plate
(Source: Hachemi 1998)

In this study offset rectangular plate fins which are oriented parallel to the fluid flow are mounted in staggered pattern and soldered to the bottom of absorber plate (Figure 1.16). As the result of this study, high thermal performances are obtained with low friction and low electrical power is consumed by the fan in comparison to the flat plate collectors.

An experimental article named "Experimental studies on a solar Air collector with metal matrix absorber" aims overcoming the physical problems of conventional flat-plate air collectors as well as the technical problems of matrix air collectors (Kolb et. al. 1998). Metal matrix absorber consists of two parallel sheets of black oxidized or black galvanized industrial woven, fine meshed wire screens made of copper (Figure 1.17). The collector is durable and flexible regarding mass flow rate and collector duct height. In addition to these high thermal performances at very low pressure losses and high outlet temperatures can be obtained.

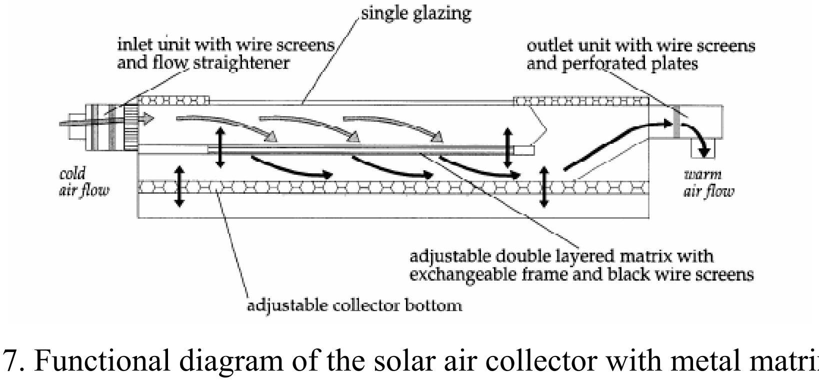


Figure 1.17. Functional diagram of the solar air collector with metal matrix absorber
(Source: Kolb et. al. 1998)

In conclusion, it is observed that, increasing mass flow rate improves the thermal performance of the collector. Changing the channel height has little effect on thermal efficiency at low mass flow rates. At higher mass flow rates in order to obtain best thermal performance, low heights for upper channel are recommended. A simulation model is needed to optimize this collector, because of the large number of design, operating parameters, high costs and time demands for testing.

Another paper named “Thermal performance of the double-pass solar collector with and without porous media” presents the thermal performance of a double-pass solar collector with and without porous media in the second channel of the collector (Sopian et. al. 1998). Thermal performance of this study is obtained by designing an experimental setup. Important relationships between the design and operating conditions which affect the thermal performance of the collector have been obtained. Effects of depth change of upper and lower channel on the thermal efficiency with and without porous media have been obtained (Figure 1.18). In addition to these, effects of mass flow rate, solar radiation and temperature rises on the thermal performance of the collector have been studied. Consequently, the existence of porous media in the second channel causes an increase on the outlet temperature and the thermal efficiency of the collector.

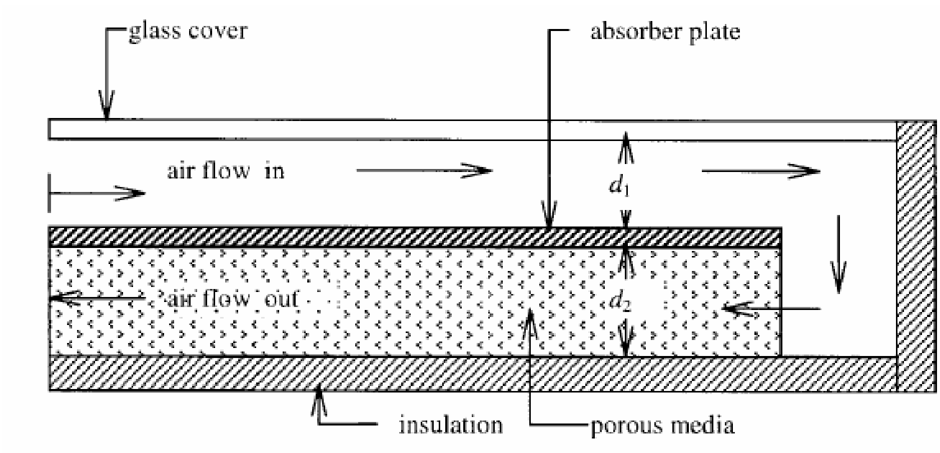


Figure 1.18. The schematic of a double-pass thermal solar collector with porous media in the second channel

(Source: Sopian et. al. 1998)

Article named “Effect of collector aspect ratio on the collector efficiency of upward type baffled solar air heaters” presents the effect of collector aspect ratio on the collector efficiency of upward type baffled solar air heaters (Yeh et. al. 1999). Fins attached with baffles for increasing heat transfer increases the collector efficiency (Figure 1.19 and 1.20). Moreover, increasing the collector aspect ratio for increasing fluid velocity also increases the efficiency. On the other hand, these applications increase the fan power and, there by, increases operating cost. Consequently, a proper increase of the collector aspect ratio and a well-arranged settlement of fins and baffles will be an economic and efficient solution for solar air heaters.

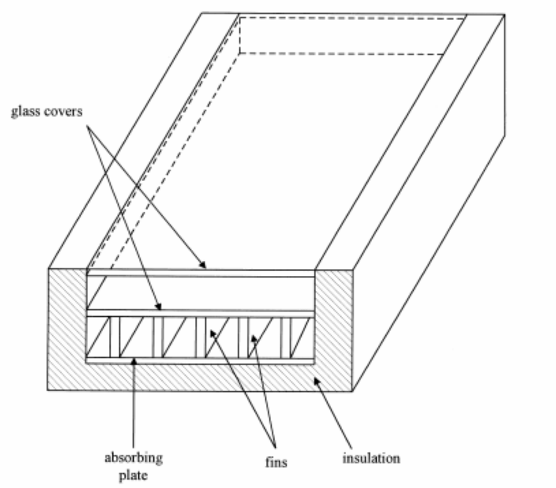


Figure 1.19. Upward type solar air heater with fins

(Source: Yeh et. al. 1999)

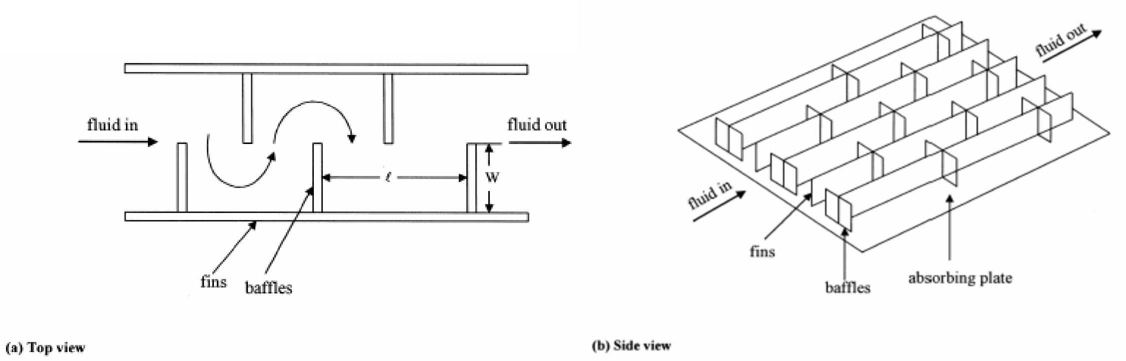


Figure 1.20. Fins with attached baffles

(Source: Yeh et. al. 1999)

Another experimental study named “Drying of apricots in a rotary column cylindrical dryer (RCCD) supported with solar” presents a newly developed rotary column cylindrical dryer (RCCD) with an air solar collector (ASC) which was designed specially (Sarsilmaz et. al. 2000) (Figure 1.21 and 1.22). The aim of this work is to investigate optimum drying air rate and rotation speed of dryer, to protect uniform and hygienic drying conditions and to reduce drying period. To reach this aim, the changes of the moisture contents in the Sugarpiece (Şekerpare) foods were studied.

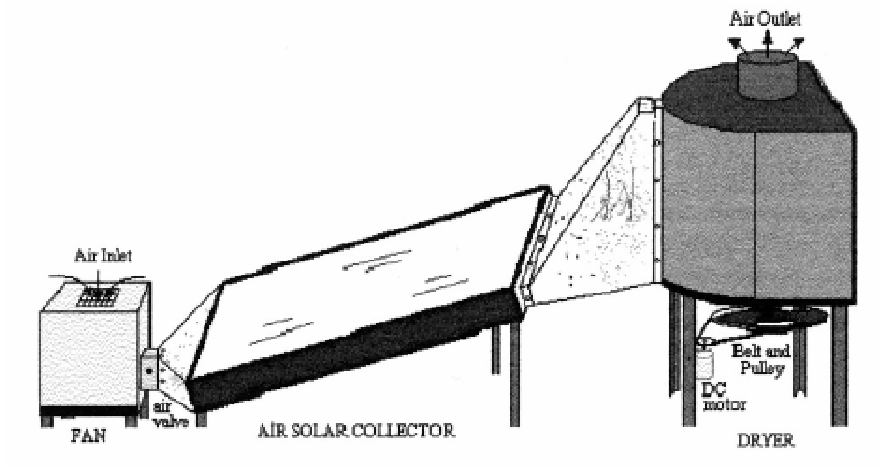


Figure 1.21. Complete drying system for drying apricots
(Source: Sarsilmaz et. al. 2000)

Apricots dried in this system are compared with the ones dried open on the ground. Consequently, using this system increased drying rate, reduced drying period and obtained more hygienic and homogenous drying conditions.

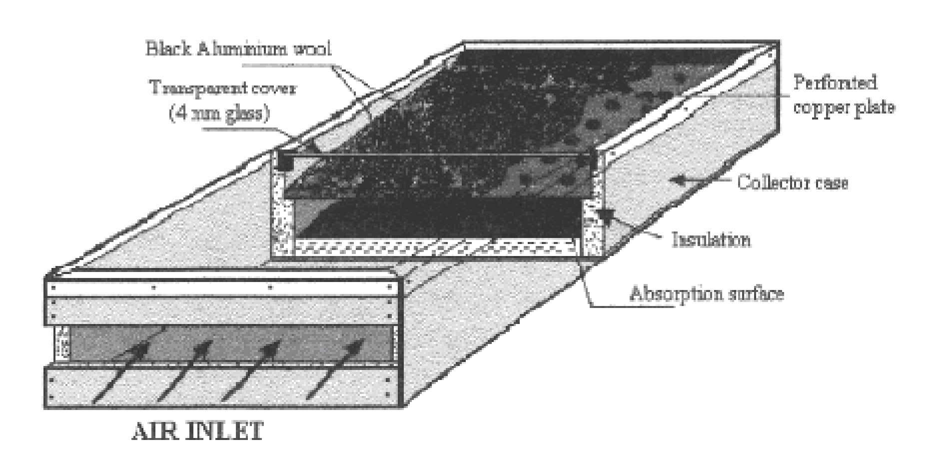


Figure 1.22. The perspective appearance of the air solar collector
(Source: Sarsilmaz et. al. 2000)

A mathematical and experimental study named "Experimental and simulation studies on a single pass, double duct solar air heater" describes a mathematical model of a single pass, double duct air heater (SPDDSAH) (Forson et. al. 2002). This model provides a design tool that predicts incident solar radiation, heat transfer coefficient, mean air flow rates, mean air temperature and relative humidity at the exit (Figure 1.23). Results of the simulation and the experimental setup are compared with each other. Predicted results from a parametric study are presented and appropriate agreement between the predicted and measured values is demonstrated. It is concluded that the significant improvement on the performance of the SPDDSAH can be obtained with appropriate choice of the collector parameters and the channel depth ratio of the two ducts from top to bottom. Moreover, it is shown that the air mass flow rate is a significant factor in determining overall efficiency of the heater.

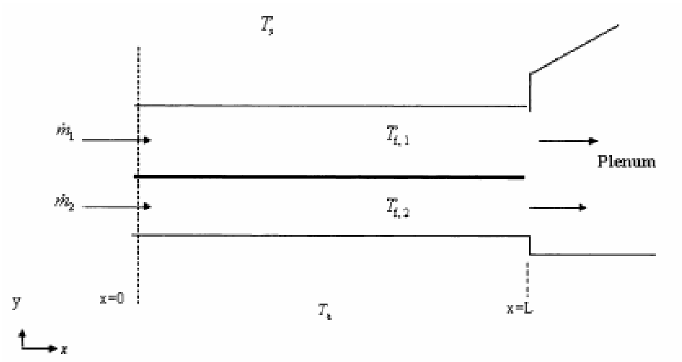


Figure 1.23. Schematic diagram of a SPDDSAH
(Source: Forson et. al. 2002)

Another experimental study named “Study of a solar air flat plate collector: use of obstacles and application for the drying grapes” presents improvement of the efficiency and temperature of the flat plate solar collectors by using several types of obstacles attached in air stream of the collector (Abene et. al. 2003) (Figure 1.24). Different collector types were examined and it was shown that using obstacles was an important factor for improving the performance of the collector (Figure 1.25). However, it was observed that form, dimensions, orientation and disposition of obstacles affects the efficiency of the collector. Consequently, solar collectors supplied with waisted delta lengthways (WLD1) and transverse-longitudinal obstacles (TL) increased the efficiency-temperature couple and reduced drying time of product more than the other types (Figure 1.26).

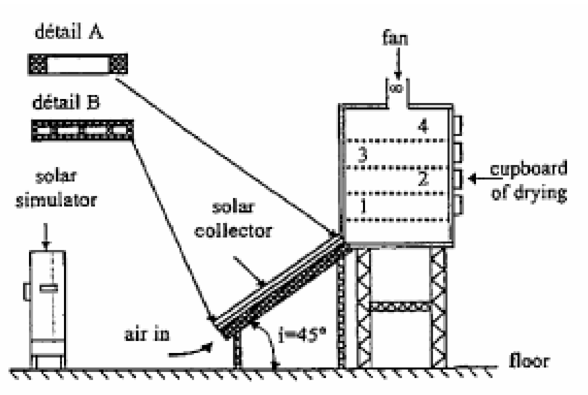


Figure 1.24. Experimental device for drying grapes

(Source: Abene et. al. 2003)

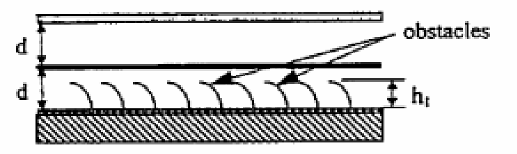
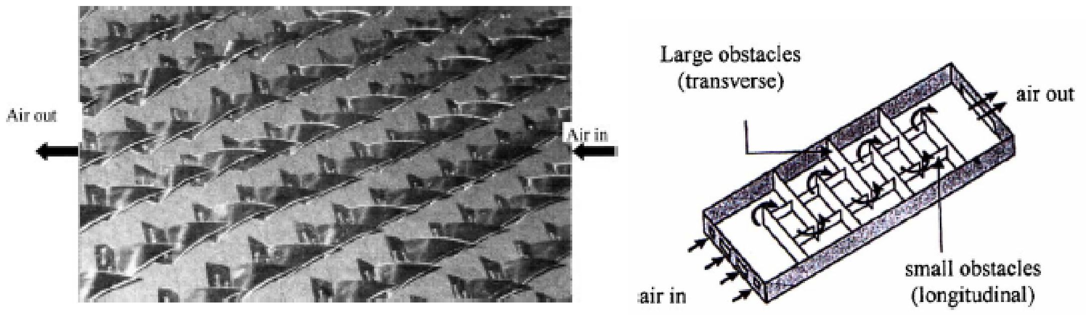


Figure 1.25. Solar air flat plate collector supplied with obstacles

(Source: Abene et. al. 2003)



(a) (b)

Figure 1.26. Presentation of the typical obstacles (a) WDL1 (b) TL

(Source: Abene et. al. 2003)

Paper named "Thermal performance of an air solar collector with an absorber plate made of recyclable aluminum cans" aims using recyclable materials to build absorber plate and reduce the cost price of air solar collector (Alvarez et. al. 2004). In this paper development and testing of single-glass air solar collector with absorber plate made of recyclable aluminum cans (RAC) is studied (Figure 1.27).

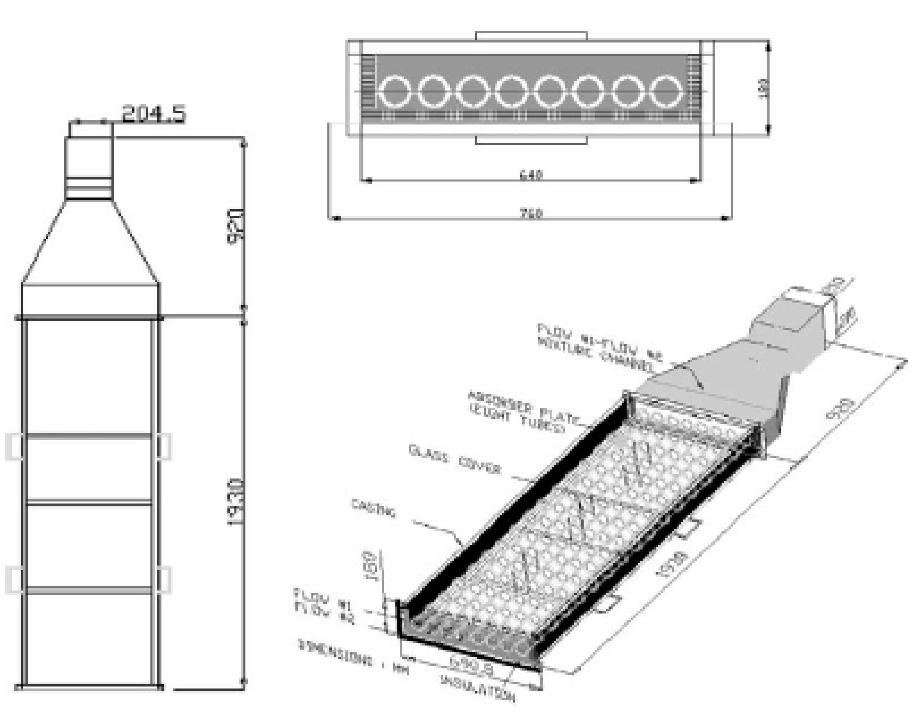


Figure 1.27. Schematic diagram of the air solar collector with an absorber plate made of recyclable aluminium cans

(Source : Alvarez et. al. 2004)

The absorber plate consists of eight circular air flow channels which contain 128 recyclable aluminum cans. These cans are blackened with opaque black paint with an absorptance of 0.903 and reflectance of 0.097. To obtain appropriate configuration for a uniform air flow distribution a hydrodynamic numerical calculation was studied. A simulation model for double flow air solar collector was provided to obtain design parameters to determine the size of the collector. Air solar collector design, built and tested by using the ASHRAE 93-86 standard. Consequently, the time constant, the thermal efficiency and the incidence angle modifier were determined and the thermal efficiency was compared with the reported ones. Moreover, it is shown that it is technically and economically feasible to increase the efficiency of the air solar by using recyclable aluminum cans.

The last paper named "Modeling the system performance of multi-tray crop drying using an inclined multi-pass solar air heater with in-built thermal storage" presents a periodical analysis of multi-tray crop drying joined to an inclined multi-pass solar air heater with in-built thermal storage (Jain 2004) (Figure 1.28). The performance of this system was evaluated for drying paddy crop. On a day of October for the climatic conditions of Delhi (India) a parametric study was done. Effects of change in the tilt angle, length and breadth of a collector and mass flow rate on the temperature of crop were studied. Drying rates and hourly reduction in moisture content in the different trays were studied by using the thin layer drying equation. It was shown that the moisture content of crop decreases with the drying time of the day.

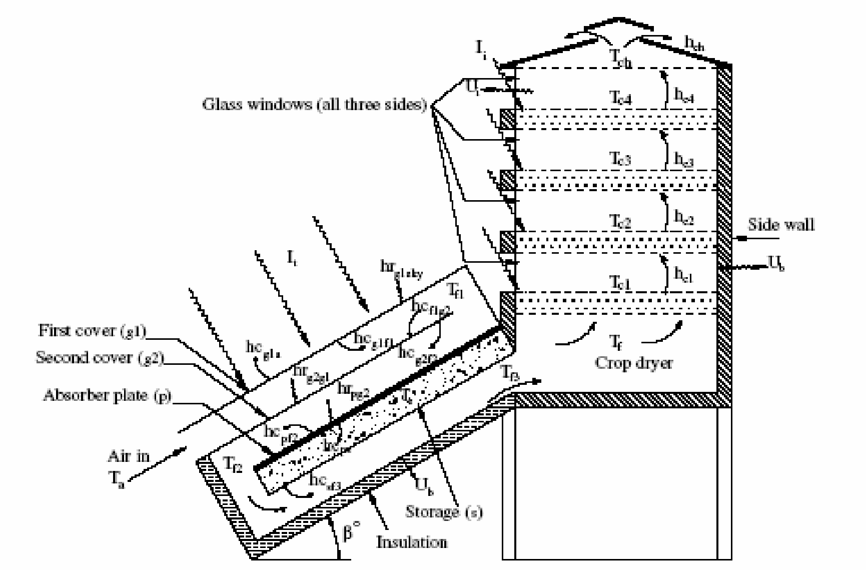


Figure 1.28. Multi-tray crop dryer with inclined multi-pass air heater with in-built thermal storage

(Source: Jain 2004)

In conclusion, the crop temperature increase can be obtained by the increase in collector length and tilt angle. Moreover, the thermal efficiency of this system increases with the increase in mass of the crop.

Under effects of these studies, an air-type solar collector was built and tested by using the ASHRAE 93-1986 standard named “Methods of testing to determine the thermal performance of solar collectors”. Performance of the collector observed and data, obtained from a data logger, are used to calculate the efficiency of our collector. Effect of porous media on the thermal performance of an air-type solar collector is tested. Polyurethane foam is used as heat absorbing media. Increment of the efficiency related to the polyurethane foam is presented and performance curves of our air-type solar collector are indicated. Factors, affect the performance of collector, are discussed in next sections.

CHAPTER 2

EXPERIMENTAL SETUP

In this study, an experimental setup, which consists of an air-type solar collector, a radial fan and air ducts, is build (Figure 2.1). In order to collect data, a data logger, an anemometer, a pitot tube and a weather station package are used. Technical drawing and dimensions of our experimental setup is given in appendix A.

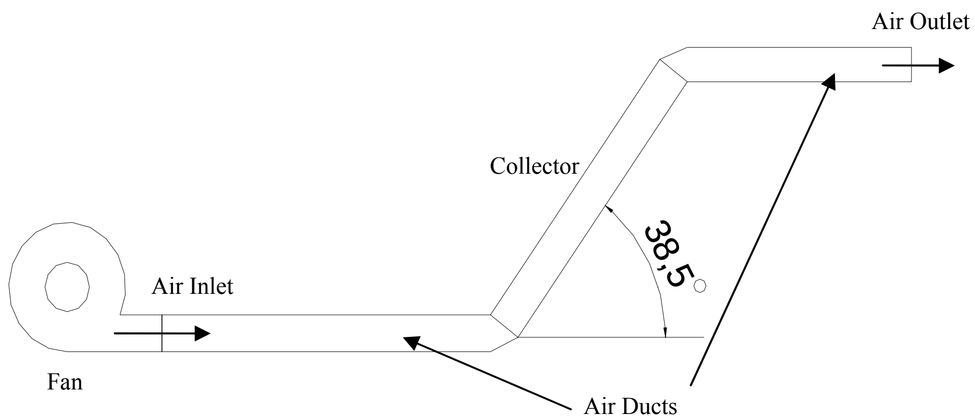


Figure 2.1. General aspect of experimental setup

2.1. Parts of Experimental Setup

2.1.1. Air-Type Solar Collector

Our air-type solar collector generally consists of three main parts. These parts are double layer glass cover which minimizes upward heat losses, insulation material which reduces conduction losses, heat absorbing media which increases heat transfer surface area (Figure 2.2). Air-type solar collector has an inclination of 38,5^o, because of the latitude of İzmir which is 38,46^o.

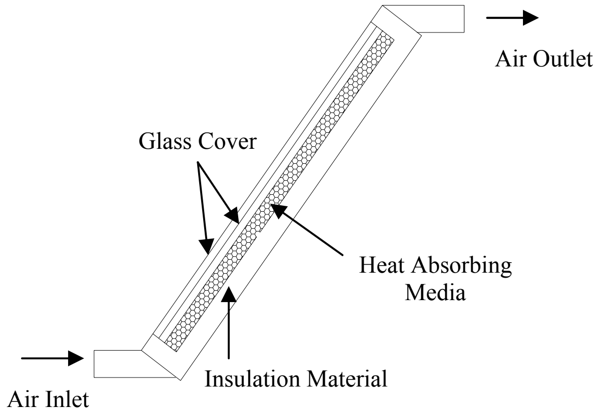


Figure 2.2. Parts of air-type solar collector

Polyurethane foam with a porosity of % 85 was used as heat absorbing media. Porous disposition for increasing heat transfer surface area and black color for enhancing absorptivity of sun rays were the most effective factors in order to choose this material as heat absorbing media (Figure 2.3).

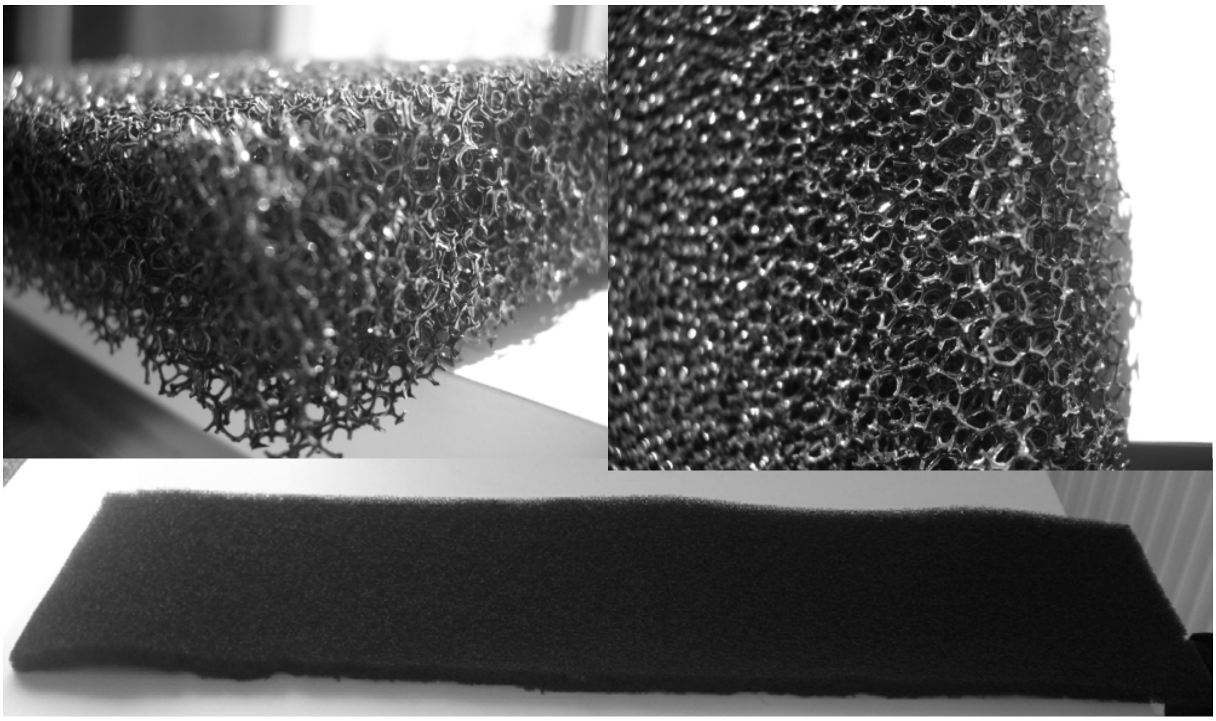
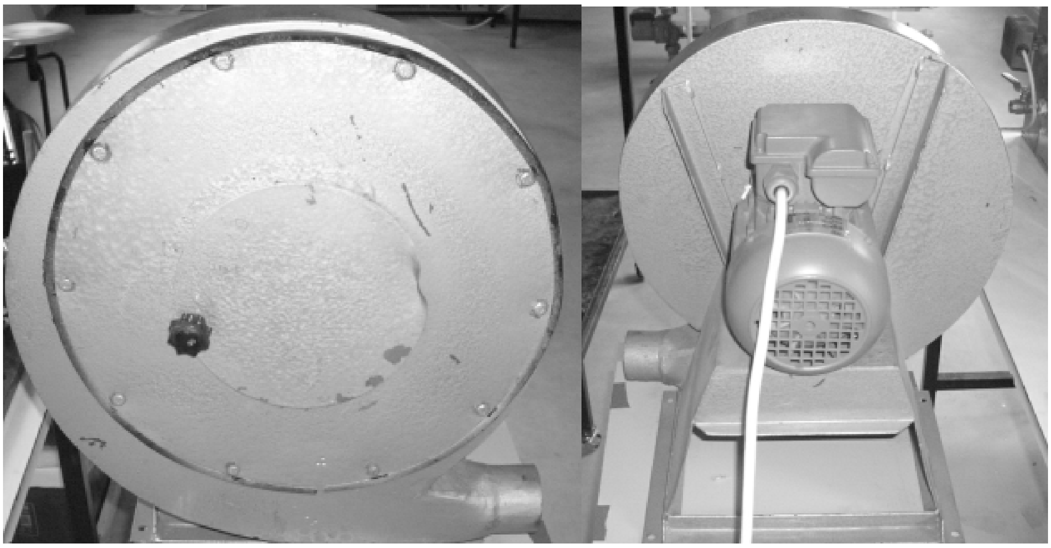


Figure 2.3. Polyurethane foam

2.1.2. Radial Fan

Air is sent into air duct by a radial fan (Figure 2.4). An electric motor drives the fan with a constant rotational speed. Air speed can be varied by moving the air lid on the front side of the fan. This fan obtains 2820 revolutions per minute and spends 0,94 kW energy per hour. Minimum air speed about 2 m/s and maximum air speed about 6 m/s are observed by testing the radial fan.

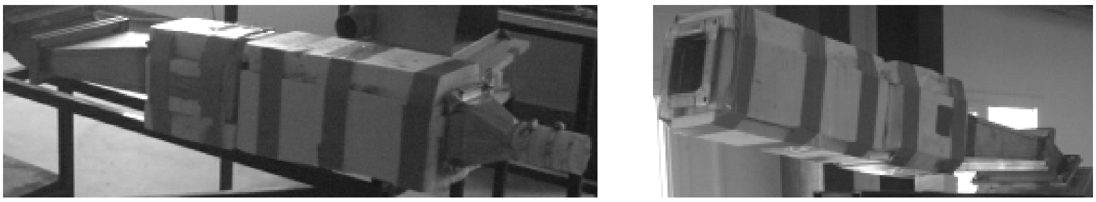


(a) (b)

Figure 2.4. Radial fan (a) front side (b) rear Side

2.1.3. Air Ducts

Experimental setup contains two parts of air ducts which are at the inlet and outlet section of the collector. These ducts have profiles of generally square and are covered by foam material to minimize heat losses and gains which can be occurred by external effects like sun rays or convective heat losses (Figure 2.5).



(a) (b)

Figure 2.5. Air ducts (a) inlet (b) outlet

2.2. Measuring Instruments

2.2.1. Data Logger

In this study, ALMEMO 2290-8 data logger is used to preserve temperature data (Figure 2.6). This data logger has five electrically isolated measuring inputs with up to 20 measuring channels and two output sockets allow for connecting any ALMEMO output modules, printer or computer. Air inlet temperature, air outlet temperature and atmospheric temperature were measured with this data logger. All data have been measured every ten minutes by using the collector testing standard ASHRAE 93-1986.

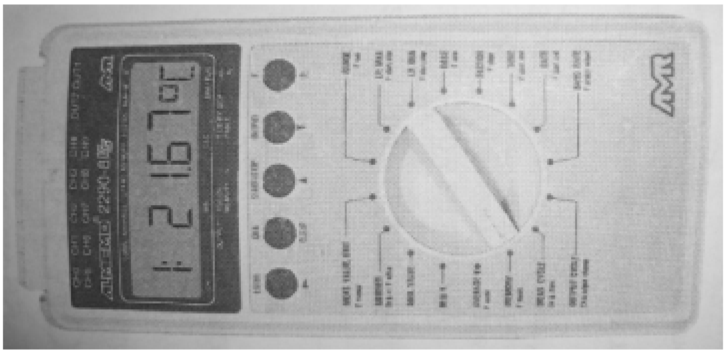


Figure 2.6. ALMEMO 2290-8 Data logger

Two types of thermo-couple, whose names are Thermo ZA 9020-FS NiCr-Ni Typ K, were used to measure temperature (Figure 2.7). These thermo-couples can measure temperatures between -200 and 1370 ^{o}C and have an accuracy of ±0,05K ±0,05% of measured values. In order to transfer data from data logger RS232 interface, electrically isolated for printer and computer connection via DSUB socket, was used.

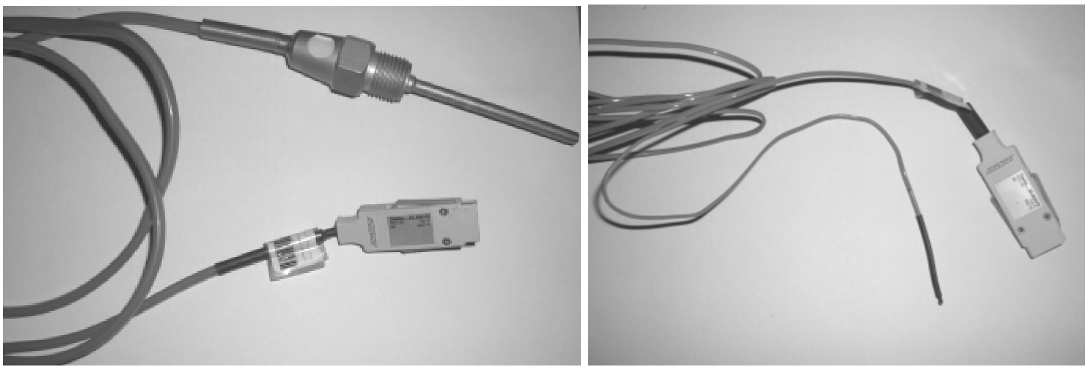


Figure 2.7. NiCr-Ni Thermo-couples

2.2.2. Anemometer

In order to measure air speed an anemometer was used (Figure 2.8). In this study three different air speeds were utilized to obtain the different thermal performance charts. Inlet air speed and outlet air speed measured individually. Mass flow rate of air is calculated for each air speed value by considering the change of density for average air temperature.

Figure 2.8. Anemometer

2.2.3. Pitot Tube

Pitot tube, having a tube set parallel and orthogonal to the direction of fluid-stream movement and attached to a manometer, is used to measure the total pressure of the fluid stream (Figure 2.9).

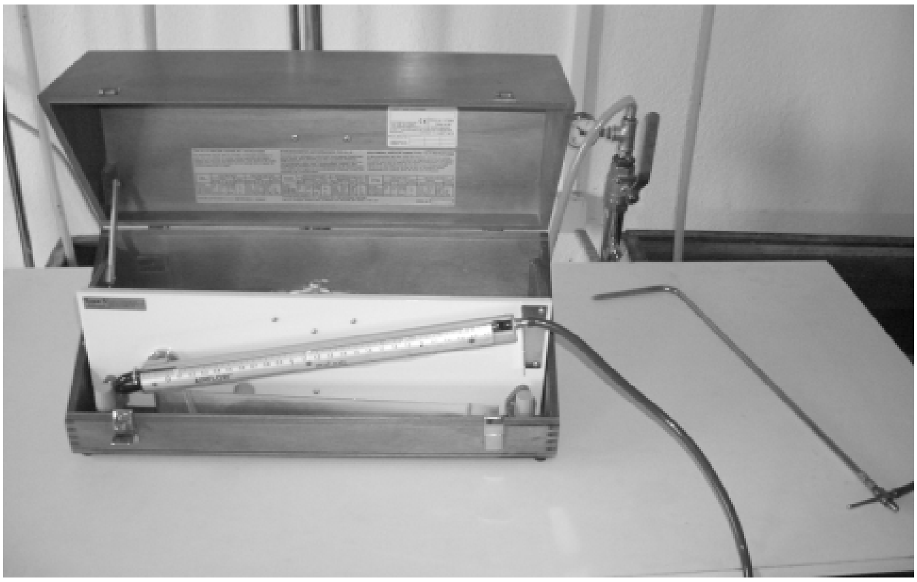


Figure 2.9. Manometer and pitot tube

2.2.4. Weather Station Package

In this study, Davis Vantage Pro with weather station package is used to collect weather data. This station is under the control of Res.Asst. Mahir Tosun. The standard version of the weather station package contains a rain collector, temperature sensor, humidity sensor, solar radiation sensor, ultra-violet (UV) sensor and anemometer. Temperature and humidity sensors are mounted in a passive radiation shield to minimize the impact of solar radiation on sensor readings. The anemometer measures wind speed and direction. The Sensor Interface Module (SIM) contains the “brains” of the ISS and the radio transmitter. The SIM is located on the front of the radiation shield in the SIM box. The SIM collects outside weather data from the ISS sensors and then transmits the data to your Vantage Pro console (Figure 2.10). In our study, solar radiation and wind speed data are gotten from this station.

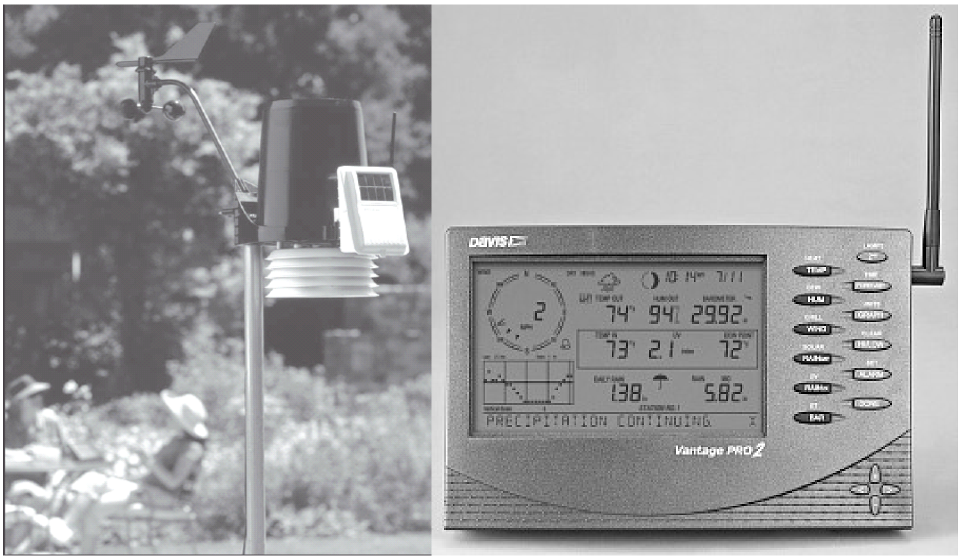


Figure 2.10. Weather station and Davis Vantage Pro console

CHAPTER 3

RESULTS AND DISCUSSION

Performance of air-type solar collector and comparison between air-type solar collector with and without absorbing media are studied in this study. In the analysis three air speeds 3 m/s, 3,5 m/s and 4 m/s are used. Data for similar days are compared with each other. Data for 3 m/s with and without polyurethane foam are compared with each other for ambient temperatures between 35 and 38 ^oC. Data for 3,5 and 4 m/s with and without polyurethane foam are compared with each other for ambient temperatures between 28 and 32 ^oC.

First of all, raw data collected from measuring instruments were processed to be used in results. Mass flow rate (m), specific heat of the air (c_p), density of air (ρ), total solar radiation on tilted surface (I_β), useful heat (Q_{useful}), hour angle (w), declination (δ), angle of incidence (θ), zenith angle (θ_z), total heat (Q) and efficiency (η) were calculated by using the data which are air speed (V), inlet temperature of air (T_{in}), outlet temperature of air (T_{out}), environment temperature (T_{amb}) and total solar radiation on horizontal surface (I_o). Calculations are given in appendix B.

Figure 3.1, 3.2 show the variation of efficiency related to the ambient temperature for air speeds 3, 3,5 and 4 m/s with and without polyurethane foam material inside the collector. For air speed 3 m/s ambient temperature changes between 35 and 38 ^oC. Increment of ambient temperature increases efficiency for total radiation on the tilted surface between 700 and 900 W/m^2. Figure 3.1 also shows that the thermal efficiency of air-type solar collector with polyurethane foam is about %16 higher than the one without polyurethane foam for any ambient temperature between 35 and 38 ^oC.

For air speeds 3,5 and 4 m/s, increment of ambient temperature increases efficiency for total radiation on the tilted surface between 600 and 1000 W/m^2. Figure 3.2 shows that, air-type solar collector for air speed is more efficient than the one for air speed 3,5 m/s. Thermal efficiency of air-type solar collector with polyurethane foam for air speed 4 m/s is between 12 and 18% higher than the one for air speed 3,5 m/s and thermal efficiency of air-type solar collector without polyurethane foam is between 7 and 12% higher than the one for 3,5 m/s. As a result of this, using polyurethane foam increases the slope of efficiency function of air-type solar collector for ambient temperature between 28 and 32 ^{o}C.

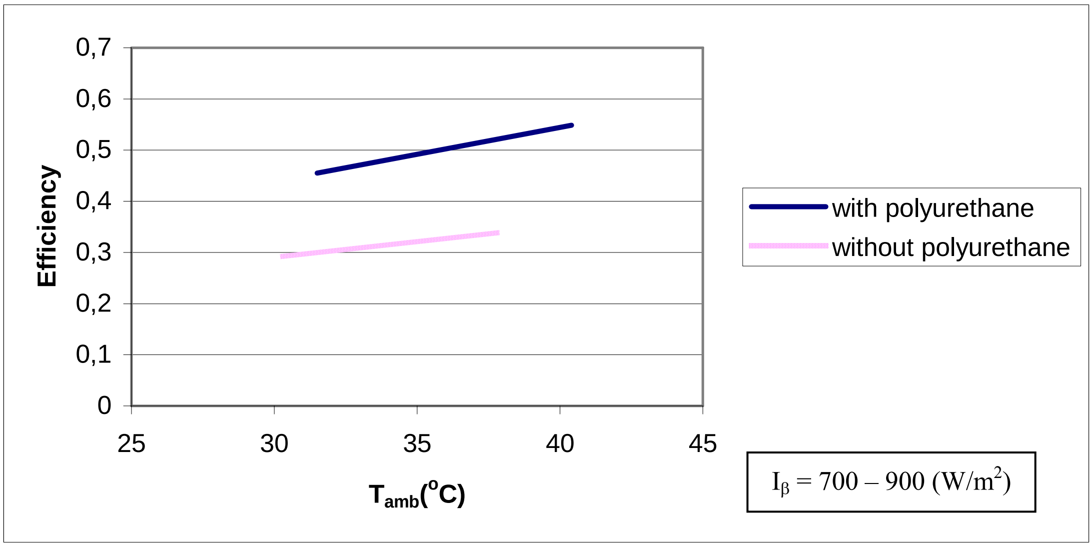


Figure 3.1. Thermal efficiency variation as a function of ambient temperature for air speed 3 m/s

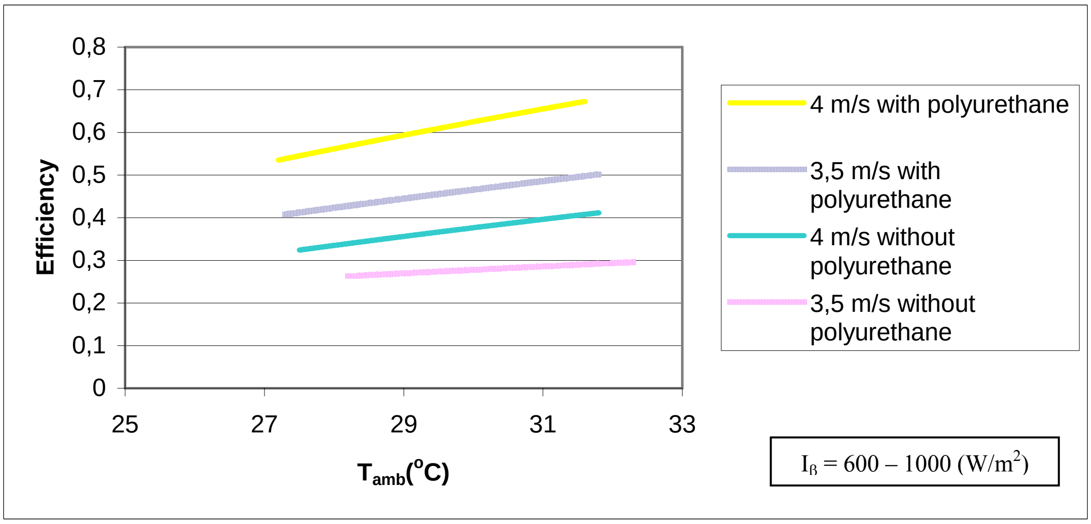


Figure 3.2. Thermal efficiency variation as a function of ambient temperature for air speeds 3,5 and 4 m/s

Figure 3.3 and 3.4 show the thermal efficiency variation related to temperature difference between inlet and outlet of air-type solar collector for air speed 3, 3,5 and 4 m/s. For air speed 3 m/s, under similar conditions, ambient temperature between 35 and 38 ^{o}C and total solar radiation on the tilted surface between 700 and 900 W/m^2, temperature difference between inlet and outlet of air-type solar collector is between 2,5 and 5,5 °C without polyurethane foam and between 6,5 and 10,5 °C with polyurethane foam. Increment of temperature difference increases efficiency for air speed 3 m/s.

For air speeds 3,5 and 4 m/s, under similar conditions, ambient temperature between 28 and 32 °C and solar radiation on the tilted surface between 600 and 1000 W/m^2, temperature differences between inlet and outlet of air-type solar collector are between 1,5 an 3,5 °C for air speed 3,5 m/s without polyurethane foam, between 1,5 and 4,5 °C for air speed 4 m/s without polyurethane foam, between 4,5 and 9 °C for air speed 3,5 m/s with polyurethane foam and between 7 and 11 °C for air speed 4 m/s with polyurethane foam. For similar temperature difference values, air-type solar collector for air speed 4 m/s is more efficient than the one for air speed 3,5 m/s. Therefore, using polyurethane foam increases the temperature difference between inlet and outlet of air-type solar collector and this increment affects efficiency directly.

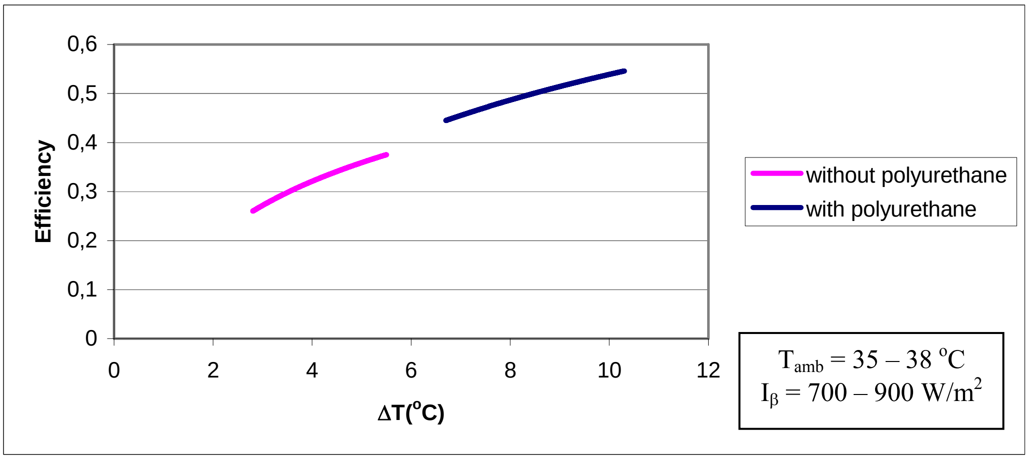


Figure 3.3. Thermal efficiency variation related to temperature difference between inlet and outlet of air-type solar collector for air speed 3 m/s

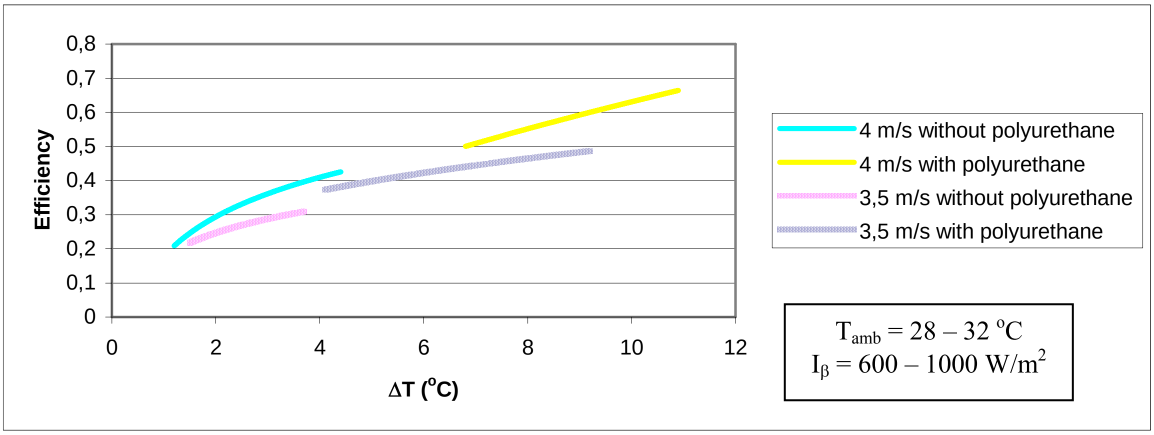


Figure 3.4 Thermal efficiency variation related to temperature difference between inlet and outlet of air-type solar collector for air speeds 3,5 and 4 m/s

Figure 3.5 show the efficiency variation related to wind speed for air speeds 3, 3,5 and 4 m/s. Figure show that, wind speed is not effective for the variation of efficiency. Small variations of the efficiency are caused by the variation of solar radiation on the tilted surface.

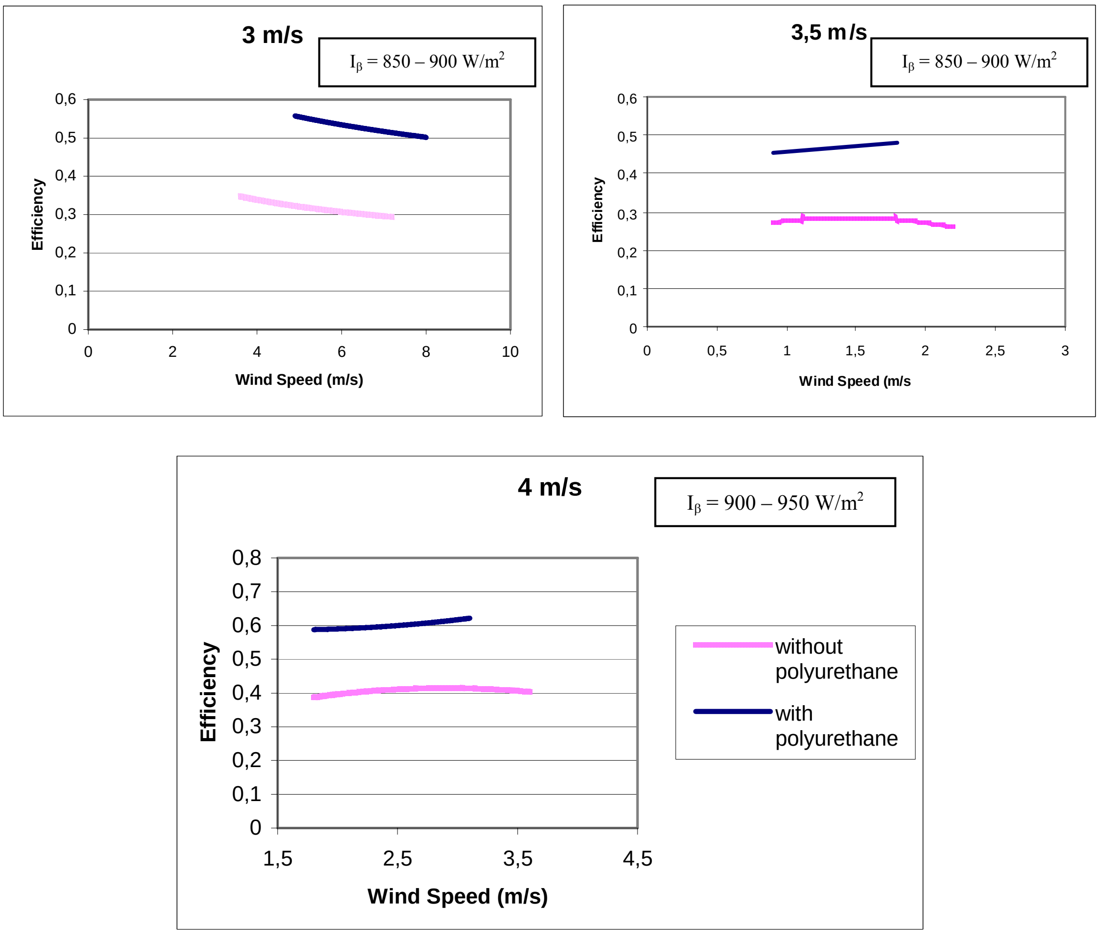


Figure 3.5. Efficiency variation related to wind speed

Figure 3.6 and 3.7 show the characteristic curves of air-type solar collector for air speed 3, 3,5 and 4 m/s. Under similar conditions, thermal efficiency of air-type solar collector for 3 m/s with polyurethane foam is about 20% higher than the one without polyurethane foam. For air speeds 3,5 and 4 m/s, thermal efficiency of air-type solar collector with polyurethane foam for 4 m/s is between 12 and 14% higher than the one for 3,5 m/s and thermal efficiency of air-type solar collector without polyurethane foam for 4 m/s is between 8 and 11% higher than the one for 3,5 m/s.

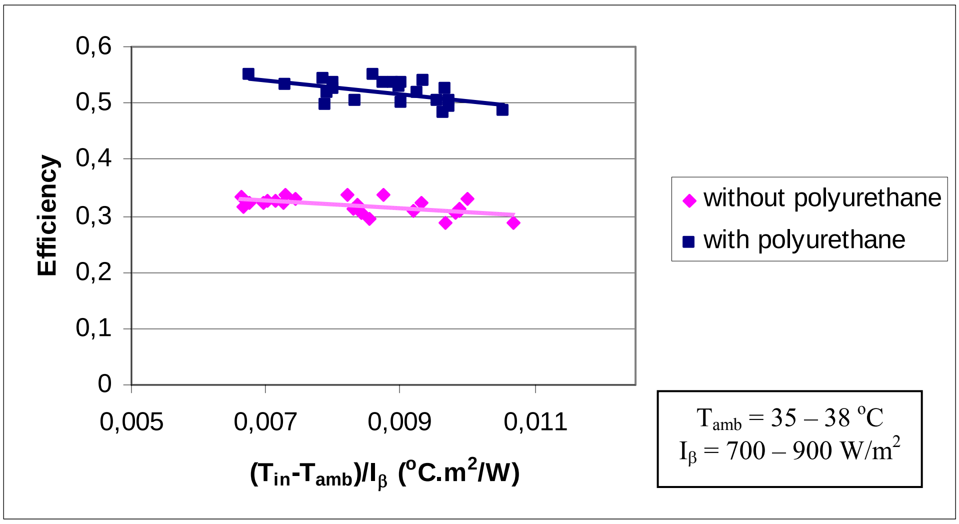


Figure 3.6. Characteristic curves for air speed 3 m/s

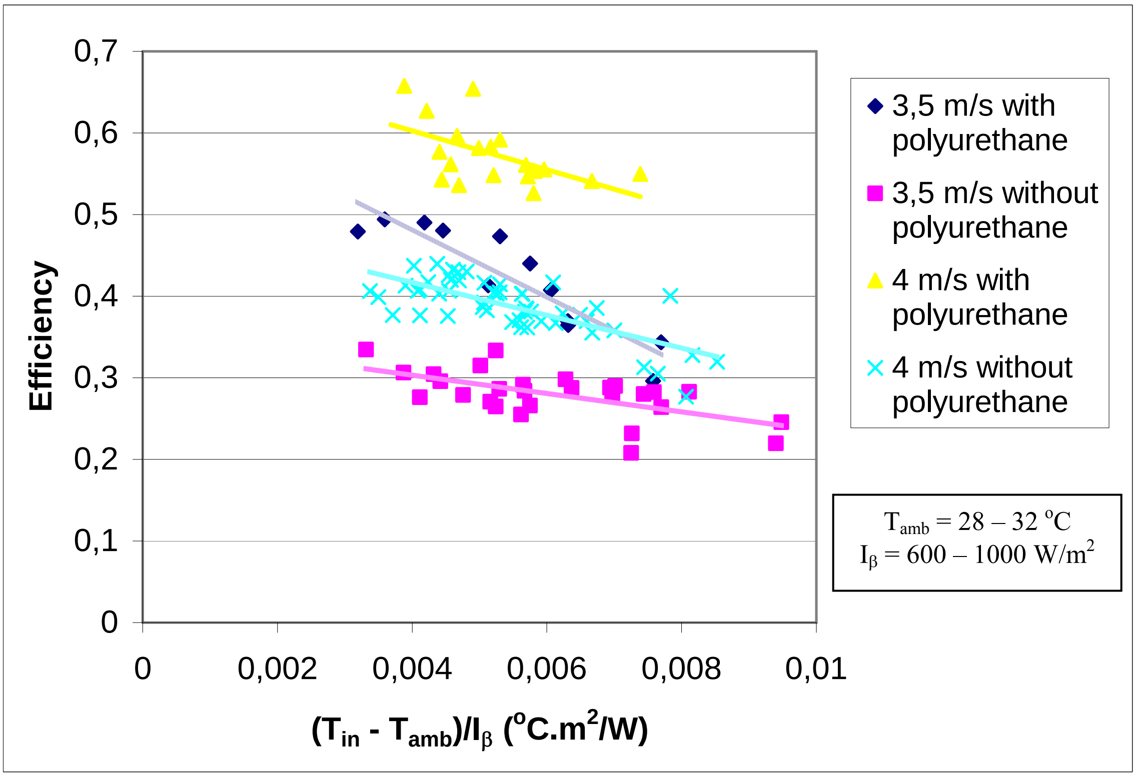


Figure 3.7. Characteristic curves for air speeds 3,5 and 4 m/s

In addition to these result, pressure drop should be taken into consideration. Inlet and outlet pressures are measured roughly and seen that heat absorbing media generates high pressure drop and this increases pumping power. Therefore, pressure drop should be taken into consideration while selecting heat absorbing media. Figure 3.8 roughly shows the pressure drop values related to polyurethane foam for air speed 3, 3,5 and

4 m/s. It is obviously seen that, for air-type solar collector with polyurethane foam increment of air speed increases pressure drop. On the other hand, for air-type solar collector with polyurethane foam increment of air speed decreases pressure drop. In conclusion, for air-type solar collector with absorbing media, increasing air speed increases not only efficiency, but also pressure drop. So that, pressure drop should be taken into consideration while selecting heat absorbing media and air speed.

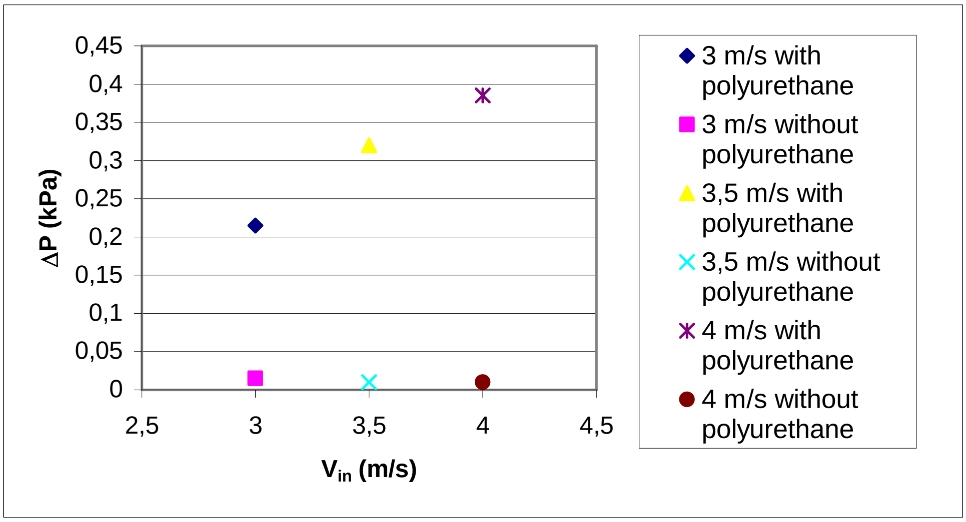


Figure 3.8. Pressure drop related to polyurethane foam for air speeds 3, 3,5 and 4 m/s

CHAPTER 4

CONCLUSIONS AND RECOMMENDATIONS

In this study, the performance of an air-type solar collector with and without heat absorbing media is analyzed and results are compared with each other for similar conditions. The analysis indicates the thermal efficiency of air-type solar collector with polyurethane foam can exceed 55% for air speed 3 m/s for ambient temperatures between 35 and 38 ^{o}C , 48% for air speed 3,5 m/s and 60% for air speed 4 m/s for ambient temperatures between 28 and 32 ^{o}C. Polyurethane foam as heat absorbing media increases heat transfer to the air stream because of enhanced heat transfer surface area. Polyurethane foam increases thermal efficiency of air-type solar collector for 3 m/s 20%. Under similar conditions, polyurethane foam increases thermal efficiency of air-type solar collector for 3,5 m/s between 7 and 16% and for 4 m/s about 16%.

The effects of ambient temperature, temperature difference between inlet and outlet of air-type solar collector and wind speed are investigated. Wind speed does not affect efficiency directly for measured values. On the other hand, ambient temperature performs significant effect on the thermal performance of air-type of solar collector with and without polyurethane foam. For air speed 3 m/s, thermal efficiency of air-type solar collector with polyurethane foam is about %20 higher than the one without polyurethane foam for ambient temperatures between 35 and 38 ^{o}C. For air speeds 3,5 and 4 m/s, thermal efficiency of air-type solar collector with polyurethane foam for air speed 4 m/s is between 12 and 18% higher than the one for air speed 3,5 m/s and thermal efficiency of air-type solar collector without polyurethane foam is between 7 and 12% higher than the one for 3,5 m/s.

Using polyurethane foam affects temperature difference between inlet and outlet of air-type solar collector. For air speed 3 m/s, under similar conditions temperature difference between inlet and outlet of air-type solar collector is between 2,5 and 5,5 ^{o}C without polyurethane foam and between 6,5 and 10,5 ^{o}C with polyurethane foam. Increment of temperature difference increases efficiency for air speed 3 m/s. Under similar conditions, temperature differences between inlet and outlet of air-type solar collector are between 1,5 an 3,5 ^{o}C for air speed 3,5 m/s without polyurethane foam, between 1,5 and 4,5 ^{o}C for air speed 4 m/s without polyurethane foam, between 4,5 and 9 ^{o}C for air speed 3,5 m/s with polyurethane foam and between 7 and 11 ^{o}C for air speed 4 m/s with polyurethane foam.

These results show that, air-type solar collector with polyurethane foam for air speed 4 m/s, efficiency reaches most efficient values for collected data. For measured data for air speeds 3,5 and 4 m/s, similar days are determined and data are compared with each other for similar conditions. Under these conditions, it is obviously seen that, air-type solar collector for air speed 4 m/s is more efficient than the one for 3,5 m/s. Air-type solar collector for air speed 3 m/s reaches 55% efficiency but measured data of this speed is not comparable with other air speeds because of the different ambient conditions.

Pressure drop should be taken into consideration for these types of designs. Adding porous media to the air stream increases the pressure drop. Increment of pressure drop causes extra pumping power. In our analysis, pressure drops for all speeds are measured roughly and it is seen that pressure drop for our air-type solar collector with polyurethane foam (85% porosity) is not so significant for flow rates which is used.

Most significant factor affects the thermal performance of our air-type solar collector is leakage. For air-type solar collector with polyurethane foam leakage is more, because of the resistance of porous media. Porous media retards air leakage from the collector increases. In order to prevent leakage, the collector should be well insulated and collector systems should be built basically with minimum number of parts. Our solar collector system consists of many parts in order to put and remove heat absorbing media inside the collector quickly and disjoint and reassemble easily for carrying from place to another. These joints cause leakage and decrease the performance of our collector.

For comparing results of air-type of solar collector with and without heat absorbing media most effectively, two air-type of solar collector with same features should be placed next to each other. Both of them should be under same condition in order to obtain more accurate results. Building the same experimental setup should be the first application for future works.

In addition, fan which accelerates air should be improved. Our fan works for only one revolution per minute. Therefore, it is difficult to vary air speed for different variations. A fan with variable revolution should be produced and used in order to obtain extra flow rates.

In order to control outlet speed of air, a variable air blower should be set at the exit of air duct. Adding variable air blower at exit increases performance of collector, because this will minimize leakage from joints and obtains steady flow for air.

For future works, heat absorbing media with different porosities should be used and performance curves for these materials should be shown and compared with each other. Moreover, different colors and different positions inside the air stream for heat absorbing media should be tested. However, the pressure drop should be taken into consideration for all tests, and should be prevented from high pressure drops obtains extra pumping power.

REFERENCES

Abene, A. Dubois, V. Le Ray, M. and Ouagued, A. 2004. "Study of a Solar Air Flat Plate Collector: Use of Obstacles and Application for the Drying of Grape", Journal *of Food Engineering.* Vol. 65, pp.15-22.

Alvarez, G. Arce, J. Lira, L. and Heras, M.R. 2004. "Thermal Performance of an Air Solar Collector with an Absorber Plate Made of Recyclable Aluminum Cans", *Solar Energy.* Vol. 77, pp.107-113.

ANSI/ASHRAE Standard 93-1986 (RA 91), "Method of testing to determine the thermal performance of solar collectors", ASHRAE Inc., 1791 Tullie Circle NE, Atlanta, GA 30329

Choudhury, G.M. 2003. "Selective Surface for Efficient Solar Thermal Conservation", *Bangladesh Renewable Energy Newsletter.* Vol. 1, No.2, pp.1-3.

Duffie, J.A. and Beckman, W.A. 1991. "Solar Engineering of Thermal Processes", (John Wiley&Sons, New York), pp.1-379.

Forson, F.K. Nazha, M.A.A. and Rajakaruna, H. 2003. "Experimental and Simulation Studies on a Single Pass, Double Duct Solar Air Heater", *Energy Conversion & Management*. Vol. 44, pp.1209-1227.

Hachemi, A. 1999. "Experimental Study of Thermal Performance of Offset Rectangular Plate Fin Absorber-Plates", *Renewable Energy.* Vol. 17, pp.371-384.

Hachemi, A. 1999. "Technical Note: Comparative Study on the Thermal Performances of Solar Air Heater Collectors with Selective and Nonselective Absorber-Plate", *Renewable Energy.* Vol. 17, pp.103-112.

Ilken, Z. and Degirmencioglu, C. 2003. "Havalı Güneş Kollektörleri Üzerine Bir Literatür Araştırması ve Temel İlkeler", *Türk Tesisat Müh. Derneği Dergisi.* No. 27 pp.28-34.

Jain, D. 2004. "Modeling The System Performance of Multi-Tray Crop Drying Using an Inclined Multi-Pass Solar Air Heater with In-Built Thermal Storage", *Journal of Food Engineering.* Vol. 71, pp.44-54

Kalogirou, S.A. 2004. "Solar Thermal Collectors and Applications", *Progress in Energy and Combustion Scienc.* No. 30, pp.231-295.

Kolb, A. Winter, E.R.F. and Viskanta, R. 1999. "Experimental Studies on a Solar Air Collector with Metal Matrix Absorber", *Solar Energy.* Vol. 65, No. 2, pp.91-98.

Mohamad, A.A. 1997. "High Efficiency Solar Air Heater", *Solar Energy.* Vol. 60, No. 2, pp.71-76.

Purday, HFP. 1949. "An Introduction to the Mechanics of Viscous Flow", (Dover Publications, New York), pp.9-16.

Sarsilmaz, C. Yildiz, C. and Pehlivan, D. 2000. "Drying of Apricots in a Rotary Column Cylindrical Dryer (RCCD) Supported with Solar Energy", *Renewable Energy.* Vol. 21, pp.117-127.

Sopian, K. Supranto, Daud, W.R.W. Othman, M.Y. and Yatim, B. 1999. "Thermal Performance of the Double-Pass Solar Collector with and without Porous Media", *Renewable Energy.* Vol. 18, pp.557-564.

Tesfamichael, T. 2000. "Characterization of Selective Solar Absorbers, Experimental and Theoretical Modelling", (University Printers, Uppsala), pp.24-38.

Yeh, H.M. Ho, C.D. and Lin, C.Y. 2000. "Effect of Collector Aspect Ratio on the Collector Efficiency of Upward Type Baffled Solar Air Heaters", *Energy Conversion & Management. Vol.* 41, pp.971-981.

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APPENDIX A

TECHNICAL DRAWING AND FIGURE OF EXPERIMENTAL SETUP

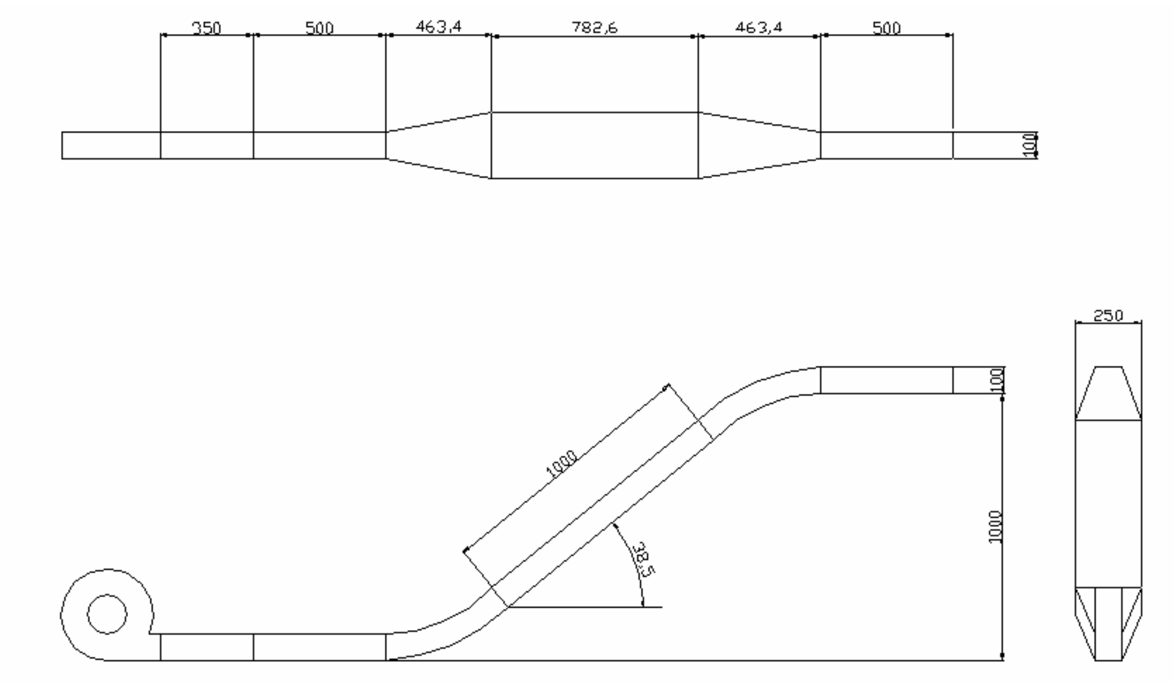

Figure A.1. Technical drawing of experimental setup

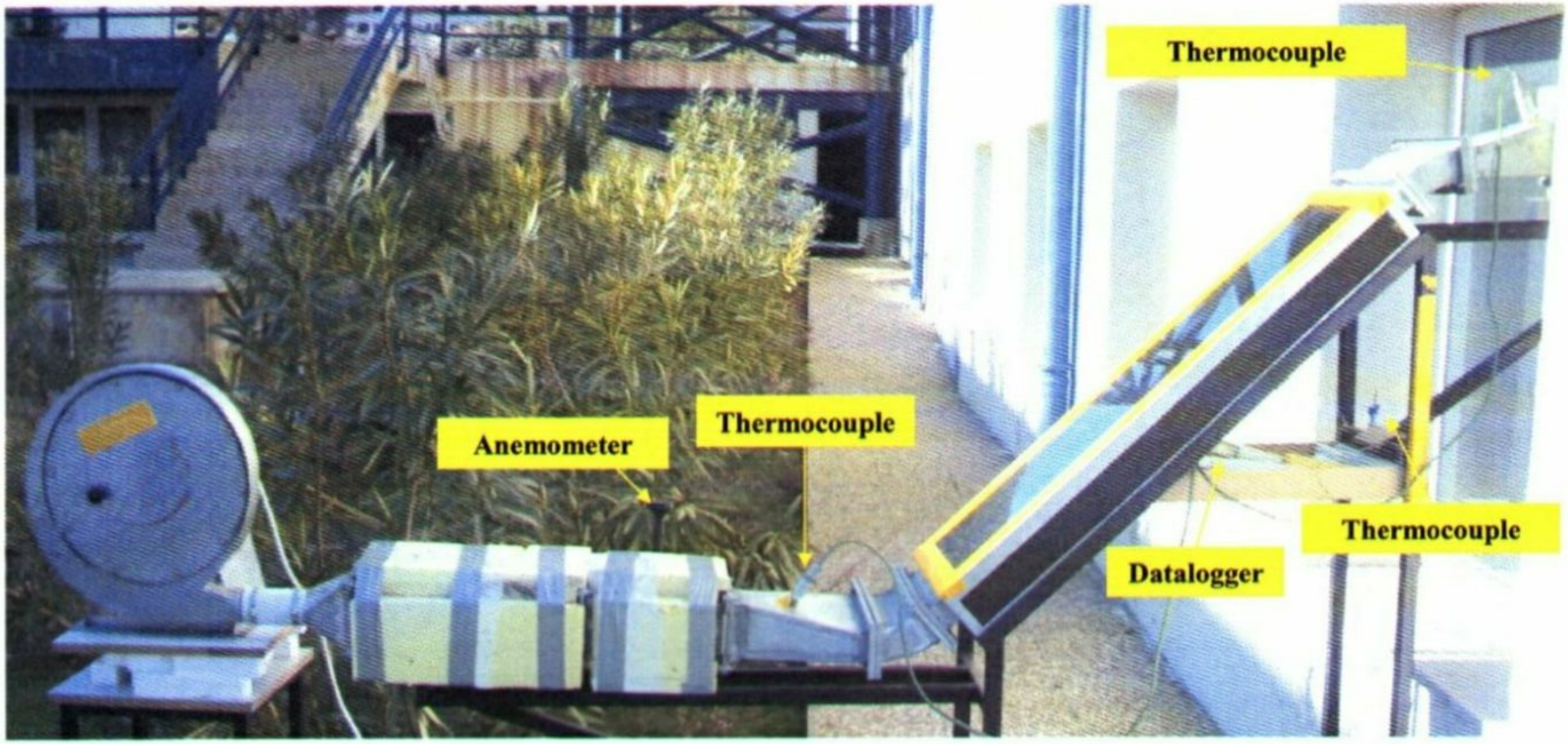

Figure A.2. Experimental setup

APPENDIX B

CALCULATIONS

B.1. Mass Flow Rate and Specific Heat

In order to calculate mass flow rate, equation given below is used.

$$m = \rho \ . \ V_{av} \ . \ A \tag{B.1}$$

In this equation, density of air is calculated according to the average temperature of air. Cross section area of air duct (A) and average air speed (V_{av}) are constant for any time of day.

Maximum air speed is measured by anemometer and average speed is needed to calculate mass flow rate. A practical and satisfactory approximation for velocity distribution for rectangular ducts is given by Purday (Purday 1949).

$$V = V_{max}(1 - (\frac{x}{a})^2)(1 - (\frac{|y|}{b})^n) \tag{B.2}$$

The constant, n, depends on the aspect ratio of the channel, b/a, as:

$$n(n+1) = \frac{2b^2}{a^2} \tag{B.3}$$

Average speed is calculated according to this approximation and the ratio between average speed and maximum speed is calculated about 0,6333 by applying numerical solution.

Specific heat of air is calculated related to the average of inlet and outlet temperature by applying interpolation.

B.2. Total Solar Radiation on the Tilted Surface

Total solar radiation on the tilted surface is calculated by using measured data total solar radiation on horizontal surface. In order to calculate total solar radiation on tilted surface, angle of incidence and zenith angle have to be calculated. Angle of incidence which is the angle between the beam radiation on a surface and the normal to that surface can be calculated by using equation below:

$$\cos\theta = \sin\delta \, . \, \sin\Phi \, . \, \cos\beta - \sin\delta \, . \, \cos\Phi \, . \, \sin\beta \, . \, \cos\gamma + \cos\delta \, . \, \cos\Phi \, . \, \cos\beta \, . \, \cos w + \cos\delta \, . \, \sin\Phi \, . \, \sin\beta \, . \, \cos\gamma \, . \, \cos w + \cos\delta \, . \, \sin\beta \, . \, \sin\gamma \, . \, \sin w \tag{B.4}$$

In this equation Φ represents latitude, δ represents declination, β represents slope, γ represents surface azimuth angle and w represents hour angle. Declination (δ) can be found from the equation below:

$$\delta = 23{,}45 \, . \, \sin\left(360 \, \frac{284 + n}{365}\right) \tag{B.5}$$

In this equation n represents the day number of the year. Latitude of Izmir is $38{,}46^{O}$ and slope of solar collector is $38{,}5^{O}$. Surface azimuth angle is zero because solar collector looks south. Hour angle is calculated for each time. Solar time for each time is calculated and accordion to the solar time hour angle can be found easily. Solar time is calculated by the equation below:

$$\text{Solar Time} - \text{Standard Time} = 4\,(L_{st} - L_{loc}) + E \tag{B.6}$$

Where L_{st} is the standard meridian for the local time zone, L_{loc} is the longitude of the location. The equation of time E (in minutes) is determined from equation below:

$$E = 229{,}2(0{,}000075 + 0{,}001868 \cos B - 0{,}032077 \sin B - 0{,}014615 \cos 2B - 0{,}04089 \sin 2B) \tag{B.7}$$

where $$B = (n-1)\frac{360}{365} \quad \text{(B.8)}$$

Hour angle for solar time 12:00 is zero and hour angle changes 15^{O} per hour and is negative for morning and positive for afternoon. Angle of incidence is calculated by using declination, latitude, slope, surface azimuth angle and hour angle.

The next step in order to calculate total solar radiation on the tilted surface is to calculate zenith angle which is the angle between the vertical and the line to the sun. Zenith angle is calculated by equation given below (Duffie and Beckman 1991):

$$\cos \theta z = \cos \Phi \,.\, \cos \delta \,.\, \cos w + \sin \Phi \,.\, \sin \delta \quad \text{(B.9)}$$

In conclusion, total solar radiation on the tilted surface is calculated by equation given below and is used for calculating total heat.

$$I_{\beta} = I_{o}\frac{\cos \theta}{\cos \theta_{z}} \quad \text{(B.10)}$$

B.3. Useful Heat and Total Heat

Useful heat is the heat which is gained from the collector and is calculated by using equation given below:

$$Q_{useful} = \dot{m}.c_{p}.(T_{out} - T_{in}) \quad \text{(B.11)}$$

where $$\dot{m} = \dot{m}_{in} - \dot{m}_{leakage} = \dot{m}_{out} \quad \text{(B.12)}$$

Total heat is calculated by using equation given below:

$$Q = I_{\beta}.A_{c} \quad \text{(B.13)}$$

where Ac is collector area.

B.4. Efficiency

Efficiency is defined as the ratio of the useful heat collected to the total heat and expressed as:

$$\eta = \frac{Q_{useful}}{Q} \tag{B.14}$$

For the test interval for each efficiency data point, the efficiency value is calculated by using the equation given below:

$$\eta_g = \frac{\int_{t_1}^{t_2} \dot{m}.c_p.(T_{out} - T_{in}).dt}{A_g \int_{t_1}^{t_2} I_\beta.dt} \tag{B.15}$$

where A_g is the gross collector area.

In this study, efficiency of air-type of collector is calculated for three different air speeds with and without absorbing media. In order to indicate the performance curves, efficiency for morning and afternoon is calculated separately (ASHRAE 93-1986).

APPENDIX C

DAILY DATA

Table C.1. Daily data for 05.04.2005

Date	**05.04.2005**	**With Polyurethane**								
Weather Condition		Clear								
Midday	**Φ (⁰)**	**δ (⁰)**		**V_{in} (m/s)**	**V_{out} (m/s)**		**P_{in} (kPa)**	**P_{out} (kPa)**		
13:14	38,46	5,596876		3,5	1,9		0,33	0,01		
Time	**T_{in}**	**T_{out}**	**$T_{amb.}$**	**ΔT**	**Wind(m/s)**	**Q_{useful} (W)**	**I_o(W/m^2)**	**I_β(W/m^2)**	**Q(W)**	**η**
10:05:59	19,1	23	14	18,67918	4,5	224,64409	566	648,7755	162,1939	0,353009
10:15:58	20,5	25,8	14	20,07225	4,5	240,85355	589	678,1833	169,5458	0,455716
10:25:58	21,4	27,6	14,8	20,9653	3,6	251,20317	627	724,8058	181,2015	0,496549
10:35:58	22	28,9	15	21,55836	3,6	258,05689	651	755,1923	188,7981	0,528676
10:45:58	22,7	30,3	15,9	22,25141	4	266,04967	679	790,1224	197,5306	0,554588
10:55:58	22,6	30,8	15,2	22,14447	3,6	264,8107	703	820,3034	205,0758	0,575964
11:05:58	23,2	31,6	15,8	22,73752	3,6	271,63664	728	851,5478	212,887	0,567011
11:15:58	23,3	31,8	17,6	22,83058	4,5	272,70127	745	873,3146	218,3287	0,559174
11:25:58	23,4	32,3	16,3	22,92363	4	273,76552	764	897,2943	224,3236	0,569258
11:35:58	23,8	32,9	17,9	23,31669	4,9	278,27667	783	921,1507	230,2877	0,566008
11:45:58	23,7	33,2	17,1	23,20975	4,5	277,04196	803	946,0643	236,5161	0,57513
11:55:58	24,1	33,6	16,8	23,6028	4,9	281,54849	818	964,9622	241,2406	0,563095
12:05:58	24,2	33,9	16,7	23,69586	4	282,60965	833	983,7292	245,9323	0,563595
12:15:58	25	34,8	17,4	24,48891	5,4	291,68708	847	1001,184	250,2961	0,557847
12:25:58	24,8	35,2	17,9	24,28197	4,5	289,31255	857	1013,776	253,444	0,584447
12:35:58	24,4	35,1	16,9	23,87502	4,9	284,64485	864	1022,678	255,6696	0,596584
12:45:58	24,7	35,5	17,3	24,16808	4,5	287,99572	870	1030,256	257,5639	0,597011
12:55:58	24,6	35,7	18,3	24,06113	4,5	286,7645	882	1044,799	261,1998	0,60495
13:05:58	25,1	36,5	18,3	24,55419	4,5	292,40082	884	1047,356	261,839	0,618396
13:15:58	24,7	36	18,5	24,14725	4	287,73776	886	1049,769	262,4423	0,612512
13:25:58	24,5	35,7	17,6	23,9403	4,5	285,36093	884	1047,298	261,8246	0,609048
13:35:58	24,9	35,8	18,3	24,33336	4,5	289,85511	885	1048,237	262,0592	0,591694
13:45:58	24,6	36	18,1	24,02641	4,9	286,33459	880	1041,923	260,4809	0,622693
13:55:58	24,8	36,2	18,3	24,21947	4,9	288,5387	873	1033,098	258,2746	0,627579
14:05:58	24,8	35,7	18,9	24,21252	4	288,45272	866	1024,13	256,0324	0,605831
14:15:58	25,4	36,4	18,9	24,80558	4,5	295,22773	859	1015,015	253,7537	0,615498
14:25:58	25,2	35,9	19	24,59863	4,5	292,85631	845	997,4862	249,3716	0,609969
14:35:58	25,9	36,2	18,8	25,29169	4	300,76266	833	982,1797	245,5449	0,595288
14:45:58	25,4	35,8	19	24,78475	4	294,96982	821	966,7279	241,682	0,611624
14:55:58	25,7	36,1	19,6	25,0778	3,6	298,30914	808	949,95	237,4875	0,621783
15:05:58	25,6	36	19	24,97086	4,5	297,0818	791	928,3242	232,081	0,636487
15:15:58	25,2	35,2	18,6	24,56391	4,5	292,42648	772	904,2132	226,0533	0,629627
15:25:58	25,5	35	17,9	24,85697	4,5	295,76812	754	881,132	220,283	0,613709
15:35:58	25,8	34,9	18,8	25,15002	4	299,10628	731	852,0713	213,0178	0,607709
15:45:58	25,4	34,4	18,9	24,74308	4	294,45406	716	832,1812	208,0453	0,61635
15:55:58	25,9	34,4	18,6	25,23613	4,5	300,07497	682	790,0857	197,5214	0,612596
16:05:58	25,4	33,4	17,9	24,72919	4,5	294,28215	657	758,3264	189,5816	0,602259

Table C.2. Daily data for 06.04.2005

Date	**06.04.2005**	**With Polyurethane**								
Weather Condition		Mostly Cloudy								
Midday	**Φ (^{0})**	**δ (^{0})**		**V_{in} (m/s)**	**V_{out} (m/s)**		**P_{in} (kPa)**	**P_{out} (kPa)**		
13:14	38,46	5,988035		3,5	1,9		0,33	0,01		
Time	**T_{in}**	**T_{out}**	**$T_{amb.}$**	**ΔT**	**Wind(m/s)**	**Q_{useful} (W)**	**I_o(W/m^2)**	**$I_β$(W/m^2)**	**Q(W)**	**η**
10:02:23	20,8	24,2	15,4	20,38168	2,7	244,45241	550	624,948	156,237	0,317941
10:12:23	23,4	27,9	16,8	22,97473	2,2	274,39841	629	718,2732	179,5683	0,362265
10:22:23	25	30,5	18	24,56779	2,7	292,66395	663	760,42	190,105	0,415252
10:32:23	25	31,5	17,7	24,56084	2,2	292,57794	678	780,6371	195,1593	0,477227
10:42:23	25,8	33	18,4	25,3539	2,7	301,63064	714	824,9061	206,2265	0,498284
10:52:23	25,5	33,1	17,1	25,04696	2,7	298,1205	721	835,5246	208,8811	0,519461
11:02:23	25	32,5	17,3	24,54001	3,1	292,3199	661	768,0568	192,0142	0,558709
11:12:23	25	32,7	17,8	24,53307	3,1	292,2339	741	863,0666	215,7667	0,510288
11:22:23	24,4	30,4	16,4	23,92612	3,6	285,27764	591	689,8071	172,4518	0,499971
11:32:23	24,1	29,7	16,8	23,61918	3,6	281,7513	637	744,8772	186,2193	0,432876
11:42:23	25,3	31,6	17,1	24,81223	3,1	295,4058	744	871,4122	217,853	0,414076
11:52:23	25,9	33,7	18,8	25,40529	2,7	302,1692	675	791,7138	197,9285	0,561667
12:02:23	27	35,1	19,2	26,49834	1,8	314,60433	803	942,9933	235,7483	0,487593
12:12:23	25,3	29,8	17,7	24,7914	2,2	295,14781	534	627,745	156,9363	0,411839
12:22:23	25,3	29,9	18,2	24,78446	1,8	295,06181	533	627,1089	156,7772	0,421347
12:32:23	25,4	29,8	17,8	24,87751	1,8	296,11835	576	678,173	169,5433	0,372681
12:42:23	26,1	32,4	18,9	25,57057	1,8	304,01928	602	709,1663	177,2916	0,507417
12:52:23	25,6	29,4	17,6	25,06362	1,3	298,23028	490	577,4505	144,3626	0,37813
13:02:23	25,7	31,2	17,9	25,15668	2,2	299,28567	557	656,5625	164,1406	0,479789
13:12:23	25,9	31,2	18,3	25,34973	2,2	301,48127	693	816,944	204,236	0,371448
13:22:23	25,1	29,2	17,8	24,54279	1,3	292,25967	379	446,7585	111,6896	0,527961
13:32:23	27	37,3	20,6	26,43584	0,9	313,83043	918	1081,9	270,4749	0,538366
13:42:23	28,1	39,3	21,9	27,5289	0,4	326,21885	915	1077,982	269,4954	0,584376
13:52:23	28,7	38,1	18,7	28,12196	1,8	332,91739	893	1051,53	262,8825	0,503323
14:02:23	28,3	37,5	19,4	27,71501	1,8	328,30995	787	926,0972	231,5243	0,560309
14:12:23	28,2	36,6	21,4	27,60807	1,8	327,09264	621	730,1536	182,5384	0,650004
14:22:23	27,8	36,9	20,8	27,20112	2,2	322,47748	466	547,3624	136,8406	0,939491
14:32:23	27,1	32,8	19,9	26,49418	2,2	314,45055	489	573,7011	143,4253	0,566132
14:42:23	26,7	30,7	18,7	26,08723	2,2	309,8184	495	579,9436	144,9859	0,394699
14:52:23	26,2	29,5	18,4	25,58029	2,2	304,04101	435	508,8424	127,2106	0,372207
15:02:23	25,9	28,9	18,1	25,27334	2,2	300,53556	465	542,9534	135,7383	0,317599
15:12:23	26,1	28,6	18,2	25,4664	2,2	302,72964	451	525,5266	131,3816	0,273489
15:22:23	25,4	26,9	17,2	24,75946	2,7	294,65677	383	445,2539	111,3135	0,194469
15:32:23	24,9	25,9	17,1	24,25251	2,7	288,8543	354	410,4613	102,6153	0,140993

Table C.3. Daily data for 11.04.2005

Date	**11.04.2005**	**With Polyurethane**								
Weather Condition		Partly Cloudy								
Midday	**Φ (°)**	**δ (°)**		**V_{in} (m/s)**	**V_{out} (m/s)**		**P_{in} (kPa)**	**P_{out} (kPa)**		
13:12	38,46	7,914912		3,5	1,9		0,33	0,01		
Time	**T_{in}**	**T_{out}**	**$T_{amb.}$**	**ΔT**	**Wind(m/s)**	**Q_{useful} (W)**	**I_o(W/m²)**	**I_β(W/m²)**	**Q(W)**	**η**
10:17:46	29,7	33	24,9	29,271	0,9	346,03966	524	580,7701	145,1925	0,322211
10:27:46	30,9	35,8	26,2	30,46405	1,3	359,4346	615	685,1477	171,2869	0,402743
10:37:46	31,3	36,1	26,5	30,85711	1,3	363,82987	532	595,3897	148,8474	0,453446
10:47:46	31,8	37,9	27	31,35016	1,3	369,33677	709	796,6958	199,1739	0,428921
10:57:46	32,2	39	28,5	31,74322	1,3	373,71813	722	814,2202	203,555	0,466621
11:07:46	32,8	40,3	26,6	32,33627	1,3	380,32158	751	849,6229	212,4057	0,491565
11:17:46	33	40	30,4	32,52933	1,3	382,4623	717	813,4449	203,3612	0,479283
11:27:46	32,5	38,8	27,9	32,02238	1,3	376,80657	703	799,5455	199,8864	0,440168
11:37:46	32,5	37,3	28,5	32,01544	1,3	376,72057	579	659,9545	164,9886	0,407372
11:47:46	32,1	36,9	27,5	31,6085	0,9	372,17183	638	728,5894	182,1473	0,369514
11:57:46	33,2	38,6	27,3	32,70155	0,9	384,34347	577	660,0134	165,0033	0,456647
12:07:46	33,6	41	28,5	33,09461	0,9	388,70319	868	994,2755	248,5689	0,413353
12:17:46	34,5	43,2	30,4	33,98766	0,9	398,59746	855	980,5385	245,1346	0,490076
12:27:46	34,9	43,5	30,5	34,38072	1,3	402,93708	860	987,2221	246,8055	0,480564
12:37:46	35,6	44,2	30,3	35,07377	1,8	410,58103	870	999,4565	249,8641	0,473499
12:47:46	35,4	44,4	31,8	34,86683	1,3	408,28842	872	1002,311	250,5779	0,49411
12:57:46	35,5	44,7	26,2	34,95988	1,8	409,30593	879	1010,723	252,6808	0,500529
13:07:46	36	42,7	29,6	35,45294	4,5	414,73166	881	1013,196	253,2989	0,364601
13:17:46	36,4	42	28,5	35,846	3,6	419,04809	907	1043,077	260,7693	0,296169
13:27:46	37,1	43,6	29,1	36,53905	2,2	426,65144	904	1039,41	259,8526	0,343568
13:37:46	36,7	42,8	28,9	36,13211	2,7	422,17387	872	1002,216	250,5539	0,335108
13:47:46	37	44,2	29,9	36,42516	2,7	425,38216	909	1044,119	261,0297	0,378512
13:57:46	37,4	44,7	30,3	36,81822	2,7	429,68312	880	1010,003	252,5008	0,396093
14:07:46	37,5	45	30,5	36,91127	2,2	430,69291	921	1055,999	263,9997	0,388941
14:17:46	37,9	44,8	30,1	37,30433	2,2	434,98614	935	1070,742	267,6854	0,352772
14:27:46	36,8	41,4	30,5	36,19738	2,7	422,84245	767	877,0774	219,2693	0,289429
14:37:46	37,3	43,5	29,8	36,69044	3,1	428,24306	916	1045,687	261,4216	0,325686
14:47:46	37,4	43,4	29,6	36,7835	3,1	429,25324	857	976,4201	244,105	0,337538
14:57:46	36	40,1	28,5	35,37655	2,7	413,7859	759	862,829	215,7073	0,26321
15:07:46	36,8	42	29,1	36,16961	2,7	422,49857	827	937,7389	234,4347	0,305689
15:17:46	36,6	40,9	28,9	35,96266	2,7	420,21526	699	790,3152	197,5788	0,300629
15:27:46	36,9	41,7	29	36,25572	3,1	423,42473	738	831,695	207,9238	0,318266
15:37:46	37,1	41,8	29,4	36,44877	2,7	425,53378	752	844,3635	211,0909	0,306796
15:47:46	37,6	42,4	29,8	36,94183	2,2	430,9286	726	811,8	202,95	0,325253

Table C.4. Daily data for 19.04.2005

Date	19.04.2005	With Polyurethane								
Weather Condition		Partly Cloudy								
Midday	Φ (^{0})	δ (^{0})		V_{in} (m/s)	V_{out} (m/s)		P_{in} (kPa)	P_{out} (kPa)		
13:11	38,46	10,87025		3,5	1,9		0,33	0,01		
Time	T_{in}	T_{out}	$T_{amb.}$	ΔT	Wind(m/s)	Q_{useful} (W)	I_o(W/m^2)	$I_β$(W/m^2)	Q(W)	η
09:37:53	24,5	26,5	18,7	2	3,6	22,837825	569	579,0393	144,7598	0,199823
09:47:53	26,6	29,3	19,3	2,7	3,1	30,575256	630	648,2715	162,0679	0,238953
09:57:53	27,1	30,5	20,2	3,4	3,1	38,390378	652	677,4661	169,3665	0,287101
10:07:00	27,2	30,2	19	3	4	33,885469	486	509,3231	127,3308	0,33707
10:17:00	26,1	28,9	19,5	2,8	4,5	31,756408	599	632,5095	158,1274	0,254369
10:27:00	27,5	29,7	18	2,2	4,5	24,857855	642	682,469	170,6172	0,184536
10:37:00	29,7	35,1	20,7	5,4	4	60,220598	797	852,2873	213,0718	0,35798
10:47:00	27	30,5	19,1	3,5	6,7	39,526277	616	662,216	165,554	0,302403
10:57:00	27,9	32,9	19,9	5	4,5	56,14689	838	905,1032	226,2758	0,314287
11:07:00	28,8	34,1	19,7	5,3	5,4	59,300316	748	811,263	202,8158	0,370335
11:17:00	28,3	34,4	20,3	6,1	6,7	68,274919	859	935,0886	233,7721	0,36992
11:27:00	28,5	35,4	21,3	6,9	4,9	77,068748	865	944,6863	236,1716	0,413324
11:37:00	29,8	36,8	21,3	7	4	77,819807	900	985,7218	246,4304	0,399977
11:47:00	28,6	36,1	20,8	7,5	5,4	83,654238	909	998,0626	249,5156	0,424649
11:57:00	28,6	36,6	20	8	6,7	89,153754	952	1047,528	261,8821	0,431195
12:07:00	27,6	34,6	20	7	6,7	78,416004	856	943,626	235,9065	0,421022
12:17:00	28,9	35,9	19,8	7	4,5	78,063738	969	1069,836	267,459	0,369685
12:27:00	28,4	34,6	20,3	6,2	4,5	69,358181	836	924,1517	231,0379	0,380237
12:37:00	28,8	34,7	20,5	5,9	4,9	65,945044	371	410,5214	102,6303	0,813853
12:47:00	27,5	33,6	19,5	6,1	5,8	68,463795	834	923,5023	230,8756	0,375597
12:57:00	28,3	33,9	20,8	5,6	4	62,732803	980	1085,665	271,4163	0,292751
13:07:00	29,9	37,7	22	7,8	4	86,562473	1011	1120,234	280,0585	0,39149
13:17:00	29,1	37,8	20,3	8,7	4,5	96,668369	992	1099,126	274,7814	0,445591
13:27:00	28,9	34	20,7	5,1	4,5	57,062568	973	1077,747	269,4368	0,268246
13:37:00	29,4	38,7	22,5	9,3	4,5	103,11906	947	1048,362	262,0906	0,498341
13:47:00	30,1	39,2	22,4	9,1	3,1	100,68998	932	1030,912	257,7281	0,494839
13:57:00	29,5	38,7	22,2	9,2	4,5	101,99244	945	1044,157	261,0393	0,494882
14:07:00	29,6	38,4	22,1	8,8	2,7	97,592066	914	1008,528	252,1319	0,49026
14:17:00	29,8	38,4	21,7	8,6	4,5	95,340758	918	1011,267	252,8168	0,477653
14:27:00	30	37,4	22,2	7,4	3,6	82,15203	910	1000,491	250,1228	0,416011
14:37:00	30,1	38,3	22,7	8,2	2,7	90,874546	871	955,4269	238,8567	0,481886
14:47:00	30,3	38	22,2	7,7	3,1	85,348326	858	938,6911	234,6728	0,460651
14:57:00	30,2	37,8	21,9	7,6	3,1	84,284057	840	916,2362	229,0591	0,466055
15:07:00	30	37,3	21,4	7,3	4	81,056002	824	895,7163	223,9291	0,458473
15:17:00	30,1	37,5	22,1	7,4	4,5	82,123372	810	877,0991	219,2748	0,47437
15:27:00	30,4	37,7	22,7	7,3	4,9	80,942919	788	849,5621	212,3905	0,482707
15:37:00	30,5	37,5	22,7	7	3,6	77,630052	762	817,5039	204,376	0,481105
15:47:00	30,2	36,9	22,6	6,7	5,4	74,419811	743	792,7226	198,1807	0,475627
15:57:00	30,1	36,3	22,4	6,2	4	68,950123	715	758,1108	189,5277	0,460789
16:07:00	30,7	35,6	21	4,9	3,1	54,502326	694	730,6923	182,6731	0,377903
16:17:00	30,2	34,5	20,7	4,3	3,1	47,961763	667	696,7097	174,1774	0,348773
16:27:00	30,2	34	21,2	3,8	4	42,421592	638	660,4449	165,1112	0,325424

Table C.5. Daily data for 20.04.2005

Date	**20.04.2005**	**With Polyurethane**								
Weather Condition		Partly Cloudy								
Midday	**Φ (^{0})**	**δ (^{0})**		**V_{in} (m/s)**	**V_{out} (m/s)**		**P_{in} (kPa)**	**P_{out} (kPa)**		
13:10	38,46	11,22631		3,5	1,9		0,33	0,01		
Time	**T_{in}**	**T_{out}**	**$T_{amb.}$**	**ΔT**	**Wind(m/s)**	**Q_{useful} (W)**	**I_o(W/m^2)**	**$I_β$(W/m^2)**	**Q(W)**	**η**
09:30:51	22,1	23,7	19	1,6	5,4	18,431047	566	567,7373	141,9343	0,164476
09:40:50	26,3	28	19,6	1,7	5,4	19,303688	609	618,471	154,6178	0,158132
09:50:50	26,8	27,5	18,8	0,7	4,5	7,9485775	460	472,2285	118,0571	0,085278
10:00:50	28,5	30,4	20,4	1,9	5,4	21,405665	632	654,9853	163,7463	0,165576
10:10:50	29,5	32,1	19,7	2,6	4,5	29,156133	542	566,43	141,6075	0,260785
10:20:50	28,4	30	19,4	1,6	3,1	18,041299	294	309,5332	77,38329	0,295298
10:30:50	26,6	26,8	18,3	0,2	2,7	2,2745027	248	262,8209	65,70521	0,043846
10:40:50	26,2	26,5	18,2	0,3	2,2	3,4158143	248	264,3557	66,08893	0,065464
10:50:50	27	27,6	19,5	0,6	1,8	6,8095857	262	280,7275	70,18188	0,122895
11:00:50	26,9	27,4	19,2	0,5	2,7	5,6775554	252	271,2561	67,81403	0,106043
11:10:50	27,3	28	19,2	0,7	2,2	7,9350409	316	341,5355	85,38387	0,11771
11:20:50	28,7	31,8	21,8	3,1	2,7	34,829067	589	638,8955	159,7239	0,276192
11:30:50	27	27,1	19	0,1	3,1	1,1358978	292	317,7439	79,43598	0,018112
11:40:50	28	29,1	19,3	1,1	3,1	12,431055	389	424,4761	106,119	0,148373
11:50:50	27,3	28,5	19	1,2	5,8	13,591323	442	483,4786	120,8696	0,142424
12:00:50	28,5	30,3	19,7	1,8	3,1	20,282533	498	545,8691	136,4673	0,188249
12:10:50	29,2	33,4	21,4	4,2	3,1	47,017089	598	656,6383	164,1596	0,362768
12:20:50	29,4	32,2	21,2	2,8	3,1	31,398913	417	458,5599	114,64	0,346911
12:30:50	29,6	32,5	20,8	2,9	3,1	32,492242	687	756,3567	189,0892	0,217647
12:40:50	29,3	34,5	21,3	5,2	5,4	58,090861	921	1014,89	253,7226	0,289993
12:50:50	28	30,3	19,8	2,3	5,4	25,938817	502	553,5231	138,3808	0,237418
13:00:50	28,3	30,2	19,7	1,9	4,9	21,420367	270	297,8201	74,45502	0,364395
13:10:50	28,6	31,4	19,7	2,8	5,4	31,485601	1012	1116,39	279,0974	0,142888
13:20:50	29,6	35,3	22,2	5,7	5,4	63,555153	959	1057,758	264,4395	0,304414
13:30:50	29,3	33,7	21	4,4	3,6	49,221935	735	810,3527	202,5882	0,30774
13:40:50	29,8	34,5	21	4,7	3,6	52,459714	594	654,4514	163,6129	0,406114
13:50:50	29,4	33,8	20,4	4,4	5,4	49,204903	994	1094,118	273,5294	0,227847
14:00:50	29,4	34,1	22,4	4,7	4,9	52,532493	644	707,9931	176,9983	0,375923
14:10:50	31	37,8	22,1	6,8	3,6	75,306706	949	1041,715	260,4287	0,366256
14:20:50	30,8	37,6	22,4	6,8	3,1	75,359379	901	987,2211	246,8053	0,386743
14:30:50	31,2	38,1	22,9	6,9	3,6	76,347344	867	947,9291	236,9823	0,408054
14:40:50	31,4	38,3	22,8	6,9	3,6	76,293891	894	975,0172	243,7543	0,39644
14:50:50	30,5	34	21,1	3,5	4,9	39,052194	913	992,8949	248,2237	0,19927
15:00:50	30,3	34,9	21,9	4,6	3,6	51,263409	865	937,633	234,4082	0,276996
15:10:50	30,8	36,5	22,1	5,7	3,1	63,290303	846	913,6548	228,4137	0,350957
15:20:50	31,4	36,8	22,1	5,4	3,1	59,865127	795	854,9995	213,7499	0,354738
15:30:50	31,2	36	21,8	4,8	2,7	53,306391	788	843,4932	210,8733	0,320182
15:40:50	31,7	37,2	23,2	5,5	4	60,899184	790	841,1666	210,2916	0,3668
15:50:50	30,6	34,5	21,3	3,9	4,5	43,470005	713	754,6662	188,6665	0,291833

Table C.6. Daily data for 25.04.2005

Date	**25.04.2005**	**With Polyurethane**								
Weather Condition		Clear								
Midday	**Φ (^{0})**	**δ (^{0})**		**V_{in} (m/s)**	**V_{out} (m/s)**		**P_{in} (kPa)**	**P_{out} (kPa)**		
13:09	38,46	12,95461		4	2		0,39	0,005		
Time	**T_{in}**	**T_{out}**	**$T_{amb.}$**	**ΔT**	**Wind(m/s)**	**Q_{useful} (W)**	**I_o(W/m^2)**	**I_β(W/m^2)**	**Q(W)**	**η**
09:41:31	23,5	26,2	19,3	2,7	4	32,525167	566	558,1059	139,5265	0,295258
09:51:31	25,9	30,5	21,3	4,6	4	54,785993	595	593,6788	148,4197	0,467539
10:01:31	26,2	31,6	21,6	5,4	4	64,160065	626	631,1416	157,7854	0,515036
10:11:31	26,5	32,4	21,1	5,9	3,6	69,968655	654	665,4579	166,3645	0,5327
10:21:31	27,2	33,1	22	5,9	3,6	69,800433	680	697,5678	174,3919	0,506957
10:31:31	28,6	34,9	21,4	6,3	1,8	74,121994	706	729,4906	182,3726	0,514786
10:41:31	28,3	34,8	20,9	6,5	3,1	76,528044	731	760,1875	190,0469	0,510034
10:51:31	28	35,1	21,4	7,1	3,1	83,592171	753	787,5484	196,8871	0,537759
11:01:31	29	36,3	23,3	7,3	3,1	85,619652	772	811,5254	202,8814	0,534528
11:11:31	28	36,2	21,6	8,2	4	96,359296	797	841,5831	210,3958	0,580091
11:21:31	29,2	37,5	22,5	8,3	3,1	97,111566	822	871,4428	217,8607	0,564588
11:31:31	29,4	38,3	23,5	8,9	1,8	103,95028	842	895,7803	223,9451	0,587927
11:41:31	29,6	38,8	23,8	9,2	2,2	107,32296	843	899,6006	224,9002	0,604425
11:51:31	30,6	39,8	23,8	9,2	2,2	106,94785	859	919,1202	229,78	0,589521
12:01:31	30,6	40	24	9,4	2,2	109,23447	874	937,3099	234,3275	0,59044
12:11:31	31	40,9	24,4	9,9	1,8	114,7824	888	954,1633	238,5408	0,60947
12:21:31	31,6	40,1	21,3	8,5	1,8	98,585207	906	975,0548	243,7637	0,51225
12:31:31	30,8	39,9	23,4	9,1	2,7	105,72971	946	1019,395	254,8488	0,525477
12:41:31	30,8	39	23,6	8,2	2,2	95,42339	874	942,7094	235,6774	0,512834
12:51:31	30,9	39,5	24,4	8,6	3,1	99,972989	823	888,2789	222,0697	0,570207
13:01:31	31,2	41	24,2	9,8	3,1	113,56303	920	993,3241	248,331	0,579223
13:11:31	31	40,8	24,5	9,8	3,1	113,64296	919	992,3028	248,0757	0,580227
13:21:31	30,9	40,7	24,5	9,8	3,1	113,68293	914	986,6715	246,6679	0,583744
13:31:31	31	41,2	24,4	10,2	3,1	118,19825	943	1017,436	254,3589	0,588577
13:41:31	30,9	41,1	24,4	10,2	3,1	118,23985	976	1052,164	263,0409	0,569351
13:51:31	30	38,7	24,7	8,7	3,6	101,43698	786	846,3698	211,5925	0,607205
14:01:31	30,1	37	20,8	6,9	3,1	80,67505	919	988,141	247,0353	0,413637
14:11:31	31	39,4	22,7	8,4	3,6	97,648036	910	976,7118	244,178	0,50652
14:21:31	31,3	39,7	22	8,4	3,1	97,545276	896	959,629	239,9072	0,514994
14:31:31	30,7	38,8	21	8,1	3,6	94,30923	877	936,9253	234,2313	0,509975
14:41:31	31,2	39,1	21,2	7,9	3,1	91,85176	854	909,7086	227,4272	0,511546
14:51:31	31,2	38,8	21,4	7,6	3,1	88,410202	845	897,1322	224,2831	0,499281
15:01:31	30,7	37,7	22,3	7	4	81,65877	831	878,9354	219,7339	0,470701
15:11:31	30,9	36,8	21,3	5,9	3,6	68,910861	830	874,1238	218,5309	0,399406
15:21:31	31,8	38,4	21,4	6,6	2,7	76,750369	790	827,9839	206,996	0,469632
15:31:31	32	39,6	24,6	7,6	3,1	88,162271	853	889,1583	222,2896	0,502346
15:41:31	31,6	38,5	21,4	6,9	3,6	80,25309	790	818,459	204,6148	0,49678

Table C.7. Daily data for 26.04.2005

Date	26.04.2005	With Polyurethane								
Weather Condition		Partly Cloudy								
Midday	Φ (^{0})	δ (^{0})		V_{in} (m/s)	V_{out} (m/s)		P_{in} (kPa)	P_{out} (kPa)		
13:09	38,46	13,28916		4	2		0,39	0,005		
Time	T_{in}	T_{out}	$T_{amb.}$	ΔT	Wind(m/s)	Q_{useful} (W)	$I_o(W/m^2)$	$I_\beta(W/m^2)$	Q(W)	η
09:55:52	23,9	27,1	21	3,2	0,9	38,463705	600	591,0023	147,7506	0,329732
10:05:52	29,1	34	23,2	4,9	0,9	57,690372	623	620,7303	155,1826	0,470869
10:15:52	30,8	36,9	23,5	6,1	0,4	71,246823	656	660,2466	165,0617	0,546712
10:25:52	31,6	38,3	24,5	6,7	0,4	77,954233	691	701,7157	175,4289	0,562831
10:35:52	32,2	38,5	22,6	6,3	0	73,197493	742	759,5012	189,8753	0,488278
10:45:52	33	39,4	22,9	6,4	0,4	74,137507	731	753,5272	188,3818	0,498469
10:55:52	33,6	40,3	22,5	6,7	0,4	77,407743	783	812,1966	203,0492	0,482862
11:05:52	33,6	40,1	23,8	6,5	0,9	75,123578	820	855,3219	213,8305	0,444986
11:15:52	34,4	42,1	25,5	7,7	1,3	88,552764	703	736,9145	184,2286	0,608814
11:25:52	31,7	33,9	21,3	2,2	0,9	25,789733	430	452,7227	113,1807	0,288612
11:35:52	32,2	35	23,6	2,8	1,3	32,731995	658	695,4564	173,8641	0,238453
11:45:52	35,3	44,3	28,4	9	1,8	102,93395	658	697,8252	174,4563	0,747328
11:55:52	35,3	42,1	27,4	6,8	1,8	78,077582	474	504,1829	126,0457	0,784581
12:05:52	34	39,4	27,1	5,4	2,2	62,443397	431	459,6225	114,9056	0,688311
12:15:52	33,2	35,9	24,9	2,7	4	31,458427	529	565,3667	141,3417	0,281907
12:25:52	34,9	42,4	27,7	7,5	2,7	86,130282	921	986,1205	246,5301	0,442512
12:35:52	35,2	42,5	26,4	7,3	1,8	83,773897	801	858,9173	214,7293	0,494148
12:45:52	35,1	42,3	26,8	7,2	1,8	82,670381	835	896,4215	224,1054	0,467237
12:55:52	35	42,3	26,4	7,3	2,2	83,833474	756	812,3021	203,0755	0,522877
13:05:52	35,1	40,7	26,3	5,6	1,8	64,481979	767	824,5699	206,1425	0,396196
13:15:52	35,1	41,5	27,4	6,4	1,8	73,589241	814	875,3084	218,8271	0,425944
13:25:52	34,3	38,1	25,6	3,8	2,2	44,019145	671	721,4946	180,3737	0,309106
13:35:52	35,2	41,3	26,8	6,1	2,2	70,15219	852	915,784	228,946	0,388104
13:45:52	35,1	41,1	27,3	6	2,7	69,038875	942	1011,847	252,9618	0,345683
13:55:52	36,6	44,4	27,5	7,8	1,3	88,986562	994	1066,66	266,665	0,422667
14:05:52	35,4	39,7	27,8	4,3	2,2	49,574349	1008	1080,282	270,0706	0,232498
14:15:52	37,1	45	29,4	7,9	1,3	89,95004	933	998,2786	249,5696	0,456509
14:25:52	37,2	44,6	28,4	7,4	2,2	84,302315	965	1030,483	257,6207	0,414475
14:35:52	36,5	43,4	29	6,9	2,2	78,873788	938	999,3126	249,8282	0,399881
14:45:52	36,3	40,7	27,5	4,4	2,2	50,556696	935	993,4074	248,3519	0,25784
14:55:52	36,9	42,9	28,5	6	2,2	68,598147	809	856,8443	214,2111	0,405611
15:05:52	35,4	40,9	28,4	5,5	5,8	63,274415	692	730,3035	182,5759	0,438959
15:15:52	33,3	37,7	26,9	4,4	6,7	51,095145	761	799,8627	199,9657	0,323641
15:25:52	33,1	37,4	25,9	4,3	6,3	49,977728	671	702,0314	175,5078	0,360678
15:35:52	31,9	34,6	25,1	2,7	6,3	31,601515	545	567,2569	141,8142	0,282246
15:45:52	31,4	34,2	24,9	2,8	6,3	32,823297	584	604,3149	151,0787	0,275181
15:55:52	32	34,7	25,1	2,7	5,8	31,590509	533	547,935	136,9837	0,292097

Table C.8. Daily data for 28.04.2005

Date	**28.04.2005**	**With Polyurethane**								
Weather Condition		Clear								
Midday	**Φ (^{0})**	**δ (^{0})**		**V_{in} (m/s)**	**V_{out} (m/s)**		**P_{in} (kPa)**	**P_{out} (kPa)**		
13:09	38,46	13,94634		4	2		0,39	0,005		
Time	**T_{in}**	**T_{out}**	**$T_{amb.}$**	**ΔT**	**Wind(m/s)**	**Q_{useful} (W)**	**I_o(W/m^2)**	**I_β(W/m^2)**	**Q(W)**	**η**
10:13:16	31,2	35,6	24,8	4,4	3,6	51,471862	642	644,0209	161,0052	0,40492
10:23:15	31,2	36,2	25,2	5	4	58,429608	669	676,7972	169,1993	0,437395
10:33:15	32	37,4	25,2	5,4	4	62,883829	694	707,3752	176,8438	0,45039
10:43:15	32,4	38,8	25,8	6,4	3,1	74,294111	720	738,7881	184,697	0,509488
10:53:15	32,1	38,8	25,8	6,7	3,6	77,817631	745	768,9889	192,2472	0,512693
11:03:15	32,4	38,8	23	6,4	3,6	74,294111	765	793,8065	198,4516	0,474176
11:13:15	32,6	38,3	22,2	5,7	3,6	66,203059	788	821,5047	205,3762	0,408289
11:23:15	32,6	39,8	26,2	7,2	3,6	83,404695	808	845,8446	211,4612	0,499573
11:33:15	33	40,8	26,6	7,8	3,6	90,132385	826	867,8394	216,9599	0,526188
11:43:15	33,3	41,1	25,2	7,8	3,6	90,036932	845	890,6306	222,6577	0,51218
11:53:15	33,6	41,9	27	8,3	4	95,622299	860	908,9426	227,2356	0,532994
12:03:15	34,2	42,2	25,8	8	3,6	92,019193	874	925,9207	231,4802	0,503505
12:13:15	34,3	43	26,8	8,7	4	99,911127	887	941,5586	235,3896	0,537608
12:23:15	34,2	43,3	27	9,1	4	104,46761	897	953,7236	238,4309	0,554956
12:33:15	34,1	43,5	26,8	9,4	3,6	107,89242	903	961,3369	240,3342	0,56861
12:43:15	34	43,5	26,3	9,5	3,6	109,05959	910	969,7134	242,4284	0,569797
12:53:15	34,4	43,3	26,8	8,9	3,6	102,1353	917	977,7897	244,4474	0,529212
13:03:15	34,4	43,9	27,3	9,5	4	108,90452	922	983,4301	245,8575	0,56105
13:13:15	34,6	44,5	27,8	9,9	3,1	113,32836	927	988,7633	247,1908	0,580692
13:23:15	34,5	44,5	27,3	10	2,7	114,4935	928	989,5189	247,3797	0,586214
13:33:15	34,7	44	23,3	9,3	3,6	106,53589	928	988,8945	247,2236	0,545815
13:43:15	34,6	43,8	27,1	9,2	3,6	105,44666	927	986,8874	246,7219	0,541333
13:53:15	34,4	43,9	27,4	9,5	4	108,90452	923	981,3678	245,3419	0,562229
14:03:15	34,4	44,2	26,8	9,8	3,1	112,28362	916	972,3423	243,0856	0,585055
14:13:15	33,8	43,1	27,4	9,3	4	106,87745	910	964,0593	241,0148	0,561671
14:23:15	34,4	43,7	27,4	9,3	3,6	106,64975	900	951,219	237,8047	0,56804
14:33:15	34,9	43,9	27,9	9	3,6	103,08088	890	938,0606	234,5152	0,556733
14:43:15	34,4	43,8	26,8	9,4	3,6	107,77734	877	921,4228	230,3557	0,592609
14:53:15	34,1	42,9	27,1	8,8	4,5	101,11339	862	902,3738	225,5935	0,567704
15:03:15	34,5	42,9	27,4	8,4	4,9	96,448777	843	878,8432	219,7108	0,556013
15:13:15	34,7	42,7	27,7	8	4,5	91,855978	826	857,1035	214,2759	0,542967
15:23:15	35,9	43,1	28,1	7,2	4,5	82,435321	809	835,0497	208,7624	0,50015
15:33:15	36,1	43,3	28,8	7,2	4,5	82,37655	790	810,6147	202,6537	0,514859
15:43:15	35,6	42,7	27,1	7,1	3,6	81,391801	768	782,8014	195,7003	0,526779
15:53:15	35,2	41,3	23,4	6,1	4,5	70,15219	743	751,6596	187,9149	0,472846

Table C.9. Daily data for 02.05.2005

Date	**02.05.2005**	**With Polyurethane**								
Weather Condition		Clear								
Midday	**Φ (⁰)**	**δ (⁰)**		**V_{in} (m/s)**	**V_{out} (m/s)**		**P_{in} (kPa)**	**P_{out} (kPa)**		
13:08	38,46	15,21036		4	2		0,39	0,005		
Time	**T_{in}**	**T_{out}**	**$T_{amb.}$**	**ΔT**	**Wind(m/s)**	**Q_{useful} (W)**	**$I_o(W/m^2)$**	**$I_\beta(W/m^2)$**	**Q(W)**	**η**
10:07:23	26,9	31,2	21,9	4,3	3,6	51,064155	675	660,3441	165,086	0,391783
10:17:23	27,4	32,4	23	5	4	59,203826	697	688,4577	172,1144	0,435684
10:27:23	28,1	33,5	23,4	5,4	4	63,742154	733	730,2291	182,5573	0,442249
10:37:23	28,9	34,5	23,5	5,6	4,5	65,897626	765	767,9214	191,9803	0,434763
10:47:23	29,3	35,1	24,7	5,8	5,4	68,132939	800	808,5033	202,1258	0,426948
10:57:23	29,8	35,4	24,5	5,6	5,8	65,69224	835	848,9659	212,2415	0,392034
11:07:23	29,6	36,7	25,9	7,1	4,9	83,129219	852	870,8904	217,7226	0,483604
11:17:23	29,6	37	25,7	7,4	5,4	86,596477	867	890,4277	222,6069	0,492721
11:27:23	29,7	37,2	25	7,5	5,4	87,720843	896	924,0637	231,0159	0,480951
11:37:23	29,4	37,3	24,9	7,9	5,8	92,43149	911	942,9848	235,7462	0,496609
11:47:23	29,7	37,6	25,8	7,9	4,9	92,334883	910	944,9625	236,2406	0,495052
11:57:23	30,1	37,5	25,3	7,4	5,4	86,445655	904	941,3186	235,3297	0,465271
12:07:23	29,8	37,6	25,4	7,8	5,8	91,150189	919	959,1763	239,7941	0,481458
12:17:23	30	37,2	24,2	7,2	5,8	84,167986	937	979,865	244,9663	0,435191
12:27:23	30,2	37,7	25,5	7,5	4,5	87,567978	956	1001,302	250,3254	0,443078
12:37:23	29	33,5	23,6	4,5	4,5	53,035959	580	608,2166	152,0542	0,441786
12:47:23	29,4	37,5	24,8	8,1	4,5	94,738511	975	1023,306	255,8265	0,469052
12:57:23	30,3	38,8	26,8	8,5	4,5	99,035788	997	1046,929	261,7321	0,479264
13:07:23	30	38,1	25,4	8,1	4	94,540395	980	1029,251	257,3128	0,465367
13:17:23	30,3	38,9	25,1	8,6	4,5	100,18338	953	1000,725	250,1813	0,507201
13:27:23	29,8	38,5	25,9	8,7	4	101,50792	948	994,9681	248,742	0,516881
13:37:23	29,9	37,6	24	7,7	4	89,965903	940	985,7304	246,4326	0,462402
13:47:23	29,9	38,3	26,2	8,4	4,5	98,024769	935	979,3067	244,8267	0,507127
13:57:23	30,9	38,9	25,9	8	5,4	93,09599	938	980,9107	245,2277	0,48084
14:07:23	31,2	39	27	7,8	4,5	90,704982	929	969,6134	242,4034	0,473949
14:17:23	29,9	38,2	26,1	8,3	4,9	96,874726	915	952,7727	238,1932	0,515135
14:27:23	30	38,2	26,2	8,2	4,5	95,690846	903	937,6935	234,4234	0,517022
14:37:23	30,7	38,4	27,8	7,7	4,9	89,714773	899	930,5634	232,6409	0,488447
14:47:23	30,7	36,9	25,1	6,2	4,5	72,427441	837	863,2157	215,8039	0,425092
14:57:23	31,6	39	26,9	7,4	4,5	85,993095	877	900,6979	225,1745	0,483709
15:07:23	31,6	38,6	26,5	7	4,9	81,401907	855	873,9569	218,4892	0,471894
15:17:23	31,7	38,5	28,4	6,8	4,5	79,076138	834	847,9492	211,9873	0,472471
15:27:23	31,9	38,4	26,8	6,5	4	75,574233	816	824,6734	206,1683	0,464292
15:37:23	32,1	38,3	27,1	6,2	4,5	72,07355	795	798,0359	199,509	0,457565
15:47:23	32,4	37,6	26,4	5,2	5,8	60,491191	760	757,1271	189,2818	0,404784
15:57:23	31,4	36,7	26,3	5,3	5,8	61,859765	726	717,1023	179,2756	0,437045
16:07:23	31,8	36,4	26,5	4,6	5,4	53,680231	710	694,5842	173,646	0,391552
16:17:23	31,8	36,4	26,8	4,6	5,8	53,680231	683	660,9566	165,2391	0,411473

Table C.10. Daily data for 03.05.2005

Date	03.05.2005	With Polyurethane								
Weather Condition		Clear								
Midday	Φ (^{0})	δ (^{0})		V_{in} (m/s)	V_{out} (m/s)		P_{in} (kPa)	P_{out} (kPa)		
13:08	38,46	15,51533		4	2		0,39	0,005		
Time	**T_{in}**	**T_{out}**	**$T_{amb.}$**	**ΔT**	**Wind(m/s)**	**Q_{useful} (W)**	**I_o(W/m^2)**	**I_β(W/m^2)**	**Q(W)**	**η**
09:54:05	29,1	32,4	24,6	3,3	0,4	38,960261	599	567,2649	141,8162	0,347965
10:04:05	30,3	34,6	25,4	4,3	1,8	50,468542	627	601,527	150,3817	0,425075
10:14:05	31,2	35,7	23,5	4,5	0,9	52,632506	653	633,6793	158,4198	0,420808
10:24:05	31,8	36,4	24,1	4,6	1,3	53,680231	684	670,522	167,6305	0,405603
10:34:05	32,1	37	23,4	4,9	1,8	57,091219	713	705,2666	176,3166	0,410124
10:44:05	32,6	38,8	27,4	6,2	1,3	71,947137	742	739,8464	184,9616	0,492687
10:54:05	33,2	40,3	29,8	7,1	1,8	82,087023	763	766,2201	191,555	0,542776
11:04:05	33	39,8	28,6	6,8	2,2	78,715633	750	757,9505	189,4876	0,526162
11:14:05	33,1	40,6	27,2	7,5	2,2	86,681052	786	798,8162	199,7041	0,549765
11:24:05	33,1	40,9	28,2	7,8	2,2	90,100568	805	822,2207	205,5552	0,555186
11:34:05	32,8	40,7	28,4	7,9	2,7	91,336265	823	844,3232	211,0808	0,548067
11:44:05	32,9	40,8	27,2	7,9	2,2	91,304041	830	854,8151	213,7038	0,54115
11:54:05	33	41	28,1	8	2,7	92,410839	829	856,6831	214,1708	0,546515
12:04:05	33,2	41,4	29	8,2	3,1	94,62076	863	894,4357	223,6089	0,535965
12:14:05	34	43	30	9	2,2	103,41142	874	908,1044	227,0261	0,576942
12:24:05	33,8	43,1	29	9,3	2,2	106,87745	892	928,7497	232,1874	0,583025
12:34:05	33,6	43	28,9	9,4	2,7	108,0842	903	941,8089	235,4522	0,581432
12:44:05	34,5	43,5	29	9	1,8	103,2278	905	945,1555	236,2889	0,553341
12:54:05	34,7	44,4	30,3	9,7	1,8	111,0389	902	942,9406	235,7351	0,59661
13:04:05	34,4	43,7	30	9,3	2,2	106,64975	920	962,3562	240,589	0,561466
13:14:05	34,3	44,1	29,2	9,8	3,1	112,32362	919	961,5751	240,3938	0,591817
13:24:05	34,3	43,8	28,7	9,5	3,1	108,94329	941	984,5265	246,1316	0,560625
13:34:05	33,9	44,4	29,8	10,5	3,1	120,36816	930	972,6152	243,1538	0,627004
13:44:05	34	44,8	29,3	10,8	2,7	123,69706	917	958,2888	239,5722	0,653977
13:54:05	33,9	44,7	30,2	10,8	3,1	123,74113	913	953,0433	238,2608	0,657811
14:04:05	33,8	43,9	28,9	10,1	3,1	115,90635	911	949,5474	237,3869	0,618429
14:14:05	33,9	44,8	29,5	10,9	2,7	124,86464	869	904,0874	226,0218	0,699727
14:24:05	34	44,9	28,7	10,9	2,2	124,82016	892	925,9265	231,4816	0,68298
14:34:05	34,1	45	30,3	10,9	2,7	124,77567	872	902,7527	225,6882	0,700262
14:44:05	34,3	43,1	31	8,8	2,2	101,04158	868	895,8214	223,9553	0,57145
14:54:05	33,7	43,6	29,5	9,9	3,1	113,69197	861	885,4208	221,3552	0,650548
15:04:05	34,6	45	29,6	10,4	2,2	118,9459	857	877,7119	219,428	0,686589
15:14:05	34,9	45,1	31,6	10,2	3,1	116,57522	836	852,2422	213,0606	0,693015
15:24:05	35,2	45,2	30,8	10	1,8	114,20779	821	832,5768	208,1442	0,694978
15:34:05	35,3	44,2	25,3	8,9	2,7	101,80841	805	811,5472	202,8868	0,635579

Table C.11. Daily data for 05.05.2005

Date	**05.05.2005**	**Without Polyurethane**								
Weather Condition		Partly Cloudy								
Midday	**Φ (^{0})**	**δ (^{0})**		**V_{in} (m/s)**	**V_{out} (m/s)**		**P_{in} (kPa)**	**P_{out} (kPa)**		
13:08	38,46	16,11139		3,5	2,7		0,03	0,02		
Time	**T_{in}**	**T_{out}**	**$T_{amb.}$**	**ΔT**	**Wind(m/s)**	**Q_{useful} (W)**	**I_o(W/m^2)**	**$I_β$(W/m^2)**	**Q(W)**	**η**
10:11:24	32,1	33,4	28,2	1,3	0,9	20,57675	635	614,8373	153,7093	0,169557
10:21:23	33,9	35,4	28,5	1,5	1,8	23,585564	684	668,6755	167,1689	0,178702
10:31:23	34,9	36,8	29,6	1,9	1,3	29,749536	702	692,16	173,04	0,217758
10:41:23	34,8	36,6	29,3	1,8	1,3	28,198636	705	700,4229	175,1057	0,20397
10:51:23	35	36,9	29,5	1,9	1,3	29,739075	723	723,1832	180,7958	0,208343
11:01:23	35	37	28,7	2	0,9	31,298784	728	732,5802	183,145	0,216457
11:11:23	35,2	37,2	29,8	2	2,7	31,276761	777	786,077	196,5193	0,201584
11:21:23	34,6	36,5	28,5	1,9	2,7	29,780917	764	776,5885	194,1471	0,194288
11:31:23	35,1	36,9	28,3	1,8	3,1	28,168906	813	829,8456	207,4614	0,171978
11:41:23	35,8	38,3	29,9	2,5	2,7	38,978939	918	940,4445	235,1111	0,209989
11:51:23	34	35,5	28	1,5	3,1	23,577308	778	799,5476	199,8869	0,1494
12:01:23	33,4	34,1	27,2	0,7	2,2	11,04127	505	520,3962	130,0991	0,107494
12:11:23	34,1	35,3	28,2	1,2	2,2	18,865149	561	579,4268	144,8567	0,164953
12:21:23	35,4	37,6	29,7	2,2	2,2	34,368096	895	926,1378	231,5344	0,188009
12:31:23	34,9	37,2	28,5	2,3	2,2	35,98727	954	988,6648	247,1662	0,184416
12:41:23	35	37,2	28,2	2,2	2,7	34,41655	884	917,145	229,2862	0,19012
12:51:23	35,9	38,8	30,5	2,9	2,7	45,167658	938	973,9008	243,4752	0,23497
13:01:23	35,2	37,5	28,1	2,3	2,7	35,949279	859	892,2266	223,0566	0,204134
13:11:23	34,2	35,5	27,1	1,3	3,1	20,426511	753	782,1542	195,5386	0,132313
13:21:23	34,7	36,2	28,3	1,5	2,7	23,519508	669	694,6795	173,6699	0,171531
13:31:23	33,9	34,9	27,1	1	3,6	15,737469	591	613,2691	153,3173	0,130012
13:41:23	34,3	35,6	29,1	1,3	3,1	20,419355	602	624,0323	156,0081	0,165781
13:51:23	34,9	36,7	28,6	1,8	3,6	28,188726	941	974,0587	243,5147	0,146619
14:01:23	35,3	37,5	29,1	2,2	3,6	34,38021	966	998,1367	249,5342	0,174509
14:11:23	33,5	34,2	27,2	0,7	3,6	11,037418	440	453,6371	113,4093	0,12327
14:21:23	34,7	35,8	28,6	1,1	2,7	17,25975	584	600,5214	150,1304	0,145615
14:31:23	35	36,2	28,2	1,2	2,7	18,805697	1034	1059,991	264,9978	0,089885
14:41:23	35,4	36,8	28,8	1,4	2,2	21,901441	617	630,2693	157,5673	0,176054
14:51:23	34,6	35,3	28,2	0,7	2,7	10,995037	697	709,1059	177,2765	0,078557
15:01:23	34,1	34,6	27,9	0,5	2,2	7,8701107	486	492,166	123,0415	0,081016
15:11:23	34,9	36	28,1	1,1	2,7	17,247639	808	813,9951	203,4988	0,107351
15:21:23	36	37,8	29,4	1,8	2,7	28,079705	898	899,361	224,8403	0,158182
15:31:23	34,5	35,4	28	0,9	2,2	14,136477	529	526,3109	131,5777	0,136081
15:41:23	34,3	34,7	27,6	0,4	3,1	6,2927862	567	559,9431	139,9858	0,056938
15:51:23	34,3	34,7	27,9	0,4	2,2	6,2927862	564	552,3516	138,0879	0,05772

Table C.12. Daily data for 09.05.2005

Date	09.05.2005	Without Polyurethane								
Weather Condition		Clear								
Midday	Φ (⁰)	δ (⁰)		V_{in} (m/s)	V_{out} (m/s)		P_{in} (kPa)	P_{out} (kPa)		
13:08	38,46	17,24553		3,5	2,7		0,03	0,02		
Time	T_{in}	T_{out}	$T_{amb.}$	ΔT	Wind(m/s)	Q_{useful} (W)	I_o(W/m²)	I_β(W/m²)	Q(W)	η
09:49:57	27,5	28	22,4	0,5	2,2	8,0516166	625	569,92	142,48	0,071576
09:59:57	29,1	30,3	23,1	1,2	2,7	19,195237	653	604,4447	151,1112	0,160893
10:09:57	29,8	31,3	23,8	1,5	2,7	23,923932	684	641,5659	160,3915	0,188926
10:19:57	30,1	31,6	23,6	1,5	2,7	23,899183	710	673,7923	168,4481	0,179703
10:29:57	29,7	31,5	23,1	1,8	2,7	28,703769	734	703,8418	175,9605	0,206616
10:39:57	29,6	31,1	23,4	1,5	3,6	23,94043	759	734,5691	183,6423	0,16512
10:49:57	30	31,9	24,8	1,9	2,7	30,261848	780	761,127	190,2817	0,201436
10:59:57	29,9	31,7	24	1,8	4,5	28,683969	800	786,381	196,5952	0,184802
11:09:57	30,8	32,9	24,8	2,1	1,8	33,343345	820	811,3108	202,8277	0,208219
11:19:57	31	33,4	24,3	2,4	1,8	38,060469	841	836,9201	209,23	0,230404
11:29:57	31,1	33,4	25,2	2,3	2,7	36,46829	860	860,2293	215,0573	0,214783
11:39:57	31,3	33,9	25,6	2,6	1,8	41,174958	876	880,2076	220,0519	0,237
11:49:57	30,6	32,9	23,2	2,3	2,2	36,531554	889	896,8216	224,2054	0,206377
11:59:57	31	33,4	24,9	2,4	2,2	38,060469	901	912,069	228,0173	0,21142
12:09:57	31	33,5	25,2	2,5	2,7	39,639446	912	925,9471	231,4868	0,216891
12:19:57	31	33,9	25,3	2,9	2,2	45,949847	921	937,4354	234,3588	0,248337
12:29:57	31,6	34,6	25,9	3	2,2	47,427034	931	949,5844	237,3961	0,253042
12:39:57	31,4	34,6	25,2	3,2	2,2	50,606444	940	960,3593	240,0898	0,266976
12:49:57	31,1	34,3	24,8	3,2	2,7	50,659265	943	964,6412	241,1603	0,266068
12:59:57	31,3	34,3	24	3	3,1	47,476554	946	968,5551	242,1388	0,248344
13:09:57	31,5	34,9	27,5	3,4	1,8	53,731929	950	973,1281	243,282	0,279745
13:19:57	32	35,5	26,6	3,5	1,8	55,206349	955	978,3604	244,5901	0,285884
13:29:57	31,6	34,8	24,7	3,2	2,2	50,571228	954	977,078	244,2695	0,262225
13:39:57	31,7	34,8	25,3	3,1	2,7	48,982348	951	973,3794	243,3448	0,254951
13:49:57	31,2	34,4	25,5	3,2	3,6	50,641658	948	969,3122	242,3281	0,264694
13:59:57	31,7	34,8	26	3,1	3,1	48,982348	940	959,7677	239,9419	0,258567
14:09:57	31,6	34,8	26,4	3,2	3,1	50,571228	932	949,8629	237,4657	0,269738
14:19:57	31,5	34,8	26,3	3,3	3,6	52,160658	923	938,578	234,6445	0,281561
14:29:57	31,9	34,6	25,7	2,7	3,6	42,662045	914	926,9292	231,7323	0,233182
14:39:57	31,5	34	25,2	2,5	4,5	39,570673	902	911,8764	227,9691	0,219855
14:49:57	32,2	35	27	2,8	3,6	44,188193	887	893,4422	223,3606	0,250576
14:59:57	33,9	36,9	28,1	3	2,2	47,047273	876	878,6767	219,6692	0,271272
15:09:57	33,3	35,8	25,9	2,5	2,7	39,323034	864	862,524	215,631	0,23098
15:19:57	32,9	35,1	26,5	2,2	3,6	34,670866	843	837,039	209,2597	0,209855
15:29:57	33,1	35,3	27	2,2	2,2	34,64665	825	814,2071	203,5518	0,215589
15:39:57	32,5	34,5	26,2	2	2,7	31,574001	799	783,1803	195,7951	0,204252
15:49:57	32,8	34,7	27	1,9	2,7	29,969161	769	748,0139	187,0035	0,202985
15:59:57	32,5	34,5	27,2	2	4,9	31,574001	745	718,4529	179,6132	0,222654

Table C.13. Daily data for 11.05.2005

Date	**11.05.2005**	**Without Polyurethane**								
Weather Condition		Clear								
Midday	**Φ (^{0})**	**δ (^{0})**		**V_{in} (m/s)**	**V_{out} (m/s)**		**P_{in} (kPa)**	**P_{out} (kPa)**		
13:08	38,46	17,78227		3,5	2,7		0,03	0,02		
Time	**T_{in}**	**T_{out}**	**$T_{amb.}$**	**ΔT**	**Wind(m/s)**	**Q_{useful} (W)**	**I_o(W/m^2)**	**$I_β$(W/m^2)**	**Q(W)**	**η**
09:59:26	31,1	32,7	27	1,6	0,9	25,400053	667	620,1561	155,039	0,207507
10:09:26	32,4	34,5	28,7	2,1	1,3	33,158479	700	658,6873	164,6718	0,255044
10:19:26	32,8	35,1	29,4	2,3	0,9	36,253143	675	641,9589	160,4897	0,286113
10:29:26	33,1	35,3	29,3	2,2	0,9	34,64665	688	660,5465	165,1366	0,26574
10:39:26	33,2	35,8	28,2	2,6	1,3	40,90311	744	720,359	180,0897	0,287678
10:49:26	33,5	36,3	29,7	2,8	1,3	43,987855	819	798,9521	199,738	0,27894
10:59:26	33,5	36,5	29,7	3	1,3	47,113331	772	758,1524	189,5381	0,314838
11:09:26	33,7	36,4	29,6	2,7	1,3	42,394567	804	794,2811	198,5703	0,270418
11:19:26	35	38,4	31,6	3,4	1,3	53,076887	884	877,9212	219,4803	0,306302
11:29:26	35,1	38,8	32,2	3,7	1,3	57,709205	876	874,0243	218,5061	0,334519
11:39:26	35,5	38,7	30,6	3,2	2,2	49,884231	866	867,5716	216,8929	0,291311
11:49:26	35,4	38,7	31,7	3,3	1,8	51,4522	852	856,5737	214,1434	0,304326
11:59:26	35,2	38,9	30,6	3,7	1,8	57,68883	870	877,3372	219,3343	0,333138
12:09:26	35,1	38,4	31,2	3,3	1,8	51,506717	873	882,6336	220,6584	0,295653
12:19:26	35,6	38,4	32,3	2,8	1,8	43,664122	791	801,4356	200,3589	0,27603
12:29:26	35,3	38,3	30,6	3	1,3	46,816028	883	896,1772	224,0443	0,264667
12:39:26	35,6	38,4	30,7	2,8	1,8	43,664122	757	769,2929	192,3232	0,287563
12:49:26	35	36,6	30,1	1,6	1,8	25,056645	508	516,7122	129,178	0,245682
12:59:26	34,9	36,4	29,8	1,5	2,2	23,502992	533	542,4141	135,6035	0,219529
13:09:26	35,8	38,1	30,1	2,3	1,8	35,87329	771	784,7089	196,1772	0,231613
13:19:26	35,2	36,9	30,5	1,7	1,3	26,599287	637	648,1507	162,0377	0,207919
13:29:26	35,1	36,5	25,3	1,4	1,3	21,924565	624	634,5042	158,6261	0,175064
13:39:26	34,4	35,2	26,8	0,8	1,8	12,572362	538	546,4798	136,62	0,116558
13:49:26	36	39,3	30,4	3,3	1,8	51,343156	999	1013,267	253,3168	0,256719
13:59:26	36,4	40,8	32,3	4,4	1,8	68,227302	986	998,2085	249,5521	0,346287
14:09:26	36,4	40,9	32	4,5	2,2	69,765528	940	949,4458	237,3615	0,37228
14:19:26	37,1	41,4	33,8	4,3	1,8	66,522705	914	920,6396	230,1599	0,366083
14:29:26	37,1	41,4	33,1	4,3	2,2	66,522705	900	903,6062	225,9015	0,372984
14:39:26	36,8	41	32,6	4,2	2,2	65,05665	889	889,2227	222,3057	0,370664
14:49:26	37,4	41,6	32,5	4,2	1,3	64,917815	874	870,4729	217,6182	0,37784
14:59:26	37,9	41,9	33,3	4	1,3	61,738332	858	850,3743	212,5936	0,367828
15:09:26	38,3	42,1	33,4	3,8	1,3	58,588599	845	832,8756	208,2189	0,356396
15:19:26	38,7	42,4	33	3,7	1,3	56,97543	821	804,1963	201,0491	0,358943
15:29:26	38	41,6	33,2	3,6	2,2	55,584335	797	775,2398	193,8099	0,363259
15:39:26	37,6	40,9	33,1	3,3	2,2	51,052308	776	748,9002	187,2251	0,345375
15:49:26	37,7	40,7	32,4	3	2,7	46,419453	752	719,3585	179,8396	0,32693
15:59:26	37,9	40,8	30,3	2,9	2,2	44,848172	730	691,4209	172,8552	0,328626

Table C.14. Daily data for 12.05.2005

Date	12.05.2005	Without Polyurethane								
Weather Condition		Clear								
Midday	Φ (^{0})	δ (^{0})		V_{in} (m/s)	V_{out} (m/s)		P_{in} (kPa)	P_{out} (kPa)		
13:08	38,46	18,04278		3,5	2,7		0,03	0,02		
Time	**T_{in}**	**T_{out}**	**$T_{amb.}$**	**ΔT**	**Wind(m/s)**	**Q_{useful} (W)**	**I_o(W/m^2)**	**I_β(W/m^2)**	**Q(W)**	**η**
10:09:18	34,1	35,9	29,1	1,8	0,9	28,267999	643	602,5684	150,6421	0,237678
10:19:18	36,2	38,5	31	2,3	0,4	35,822625	667	631,825	157,9562	0,28725
10:29:18	37,3	39,8	32,1	2,5	0,4	38,772398	696	665,6404	166,4101	0,295109
10:39:18	37,7	39,8	31,2	2,1	1,8	32,545678	719	693,5273	173,3818	0,237755
10:49:18	37,4	39,5	30,8	2,1	2,2	32,580383	736	715,3391	178,8348	0,230751
10:59:18	37,4	39,5	30,8	2,1	2,2	32,580383	760	743,6778	185,9195	0,221958
11:09:18	37,7	39,8	30,9	2,1	2,7	32,545678	778	765,8802	191,4701	0,215294
11:19:18	37,8	39,8	30,2	2	2,7	30,990375	795	786,7942	196,6985	0,199556
11:29:18	37,7	39,9	29,7	2,2	2,2	34,089413	812	807,4035	201,8509	0,213909
11:39:18	37,7	39,8	29,8	2,1	3,1	32,545678	828	826,7127	206,6782	0,199452
11:49:18	38	40,2	31	2,2	3,1	34,053053	847	848,7196	212,1799	0,203278
11:59:18	38,5	40,9	31,2	2,4	2,7	37,069447	863	867,4212	216,8553	0,216514
12:09:18	39,2	41,9	31,8	2,7	1,3	41,576665	861	867,6711	216,9178	0,242769
12:19:18	39,5	42,3	31,7	2,8	2,2	43,062534	880	888,7344	222,1836	0,245486
12:29:18	39,2	41,8	32,4	2,6	3,1	40,043953	894	904,4345	226,1086	0,224316
12:39:18	39,4	42,3	32,4	2,9	2,2	44,608473	895	906,6346	226,6586	0,249278
12:49:18	39,5	42,6	32,5	3,1	1,8	47,650749	902	914,5548	228,6387	0,263973
12:59:18	40,7	44,1	35,3	3,4	1,8	52,009104	921	934,2957	233,5739	0,282029
13:09:18	40	43	26,1	3	2,7	46,039221	896	909,0416	227,2604	0,256592
13:19:18	39,4	43,1	32,2	3,7	3,1	56,832689	875	887,4925	221,8731	0,324439
13:29:18	38,9	42,3	33	3,4	3,1	52,346432	851	862,5733	215,6433	0,307461
13:39:18	39	42,5	31,5	3,5	2,7	53,857101	799	809,0018	202,2504	0,337282
13:49:18	37,4	40,3	32,4	2,9	2,7	44,928056	647	654,1326	163,5331	0,347978
13:59:18	38	42,3	33,4	4,3	2,7	66,309472	909	917,2784	229,3196	0,366247
14:09:18	37,6	41,9	32,2	4,3	2,7	66,404247	889	895,0033	223,7508	0,375899
14:19:18	37,9	42,2	33,3	4,3	2,2	66,333166	870	873,4307	218,3577	0,38477
14:29:18	38,5	43	33,3	4,5	1,8	69,244844	862	862,5661	215,6415	0,406719
14:39:18	38,4	42,5	33,7	4,1	2,2	63,157531	828	825,406	206,3515	0,387665
14:49:18	39	42,3	33,5	3,3	2,2	50,797738	799	793,0423	198,2606	0,324525
14:59:18	38,4	42,3	33,4	3,9	2,2	60,098167	823	812,8356	203,2089	0,374592
15:09:18	38,4	42,2	33,2	3,8	1,8	58,567659	805	790,6247	197,6562	0,375307
15:19:18	39	42,7	33,9	3,7	1,3	56,914258	785	766,1383	191,5346	0,376369
15:29:18	39,2	42,7	33	3,5	1,8	53,818523	774	750,0687	187,5172	0,363522
15:39:18	38,7	41,9	33,1	3,2	1,8	49,320134	693	666,2502	166,5626	0,375048
15:49:18	38,5	41,3	34,4	2,8	2,2	43,216833	679	646,985	161,7462	0,338422
15:59:18	38,1	40,9	32,4	2,8	2,2	43,278543	646	609,3952	152,3488	0,35981
16:09:18	36,9	39	30,9	2,1	2,2	32,638219	506	471,9708	117,9927	0,350357
16:19:18	34,6	35,4	28,8	0,8	2,7	12,563555	308	283,6544	70,91361	0,2244
16:29:18	33,3	33,4	27,8	0,1	2,7	1,5795255	193	175,2058	43,80144	0,045675

Table C.15. Daily data for 16.05.2005

Date	16.05.2005	Without Polyurethane								
Weather Condition		Clear								
Midday	Φ (^{0})	δ (^{0})		V_{in} (m/s)	V_{out} (m/s)		P_{in} (kPa)	P_{out} (kPa)		
13:08	38,46	19,03059		4	3,2		0,04	0,03		
Time	T_{in}	T_{out}	$T_{amb.}$	ΔT	Wind(m/s)	Q_{useful} (W)	I_o(W/m^2)	$I_β$(W/m^2)	Q(W)	η
10:14:09	28,5	29,4	23,8	0,9	3,6	17,106419	660	612,4837	153,1209	0,141502
10:24:09	31,2	33,6	25,9	2,4	3,6	45,077407	686	643,3888	160,8472	0,354964
10:34:09	31,7	34,8	26,6	3,1	3,1	58,053153	710	672,2073	168,0518	0,437544
10:44:09	32,4	35,6	27,2	3,2	3,1	59,769304	735	701,7486	175,4372	0,431515
10:54:09	32,4	35,9	26,5	3,5	3,1	65,338431	756	727,2221	181,8055	0,455199
11:04:09	32,4	36,1	27,2	3,7	3,6	69,047921	780	755,3228	188,8307	0,463146
11:14:09	32,9	36,7	27,6	3,8	3,1	70,777743	802	781,2327	195,3082	0,459003
11:24:09	32,8	37	28,1	4,2	2,7	78,200632	819	801,9764	200,4941	0,494024
11:34:09	33,3	36,5	26,4	3,2	2,7	59,581434	839	825,3515	206,3379	0,365739
11:44:09	33,8	38,1	29	4,3	2,7	79,767968	858	847,4445	211,8611	0,476888
11:54:09	33,4	38	28,4	4,6	3,1	85,408214	872	864,2755	216,0689	0,500665
12:04:09	33	37,1	27,6	4,1	3,1	76,29859	883	877,7828	219,4457	0,440381
12:14:09	33,9	38,3	28,7	4,4	3,1	81,57997	898	894,9196	223,7299	0,461848
12:24:09	33,9	38,3	29	4,4	3,1	81,57997	906	904,727	226,1817	0,456841
12:34:09	34,7	39,2	29,5	4,5	3,1	83,18444	920	920,1673	230,0418	0,45801
12:44:09	35,1	39,6	30,6	4,5	3,1	83,066957	912	913,2239	228,306	0,46084
12:54:09	35,7	39,9	29,7	4,2	4,5	77,405792	934	935,9463	233,9866	0,419008
13:04:09	35,6	40,3	30,4	4,7	3,6	86,574746	938	940,263	235,0657	0,466489
13:14:09	35,1	39,9	29,8	4,8	3,1	88,557758	940	942,1906	235,5477	0,476198
13:24:09	34,9	39	29,1	4,1	3,1	75,790268	941	942,7286	235,6821	0,407311
13:34:09	34,8	38,8	29	4	3,6	73,980884	854	854,793	213,6982	0,438488
13:44:09	34,7	39	29,9	4,3	4	79,515418	921	920,6305	230,1576	0,437588
13:54:09	35	39,2	30	4,2	4,5	77,597693	927	924,996	231,249	0,425019
14:04:09	35,2	39,7	30,1	4,5	3,6	83,037585	924	919,9656	229,9914	0,457301
14:14:09	35	39,3	30,2	4,3	4	79,431224	916	909,5599	227,39	0,442445
14:24:09	35,1	39,1	30,7	4	3,6	73,902565	889	879,9541	219,9885	0,425499
14:34:09	35,1	39	30,4	3,9	3,6	72,067728	807	795,8438	198,9609	0,458788
14:44:09	35,4	39,5	31,3	4,1	4	75,656466	882	866,1182	216,5296	0,442556
14:54:09	35,3	39,3	30,8	4	3,6	73,850349	869	849,225	212,3062	0,440585
15:04:09	35,4	39,4	30,4	4	3,1	73,824241	857	832,9073	208,2268	0,449057
15:14:09	35,6	39,5	31,2	3,9	3,6	71,94045	838	809,4046	202,3511	0,450305
15:24:09	35,9	39,7	30,7	3,8	3,6	70,033812	819	785,55	196,3875	0,451683
15:34:09	35,6	39,1	30,7	3,5	3,6	64,607633	798	759,4298	189,8575	0,431018

Table C.16. Daily data for 17.05.2005

Date	**17.05.2005**	**Without Polyurethane**								
Weather Condition		Clear								
Midday	**Φ (^{0})**	**δ (^{0})**		**V_{in} (m/s)**	**V_{out} (m/s)**		**P_{in} (kPa)**	**P_{out} (kPa)**		
13:08	38,46	19,26363		4	3,2		0,04	0,03		
Time	**T_{in}**	**T_{out}**	**$T_{amb.}$**	**ΔT**	**Wind(m/s)**	**Q_{useful} (W)**	**I_o(W/m^2)**	**I_β(W/m^2)**	**Q(W)**	**η**
09:34:52	25,1	25,4	23,8	0,3	1,8	5,7744391	524	457,1089	114,2772	0,064001
09:44:52	30,2	31,1	25,3	0,9	1,8	17,006707	490	434,9392	108,7348	0,198103
09:54:52	32,1	33,3	25,2	1,2	1,8	22,515229	630	567,8349	141,9587	0,200888
10:04:52	33	34,9	28,6	1,9	1,8	35,49422	654	597,5058	149,3764	0,300964
10:14:52	33,5	36,3	30,1	2,8	1,8	52,133755	682	630,6223	157,6556	0,418841
10:24:52	33,6	36,2	30,4	2,6	2,2	48,409915	707	660,7656	165,1914	0,371182
10:34:52	34	37	31,3	3	1,8	55,740158	730	688,7888	172,1972	0,409998
10:44:52	34,9	38,1	32,8	3,2	2,2	59,247358	754	717,4964	179,3741	0,418359
10:54:52	34,8	38,3	32,6	3,5	2,2	64,790377	779	746,9113	186,7278	0,439482
11:04:52	34,9	38,3	31,6	3,4	2,7	62,928129	799	771,2583	192,8146	0,413375
11:14:52	35,2	38,6	32	3,4	2,2	62,861561	817	793,3574	198,3394	0,401435
11:24:52	35,3	39	31,6	3,7	2,7	68,347798	837	817,0843	204,2711	0,423796
11:34:52	36,2	40	33,4	3,8	2,7	69,959394	855	838,5462	209,6365	0,422687
11:44:52	36	39,9	32,5	3,9	2,7	71,838619	868	854,7623	213,6906	0,425806
11:54:52	36,1	40	32,2	3,9	2,7	71,81316	881	870,6201	217,655	0,417902
12:04:52	36,8	41	33,4	4,2	2,2	77,104178	894	886,1234	221,5308	0,440842
12:14:52	36,4	40,5	32,5	4,1	2,2	75,388822	904	898,292	224,573	0,425196
12:24:52	36,3	40,5	32,3	4,2	2,7	77,241284	916	912,085	228,0213	0,429056
12:34:52	36,6	41	31,9	4,4	3,1	80,804533	925	922,5253	230,6313	0,443769
12:44:52	36,8	41,1	33,2	4,3	3,1	78,925954	933	931,5945	232,8986	0,429232
12:54:52	36,6	40,9	32,3	4,3	2,7	78,982104	939	938,2872	234,5718	0,426474
13:04:52	37,4	41,8	33,3	4,4	3,1	80,574693	944	943,596	235,899	0,432625
13:14:52	37,1	41,4	32,4	4,3	3,1	78,841724	945	944,5174	236,1294	0,422908
13:24:52	37,4	41,7	32,5	4,3	2,7	78,757489	945	944,0476	236,0119	0,422666
13:34:52	37,2	41,5	33,5	4,3	3,1	78,813646	944	942,1847	235,5462	0,423804
13:44:52	37,6	41,9	33,3	4,3	3,1	78,70133	950	946,9005	236,7251	0,421092
13:54:52	36,8	41,1	32,9	4,3	3,1	78,925954	950	945,2155	236,3039	0,423047
14:04:52	37,2	41,5	33,5	4,3	3,1	78,813646	945	938,1422	234,5355	0,42563
14:14:52	36,8	41	32,7	4,2	3,6	77,104178	934	924,7152	231,1788	0,422444
14:24:52	37,4	41,4	32,9	4	3,6	73,30196	924	911,8879	227,972	0,407262
14:34:52	37,5	41,7	33,7	4,2	3,1	76,912207	912	896,6934	224,1734	0,434561
14:44:52	37,4	40,1	26,1	2,7	3,1	49,593414	899	880,1251	220,0313	0,285482
14:54:52	37,1	40,8	31,8	3,7	3,6	67,91303	886	863,1605	215,7901	0,398622
15:04:52	37,7	41,5	33,5	3,8	3,6	69,587234	872	844,8181	211,2045	0,417317
15:14:52	37,7	41,4	33,2	3,7	3,1	67,768072	854	822,2113	205,5528	0,417581
15:24:52	37,9	41,6	33,3	3,7	3,1	67,719749	837	800,1828	200,0457	0,428771
15:34:52	37,7	41,3	33,6	3,6	2,7	65,948257	821	778,6965	194,6741	0,429076
15:44:52	36,9	40,4	32,5	3,5	2,2	64,31061	800	752,0663	188,0166	0,433237
15:54:52	36,8	40	32,8	3,2	3,1	58,850502	773	719,4735	179,8684	0,414414
16:04:52	36,1	39,3	33,1	3,2	2,7	58,99673	749	689,3697	172,3424	0,433586
16:14:52	35,7	38,7	32,5	3	3,1	55,407343	723	657,1044	164,2761	0,427201

Table C.17. Daily data for 23.05.2005

Date	23.05.2005	Without Polyurethane								
Weather Condition		Clear								
Midday	Φ (°)	δ (°)		V_{in} (m/s)	V_{out} (m/s)		P_{in} (kPa)	P_{out} (kPa)		
13:08	38,46	20,53966		4	3,2		0,04	0,03		
Time	T_{in}	T_{out}	$T_{amb.}$	ΔT	Wind(m/s)	Q_{useful} (W)	$I_o(W/m^2)$	$I_\beta(W/m^2)$	Q(W)	η
09:50:21	28,3	28,9	24,2	0,6	0,4	11,417962	627	549,9795	137,4949	0,105182
10:00:21	29,7	31,2	27,4	1,5	0,4	28,364067	656	584,0721	146,018	0,246038
10:10:21	31,6	33,5	28,3	1,9	0,4	35,667697	683	616,2183	154,0546	0,293251
10:20:21	32,4	34,9	29,8	2,5	0,9	46,75184	709	647,2532	161,8133	0,365952
10:30:21	32,3	34,9	28,9	2,6	1,3	48,630392	736	678,9862	169,7466	0,362866
10:40:21	32	34,8	28,8	2,8	1,8	52,407714	759	706,7824	176,6956	0,375672
10:50:21	32,9	35,9	29,2	3	1,8	55,955447	781	733,3566	183,3392	0,386569
11:00:21	33,5	36,6	29,6	3,1	2,2	57,689178	807	763,418	190,8545	0,382852
11:10:21	33,1	36,3	28,6	3,2	2,2	59,623186	833	793,233	198,3082	0,380815
11:20:21	33,5	37	29,2	3,5	2,2	65,087273	854	818,0027	204,5007	0,403126
11:30:21	34	37,6	30,6	3,6	2,2	66,817721	865	832,8276	208,2069	0,406477
11:40:21	33	36,7	29,7	3,7	2,7	68,903102	874	845,3108	211,3277	0,412973
11:50:21	33,8	37,5	30	3,7	2,2	68,709982	889	863,2085	215,8021	0,403277
12:00:21	33,7	37,5	30,1	3,8	1,8	70,579406	899	875,8741	218,9685	0,408259
12:10:21	33,7	37,5	28,7	3,8	2,7	70,579406	909	888,1501	222,0375	0,402616
12:20:21	34,1	38	30	3,9	2,7	72,322243	920	901,0196	225,2549	0,406665
12:30:21	34,7	38,9	30,3	4,2	2,2	77,679928	932	914,4894	228,6223	0,430358
12:40:21	34,5	38,7	30,3	4,2	2,7	77,734748	941	924,63	231,1575	0,425938
12:50:21	34	38,3	29,7	4,3	2,7	79,71185	949	933,3934	233,3483	0,432671
13:00:21	34,6	38,9	30,2	4,3	3,1	79,543481	954	938,8041	234,701	0,429269
13:10:21	34,5	38,9	30,4	4,4	3,1	81,407688	953	937,9019	234,4755	0,439752
13:20:21	34,1	38,5	30,3	4,4	3,1	81,522545	960	944,4606	236,1152	0,437314
13:30:21	33,9	38,1	29,6	4,2	3,6	77,899196	956	939,7829	234,9457	0,419957
13:40:21	34,3	38,5	29,5	4,2	3,1	77,789566	964	946,4764	236,6191	0,4164
13:50:21	34,1	38,1	30,4	4	3,6	74,163609	1017	996,8238	249,206	0,37694
14:00:21	33,6	37,6	30,3	4	2,7	74,294111	965	943,8105	235,9526	0,398813
14:10:21	34,1	38,2	30,9	4,1	2,7	76,004322	972	948,137	237,0342	0,406131
14:20:21	34,5	38,4	30,5	3,9	3,1	72,220443	1000	972,3649	243,0912	0,376297
14:30:21	35	39,1	31,1	4,1	3,1	75,763509	950	920,3268	230,0817	0,417078
14:40:21	34,8	38,8	30,6	4	3,1	73,980884	927	894,2051	223,5513	0,419162
14:50:21	34,4	37,5	28,7	3,1	3,1	57,50714	758	727,6079	181,902	0,400427
15:00:21	33,1	34,8	28	1,7	2,7	31,757987	264	252,0076	63,0019	0,638468
15:10:21	32,4	33,3	27,2	0,9	2,7	16,877618	318	301,6503	75,41257	0,28347
15:20:21	33,2	35,8	28,8	2,6	4	48,47776	882	830,7452	207,6863	0,295647
15:30:21	33,3	35,6	29,4	2,3	2,7	42,891674	529	494,3083	123,5771	0,439617
15:40:21	33,9	37	29,3	3,1	3,6	57,608276	848	785,3431	196,3358	0,371642
15:50:21	34,1	36,6	26,6	2,5	3,6	46,474599	811	743,591	185,8977	0,316651
16:00:21	34,4	37,1	29,7	2,7	4	50,122099	782	708,9866	177,2466	0,358171
16:10:21	34,1	36,7	28,5	2,6	3,6	48,325101	743	665,1721	166,293	0,368077
16:20:21	33,8	35,8	28,5	2	4,5	37,251444	703	620,4725	155,1181	0,304173

Table C.18. Daily data for 24.05.2005

Date	**24.05.2005**	**Without Polyurethane**								
Weather Condition		Clear								
Midday	**Φ (^{0})**	**δ (^{0})**		**V_{in} (m/s)**	**V_{out} (m/s)**		**P_{in} (kPa)**	**P_{out} (kPa)**		
13:08	38,46	20,73138		4	3,2		0,04	0,03		
Time	**T_{in}**	**T_{out}**	**$T_{amb.}$**	**ΔT**	**Wind(m/s)**	**Q_{useful} (W)**	**I_o(W/m^2)**	**$I_β$(W/m^2)**	**Q(W)**	**η**
09:56:46	27,2	27,4	25	0,2	3,1	3,8229253	659	581,5563	145,3891	0,033305
10:06:46	30,3	31,3	24,3	1	3,1	18,886564	687	614,8053	153,7013	0,155638
10:16:46	31,3	32,6	24,1	1,3	3,1	24,455072	714	646,9584	161,7396	0,19151
10:26:46	31,7	33,4	24,3	1,7	3,6	31,913202	738	676,1444	169,0361	0,239128
10:36:46	31,9	34,1	25,7	2,2	3,6	41,23488	763	705,9768	176,4942	0,29592
10:46:46	31,7	34,7	26,4	3	3,6	56,190253	785	732,7474	183,1869	0,388514
10:56:46	31,9	35	27	3,1	4	58,012718	807	759,2091	189,8023	0,387134
11:06:46	32,6	35,9	27,3	3,3	3,6	61,583281	827	783,4692	195,8673	0,398236
11:16:46	33,2	36,7	28,2	3,5	3,1	65,155776	847	807,3987	201,8497	0,40885
11:26:46	33,3	36,9	28,2	3,6	3,6	66,98214	864	828,1236	207,0309	0,409792
11:36:46	33	36,5	27,4	3,5	3,6	65,201443	881	848,4909	212,1227	0,389322
11:46:46	33,6	37,3	28,2	3,7	3,1	68,758265	895	865,6014	216,4004	0,402445
11:56:46	33,3	37,1	28,5	3,8	3,1	70,678579	908	881,3644	220,3411	0,406286
12:06:46	34	37,7	28,3	3,7	3,1	68,661697	917	892,8518	223,2129	0,389614
12:16:46	33,5	37,4	29,4	3,9	3,6	72,474928	924	901,9865	225,4966	0,407087
12:26:46	33,6	37,6	29,6	4	3,1	74,294111	932	911,6947	227,9237	0,412862
12:36:46	34,4	38,3	29,4	3,9	2,7	72,245894	936	917,0858	229,2715	0,399119
12:46:46	34,7	38,7	29,6	4	3,1	74,006989	941	923,0505	230,7626	0,406206
12:56:46	34,6	38,6	30,1	4	3,1	74,033094	942	924,6848	231,1712	0,405631
13:06:46	35,1	39,2	30,7	4,1	2,2	75,736749	946	928,8567	232,2142	0,413102
13:16:46	35	39,1	30,5	4,1	2,7	75,763509	944	926,7297	231,6824	0,414197
13:26:46	35	39	31,5	4	3,1	73,928671	942	924,195	231,0487	0,405274
13:36:46	35,3	39,2	31	3,9	3,6	72,016818	938	919,2911	229,8228	0,396899
13:46:46	34,8	38,5	30,2	3,7	3,6	68,468538	945	924,7442	231,186	0,375119
13:56:46	35	38,8	30,6	3,8	3,1	70,257039	938	916,0701	229,0175	0,388562
14:06:46	35,2	39	31,2	3,8	4	70,207436	921	897,2443	224,3111	0,396435
14:16:46	35,3	38,5	27,5	3,2	3,6	59,163822	914	887,7737	221,9434	0,33764
14:26:46	35,1	37,9	26,7	2,8	4	51,841438	904	874,9792	218,7448	0,300178
14:36:46	35,1	38,3	28,5	3,2	4	59,205591	894	861,7757	215,4439	0,348071
14:46:46	35,1	38,3	29,1	3,2	4,5	59,205591	883	847,1929	211,7982	0,354062
14:56:46	35,4	38,9	32,1	3,5	4	64,653322	867	827,4145	206,8536	0,395883
15:06:46	35,5	39	32,9	3,5	4	64,630478	852	808,202	202,0505	0,405151
15:16:46	35,5	38,9	32,9	3,4	3,6	62,794989	827	779,1623	194,7906	0,408316
15:26:46	35,7	38,8	33,6	3,1	3,6	57,244138	808	755,4548	188,8637	0,383903
15:36:46	35,4	38,4	37	3	4	55,466083	788	730,4514	182,6128	0,384712
15:46:46	35,6	38,3	44,2	2,7	4	49,910664	766	703,2475	175,8119	0,359571
15:56:46	35,2	37,8	48,8	2,6	4	48,138479	744	675,7048	168,9262	0,36094
16:06:46	35,1	37,3	48,8	2,2	3,6	40,775629	718	644,2226	161,0556	0,320674
16:16:46	35,6	37,5	47,9	1,9	3,6	35,171919	693	613,357	153,3393	0,290524

Table C.19. Daily data for 06.06.2005

Date	06.06.2005	Without Polyurethane								
Weather Condition		Clear								
Midday	Φ (^{0})	δ (^{0})		V_{in} (m/s)	V_{out} (m/s)		P_{in} (kPa)	P_{out} (kPa)		
13:10	38,46	22,6466		4	3,2		0,04	0,03		
Time	T_{in}	T_{out}	$T_{amb.}$	ΔT	Wind(m/s)	Q_{useful} (W)	$I_o(W/m^2)$	$I_\beta(W/m^2)$	Q(W)	η
09:47:43	29,3	29,5	24,9	0,2	1,8	3,7955617	651	546,5986	136,6497	0,035181
09:57:42	32	33,7	27,7	1,7	1,3	31,879945	681	581,6285	145,4071	0,277697
10:07:42	32,9	35,2	28,5	2,3	1,3	42,951686	710	615,6421	153,9105	0,353469
10:17:42	32,9	35,6	28,8	2,7	1,3	50,386321	735	645,9517	161,4879	0,395196
10:27:42	34	36,9	30,5	2,9	1,3	53,891613	762	677,7551	169,4388	0,402854
10:37:42	34,6	37,6	29,2	3	1,8	55,622707	781	702,1201	175,53	0,401366
10:47:42	34,4	37,6	29,7	3,2	1,3	59,351769	801	727,0014	181,7503	0,413617
10:57:42	34,5	37,9	30,7	3,4	1,3	63,016881	819	749,6885	187,4221	0,425869
11:07:42	35,2	38,7	30,6	3,5	1,3	64,699009	842	776,6028	194,1507	0,422083
11:17:42	35,5	38,9	29,9	3,4	1,8	62,794989	862	800,4176	200,1044	0,397473
11:27:42	35,4	39,1	30,4	3,7	1,8	68,323648	878	820,1442	205,036	0,422066
11:37:42	35,6	39,3	31,6	3,7	1,3	68,275347	890	835,7226	208,9307	0,413906
11:47:42	35,6	39,5	30,6	3,9	1,8	71,94045	904	852,7651	213,1913	0,427409
11:57:42	36,1	39,8	30,2	3,7	2,2	68,154587	913	864,6728	216,1682	0,39934
12:07:42	36,2	40,1	32,1	3,9	1,3	71,7877	924	878,0511	219,5128	0,414219
12:17:42	36,7	40,9	31,3	4,2	1,8	77,1316	934	890,0643	222,5161	0,439046
12:27:42	36,4	40,7	31,5	4,3	1,8	79,038252	946	903,572	225,893	0,443174
12:37:42	37	41,3	31,8	4,3	1,8	78,869801	951	909,9722	227,4931	0,439119
12:47:42	37,2	41,4	32	4,2	2,2	76,994483	956	915,9397	228,9849	0,425885
12:57:42	37,4	41,7	32,8	4,3	2,2	78,757489	957	917,6399	229,41	0,43483
13:07:42	37	41,6	31,3	4,6	1,8	84,327291	961	921,7814	230,4454	0,463489
13:17:42	36,9	41,7	32,1	4,8	1,3	87,993695	961	921,6503	230,4126	0,48371
13:27:42	37,6	42,3	32	4,7	1,8	85,960998	956	916,2889	229,0722	0,475301
13:37:42	37,8	43,4	32,1	5,6	2,2	102,18389	954	913,3684	228,3421	0,566808
13:47:42	37,4	43,4	31,7	6	2,2	109,56111	956	913,8313	228,4578	0,607421
13:57:42	37,2	43,3	32,6	6,1	2,7	111,44689	950	906,1998	226,55	0,623079
14:07:42	37,7	44,1	32,7	6,4	2,7	116,65618	937	891,469	222,8673	0,662981
14:17:42	37,7	43,5	31,8	5,8	2,7	105,83331	926	878,2301	219,5575	0,610539
14:27:42	37,3	43,4	32,5	6,1	2,7	111,40705	916	865,5174	216,3793	0,652133
14:37:42	37,1	42,9	32,3	5,8	2,2	106,06059	903	849,5498	212,3874	0,632506
14:47:42	37,1	43,1	31,7	6	2,7	109,67867	895	837,8479	209,462	0,663218
14:57:42	37,9	43,5	32,2	5,6	2,7	102,14731	882	821,0153	205,2538	0,63034
15:07:42	37,5	43	31,4	5,5	2,7	100,4849	869	803,7442	200,9361	0,633406
15:17:42	37,5	43,3	32,5	5,8	3,1	105,90907	846	776,8364	194,2091	0,690722
15:27:42	37	42,4	31,8	5,4	2,7	98,85186	825	751,4247	187,8562	0,666498
15:37:42	36,6	41,5	31,3	4,9	3,6	89,906884	811	731,973	182,9933	0,622296
15:47:42	36,5	41,4	30,3	4,9	3,6	89,938878	793	708,4543	177,1136	0,643184
15:57:42	35,8	40,1	30,2	4,3	4	79,206683	770	680,0761	170,019	0,59007
16:07:42	35,8	40,2	29,6	4,4	4	81,034337	748	652,2147	163,0537	0,629474

Table C.20. Daily data for 07.06.2005

Date	07.06.2005	Without Polyurethane								
Weather Condition		Clear								
Midday	Φ (^{0})	δ (^{0})		V_{in} (m/s)	V_{out} (m/s)		P_{in} (kPa)	P_{out} (kPa)		
13:10	38,46	22,748		4	3,2		0,04	0,03		
Time	T_{in}	T_{out}	$T_{amb.}$	ΔT	Wind(m/s)	Q_{useful} (W)	$I_o(W/m^2)$	$I_\beta(W/m^2)$	Q(W)	η
09:55:49	31,1	31,2	26,9	0,1	2,2	1,8863749	688	584,7295	146,1824	0,016345
10:05:48	33,5	33,9	27	0,4	1,8	7,4789899	715	617,1983	154,2996	0,061393
10:15:48	34,6	35,2	27	0,6	2,7	11,171519	742	649,4168	162,3542	0,087154
10:25:48	35	35,9	27,8	0,9	2,7	16,724983	765	677,8374	169,4594	0,125009
10:35:48	35,2	36,4	27,9	1,2	2,7	22,272574	790	707,7134	176,9284	0,159446
10:45:48	35,6	36,9	28,6	1,3	2,2	24,090448	815	737,294	184,3235	0,16554
10:55:48	35,5	36,9	27,6	1,4	3,6	25,948127	837	763,8394	190,9599	0,172109
11:05:48	35,1	36,7	26,7	1,6	3,1	29,686325	854	785,4421	196,3605	0,191488
11:15:48	35	37	27	2	3,6	37,094855	871	806,6378	201,6595	0,232989
11:25:48	35,5	37,8	27,4	2,3	2,7	42,561524	889	828,3676	207,0919	0,260312
11:35:48	35	36,8	27,7	1,8	3,6	33,397115	907	849,7157	212,4289	0,199129
11:45:48	35	36,8	28	1,8	3,1	33,397115	921	866,9185	216,7296	0,195178
11:55:48	35,1	36,9	27,8	1,8	3,1	33,38537	936	884,654	221,1635	0,191198
12:05:48	35,5	37,3	28,1	1,8	3,1	33,338386	947	898,1927	224,5482	0,188051
12:15:48	36	38,2	28,7	2,2	4	40,646411	954	907,4995	226,8749	0,226921
12:25:48	36,4	38,7	28,8	2,3	4,9	42,426419	958	913,5024	228,3756	0,235302
12:35:48	35,7	37,7	28,3	2	3,1	37,003494	966	922,8774	230,7194	0,203141
12:45:48	36,3	38,4	28,9	2,1	3,6	38,76458	972	929,9065	232,4766	0,211201
12:55:48	36,2	38,4	29,2	2,2	3,6	40,617692	975	933,6244	233,4061	0,220416
13:05:48	37	39,3	29,9	2,3	2,7	42,336336	976	934,9827	233,7457	0,229408
13:15:48	36,4	38,5	29,5	2,1	3,1	38,750873	973	932,0644	233,0161	0,210637
13:25:48	36,7	39	29,6	2,3	3,6	42,381379	970	928,7036	232,1759	0,231205
13:35:48	36,8	39,1	29,8	2,3	2,7	42,366365	972	929,6835	232,4209	0,23088
13:45:48	36,8	39,2	29,4	2,4	3,1	44,200547	973	929,2503	232,3126	0,240987
13:55:48	36,6	38,9	29,4	2,3	3,1	42,396393	967	921,6787	230,4197	0,23305
14:05:48	37	39,3	30	2,3	3,1	42,336336	953	906,0541	226,5135	0,236733
14:15:48	37,4	39,6	29,9	2,2	3,1	40,445357	946	896,6566	224,1641	0,228529
14:25:48	36,9	39,1	30,3	2,2	3,1	40,517168	935	883,0279	220,757	0,232469
14:35:48	36,6	38,6	29,6	2	3,1	36,886011	923	868,0252	217,0063	0,215292
14:45:48	36,5	38,6	29,3	2,1	3,1	38,737166	911	852,5892	213,1473	0,230191
14:55:48	36,8	38,7	29,5	1,9	3,6	35,023107	893	831,1257	207,7814	0,213495
15:05:48	36,9	38,5	30,4	1,6	3,6	29,498365	874	808,35	202,0875	0,184883
15:15:48	36,7	38,1	29,9	1,4	3,6	25,838484	855	785,1952	196,2988	0,16672
15:25:48	36,5	37,8	29,4	1,3	4,5	24,014091	839	764,3888	191,0972	0,159166
15:35:48	36,3	37,5	29,8	1,2	4	22,186433	815	735,9164	183,9791	0,152742
15:45:48	35,8	36,7	29	0,9	4	16,678003	794	709,8075	177,4519	0,119043
15:55:48	35,1	35,8	28,7	0,7	3,6	13,00832	780	689,5065	172,3766	0,095583
16:05:48	35,2	35,8	28,5	0,6	4	11,148032	741	646,8341	161,7085	0,087318
16:15:48	34,9	35,3	28,2	0,4	4	7,44246	707	608,4868	152,1217	0,061968
16:25:48	35,1	35,2	28,4	0,1	3,6	1,8602888	682	577,6976	144,4244	0,016315
16:35:48	35,2	36,2	28,7	1	4	18,567003	658	547,4355	136,8589	0,171834

Table C.21. Daily data for 13.06.2005

Date	**13.06.2005**	**Without Polyurethane**								
Weather Condition		Clear								
Midday	**Φ (^{0})**	**δ (^{0})**		**V_{in} (m/s)**	**V_{out} (m/s)**		**P_{in} (kPa)**	**P_{out} (kPa)**		
13:11	38,46	23,21392		4	3,2		0,04	0,03		
Time	**T_{in}**	**T_{out}**	**$T_{amb.}$**	**ΔT**	**Wind(m/s)**	**Q_{useful} (W)**	**$I_o(W/m^2)$**	**$I_β(W/m^2)$**	**Q(W)**	**η**
09:44:00	28,2	28,6	23,7	0,4	4,5	7,61718695	625	514,8602	128,715	0,074956
09:54:00	32,1	32,8	27,3	0,7	4	13,1452948	649	544,6004	136,1501	0,12229
10:04:00	32,6	33,8	28	1,2	4,5	22,4761012	679	579,1729	144,7932	0,196613
10:14:00	33,3	34,6	28,2	1,3	4	24,2855193	707	611,8839	152,971	0,201084
10:24:00	33,1	34,7	27,7	1,6	5,4	29,8950879	737	646,1539	161,5385	0,234403
10:34:00	33,6	35,6	28,1	2	5,4	37,2775381	769	682,0326	170,5081	0,276912
10:44:00	33,3	35,6	27,5	2,3	5,4	42,8916743	759	680,1294	170,0323	0,319507
10:54:00	33,1	35,5	27,7	2,4	4,9	44,7800131	802	725,2932	181,3233	0,312802
11:04:00	33,9	36,5	27,8	2,6	4,9	48,3590274	820	747,6692	186,9173	0,327693
11:14:00	34,2	36,7	28,3	2,5	4	46,4582872	840	771,5057	192,8764	0,305087
11:24:00	34,2	37,2	28,9	3	4,5	55,701009	859	794,0711	198,5178	0,355388
11:34:00	34,1	37,2	28,4	3,1	4,5	57,5678229	876	814,4192	203,6048	0,358122
11:44:00	33,7	37,1	28,1	3,4	4,9	63,1943623	889	830,6523	207,6631	0,385442
11:54:00	34,1	37,5	28,6	3,4	4	63,1056253	903	847,4138	211,8535	0,377287
12:04:00	34,2	37,6	28,5	3,4	4,9	63,0834399	918	864,7188	216,1797	0,369607
12:14:00	34,1	37,7	29,1	3,6	4	66,7942305	930	878,7964	219,6991	0,385079
12:24:00	34,2	37,7	29,3	3,5	4	64,9274161	943	893,4098	223,3525	0,368194
12:34:00	34	37,5	28,5	3,5	4,5	64,9730919	945	897,1703	224,2926	0,366909
12:44:00	34,5	38,1	29,4	3,6	4,9	66,700264	959	911,8924	227,9731	0,370581
12:54:00	35,3	39	29,6	3,7	4	68,3477977	960	913,822	228,4555	0,378933
13:04:00	35,5	39,6	29,9	4,1	3,6	75,6297042	965	919,1161	229,779	0,41689
13:14:00	35,3	39,3	30,4	4	4,5	73,8503493	971	924,9203	231,2301	0,404527
13:24:00	35,7	39,8	30,8	4,1	4	75,5761786	970	923,6098	230,9025	0,414568
13:34:00	36,3	40,2	31,6	3,9	3,1	71,7622402	975	927,5588	231,8897	0,391971
13:44:00	36,6	40,2	31,3	3,6	4,5	66,2068145	977	928,1896	232,0474	0,361381
13:54:00	37	40,6	31,8	3,6	4,5	66,1128001	976	925,5024	231,3756	0,361916
14:04:00	36,4	40,4	31,6	4	4,5	73,5631272	974	921,3951	230,3488	0,404496
14:14:00	35,5	39,4	30,4	3,9	4	71,9659068	959	904,5436	226,1359	0,403085
14:24:00	35,1	38,7	30	3,6	4,5	66,5593	941	884,46	221,115	0,381268
14:34:00	35,1	38,7	30,1	3,6	4,9	66,5593	937	877,0941	219,2735	0,38447
14:44:00	35,4	38,8	30,3	3,4	4,5	62,8171799	925	861,7679	215,442	0,369307
14:54:00	35,3	38,7	30,2	3,4	4,9	62,8393707	906	839,5054	209,8763	0,379234
15:04:00	35,5	38,7	29,9	3,2	4,5	59,1220517	890	819,622	204,9055	0,365456
15:14:00	35,7	39,1	30,7	3,4	4,5	62,7506048	870	795,6565	198,9141	0,399569
15:24:00	35,4	38,5	30,2	3,1	4,9	57,3048366	853	774,0346	193,5086	0,375086
15:34:00	36,8	39,4	30,9	2,6	4,5	47,8669535	836	751,9807	187,9952	0,322499
15:44:00	36,7	39,5	31,4	2,8	4,5	51,5490268	820	730,3689	182,5922	0,357584
15:54:00	36,5	39,1	31,4	2,6	4,5	47,9178712	801	705,625	176,4063	0,344051
16:04:00	36,3	38,8	31,2	2,5	4	46,1156733	776	675,207	168,8017	0,346028
16:14:00	35,9	38,4	30,9	2,5	4	46,1809444	752	645,3122	161,3281	0,36257
16:24:00	36,3	38,4	30	2,1	4	38,76458	726	613,3589	153,3397	0,320199
16:34:00	36,3	38,1	30,3	1,8	3,6	33,2444058	700	581,0805	145,2701	0,289856
16:44:00	37,1	38,5	30,1	1,4	3,6	25,8019306	672	546,84	136,71	0,239051
16:54:00	36,9	37,6	29,5	0,7	3,6	12,9260956	643	511,5288	127,8822	0,128026

Table C.22. Daily data for 15.06.2005

Date	15.06.2005	Without Polyurethane								
Weather Condition		Clear								
Midday	Φ (^{0})	δ (^{0})		V_{in} (m/s)	V_{out} (m/s)		P_{in} (kPa)	P_{out} (kPa)		
13:12	38,46	23,31441		3,5	2,7		0,03	0,02		
Time	T_{in}	T_{out}	$T_{amb.}$	ΔT	**Wind(m/s)**	Q_{useful} (W)	$I_o(W/m^2)$	$I_\beta(W/m^2)$	**Q(W)**	**η**
09:37:56	30,4	30,6	25,9	0,2	5,8	3,19040754	619	501,7523	125,4381	0,032215
09:47:56	32	32,7	26,5	0,7	6,3	11,0951936	648	535,9917	133,9979	0,104876
09:57:56	32,6	33,2	25,5	0,6	5,8	9,49200955	674	567,546	141,8865	0,084734
10:07:56	33,2	33,8	25,6	0,6	6,3	9,47220022	697	596,2811	149,0703	0,080482
10:17:56	33,2	34	26,4	0,8	6,3	12,6251979	721	625,5574	156,3893	0,102252
10:27:56	33,4	34,5	25,8	1,1	6,7	17,3384597	743	652,7801	163,195	0,134568
10:37:56	33,3	34,8	25,9	1,5	6,7	23,6350989	769	683,223	170,8057	0,175265
10:47:56	33,4	35,2	26,3	1,8	6,3	28,337352	795	713,4094	178,3523	0,201243
10:57:56	33,9	35,5	26,1	1,6	6,3	25,1535314	811	734,2781	183,5695	0,173555
11:07:56	33,7	35,7	26,2	2	6,7	31,4419143	827	754,7305	188,6826	0,211065
11:17:56	34	36	26,9	2	6,3	31,4088876	845	776,6175	194,1544	0,204901
11:27:56	33,7	36	26,3	2,3	6,3	36,1392114	855	790,735	197,6838	0,231551
11:37:56	33,7	36,2	26,5	2,5	7,2	39,2679903	878	816,4918	204,1229	0,243661
11:47:56	34,2	36,7	26,9	2,5	7,2	39,1991798	889	830,7169	207,6792	0,239069
11:57:56	34,2	36,9	27,2	2,7	7,2	42,3202503	903	847,3333	211,8333	0,253042
12:07:56	34,4	37,2	27,5	2,8	6,7	43,8491293	915	861,6696	215,4174	0,257822
12:17:56	34,4	37	26,5	2,6	6,7	40,7313629	920	868,985	217,2462	0,237474
12:27:56	34,7	37,4	27,5	2,7	7,6	42,2459259	933	883,4334	220,8584	0,242276
12:37:56	35,1	37,8	27,8	2,7	7,6	42,1864609	936	887,9893	221,9973	0,240694
12:47:56	34,5	37,5	27,9	3	6,7	46,9481763	940	893,0554	223,2638	0,266342
12:57:56	34,6	37,6	27,9	3	6,7	46,9316589	948	901,4914	225,3729	0,263757
13:07:56	34,8	37,8	27,2	3	7,6	46,8986232	950	903,7887	225,9472	0,262901
13:17:56	35,2	38,1	27,4	2,9	7,2	45,2794471	952	905,6474	226,4119	0,253304
13:27:56	35,1	38,3	28,8	3,2	6,7	49,9547174	950	903,2613	225,8153	0,280196
13:37:56	35,2	38,4	28,4	3,2	6,3	49,9370964	943	895,6863	223,9216	0,282466
13:47:56	35,9	39,1	29,2	3,2	6,3	49,813739	950	900,9598	225,24	0,280119
13:57:56	35,9	38,9	29	3	5,8	46,7169024	947	896,287	224,0718	0,264074
14:07:56	36	39,1	29,9	3,1	6,3	48,2485232	927	875,1097	218,7774	0,279332
14:17:56	36,4	39,6	30,3	3,2	5,8	49,7256159	924	869,5635	217,3909	0,28972
14:27:56	36,8	39,9	29,8	3,1	5,8	48,1119267	920	862,6066	215,6516	0,282579
14:37:56	37	40,2	31,7	3,2	5,4	49,6198562	904	843,9637	210,9909	0,297873
14:47:56	37,4	40,4	32,7	3	6,3	46,4690358	892	828,6445	207,1611	0,284115
14:57:56	37,2	40,3	33,1	3,1	5,8	48,0436201	883	815,6602	203,915	0,298419
15:07:56	37,9	40,5	33,4	2,6	5,4	40,2301929	864	793,0131	198,2533	0,257023
15:17:56	37,8	40,5	39,2	2,7	5,4	41,7849456	855	779,1031	194,7758	0,271722
15:27:56	37,7	40,7	42,1	3	5,8	46,4194534	836	755,627	188,9068	0,311238
15:37:56	38,2	40,8	42,3	2,6	5,4	40,1872189	822	736,2332	184,0583	0,276549
15:47:56	38,7	41,2	43,2	2,5	5,4	38,57957	811	719,0004	179,7501	0,271849
15:57:56	38,8	41,1	46,1	2,3	5,4	35,4932044	811	710,8191	177,7048	0,25298
16:07:56	36,9	37,8	32,9	0,9	5,4	14,017549	509	440,4364	110,1091	0,161246

Table C.23. Daily data for 22.07.2005

Date	22.07.2005	Without Polyurethane								
Weather Condition		Clear								
Midday	Φ (°)	δ (°)		V_{in} (m/s)	V_{out} (m/s)		P_{in} (kPa)	P_{out} (kPa)		
13:17	38,46	20,24		3	2,3		0,025	0,01		
Time	T_{in}	T_{out}	$T_{amb.}$	ΔT	Wind(m/s)	Q_{useful} (W)	I_o(W/m²)	$I_β$(W/m²)	Q(W)	η
10:14	34,4	35,3	29,8	0,9	5,8	15,257975	635	571,9505	142,9876	0,106708
10:24	38,3	39,9	31,4	1,6	4,5	26,721259	656	598,2041	149,551	0,178677
10:34	40,4	42,4	32	2	4,5	33,128076	678	625,095	156,2737	0,211987
10:44	40,3	43,2	31,5	2,9	5,4	47,975346	706	657,3128	164,3282	0,291948
10:54	40,4	43,7	32,3	3,3	4,9	54,533754	729	684,6753	171,1688	0,318596
11:04	40,3	43,9	32,1	3,6	4,5	59,480662	753	712,737	178,1843	0,333815
11:14	40,8	44,9	32,9	4,1	4,9	67,558956	772	735,7956	183,9489	0,36727
11:24	41,2	45,5	33	4,3	4,5	70,72661	794	761,4276	190,3569	0,371547
11:34	41,7	46,4	32,6	4,7	4,5	77,110082	811	781,9679	195,492	0,394441
11:44	41,8	46,8	33,7	5	4	81,957623	823	797,341	199,3353	0,411155
11:54	41,2	46,5	33,5	5,3	4,5	87,016993	835	812,3513	203,0878	0,42847
12:04	41,6	47	33,3	5,4	4,5	88,514233	848	827,9816	206,9954	0,427615
12:14	41,8	47,3	33,5	5,5	4,5	90,071564	859	841,3065	210,3266	0,428246
12:24	42,1	47,9	34,3	5,8	4	94,829235	867	851,3289	212,8322	0,445559
12:34	41,9	47,6	33,7	5,7	4	93,279053	879	864,9183	216,2296	0,431389
12:44	41,7	47,5	33,8	5,8	4,5	94,967301	886	873,2254	218,3064	0,435018
12:54	42,6	48,6	34,3	6	4	97,884948	893	881,1607	220,2902	0,444346
13:04	42,9	48,8	34,5	5,9	4	96,165737	897	885,7596	221,4399	0,434275
13:14	43,3	48,6	35,3	5,3	3,6	86,354622	900	888,9906	222,2477	0,388551
13:24	43,1	48,6	35,3	5,5	4	89,646026	902	890,8508	222,7127	0,402519
13:34	43,1	48,6	35,7	5,5	3,6	89,646026	902	890,3502	222,5875	0,402745
13:44	42,7	48,2	35,2	5,5	4	89,776973	898	885,5163	221,3791	0,405535
13:54	42,9	48,3	35,5	5,4	4	88,096453	897	883,2528	220,8132	0,398964
14:04	42,8	48	34,9	5,2	4	84,895522	897	881,5735	220,3934	0,3852
14:14	43,3	48,4	35,8	5,1	3,6	83,126315	896	878,4998	219,625	0,378492
14:24	43	46,2	31,2	3,2	4	52,395752	880	860,3378	215,0845	0,243605
14:34	42,8	47,3	35,5	4,5	3,6	73,561016	872	849,6293	212,4073	0,346321
14:44	43	47,6	35,2	4,6	4	75,127263	863	837,5502	209,3876	0,358795
14:54	42,7	47,4	35,4	4,7	4	76,830395	852	823,1348	205,7837	0,373355
15:04	43,2	47,8	35,8	4,6	4	75,072506	839	806,3983	201,5996	0,372384
15:14	42,6	47,1	35,2	4,5	4	73,614578	821	784,493	196,1232	0,375349
15:24	43,2	47,3	35,7	4,1	3,6	66,973457	804	763,1944	190,7986	0,351017
15:34	42,7	46,9	35,3	4,2	3,6	68,719437	783	737,763	184,4407	0,372583
15:44	42,6	46,6	35,3	4	3,6	65,49469	763	712,9519	178,238	0,367456
15:54	42,9	46,8	35,2	3,9	4	63,799301	744	688,7292	172,1823	0,370533
16:04	42,5	46,2	35,3	3,7	3,6	60,637633	723	662,3061	165,5765	0,366221
16:14	42,3	45,7	35,3	3,4	3,6	55,791877	698	631,9175	157,9794	0,353159
16:24	42,4	45,3	35	2,9	3,6	47,613072	675	603,0509	150,7627	0,315815
16:34	42,5	45,3	35,8	2,8	4	45,962912	651	572,9816	143,2454	0,320868
16:44	42,4	44,9	34,4	2,5	3,6	41,075501	627	542,6031	135,6508	0,302803

Table C.24. Daily data for 25.07.2005

Date	**25.07.2005**	**Without Polyurethane**								
Weather Condition		Clear								
Midday	**Φ (°)**	**δ (°)**		**V_{in} (m/s)**	**V_{out} (m/s)**		**P_{in} (kPa)**	**P_{out} (kPa)**		
13:18	38,46	19,602		3	2,3		0,025	0,01		
Time	**T_{in}**	**T_{out}**	**$T_{amb.}$**	**ΔT**	**Wind(m/s)**	**Q_{useful} (W)**	**$I_o(W/m^2)$**	**$I_\beta(W/m^2)$**	**Q(W)**	**η**
10:16	40,8	41,8	31,1	1	4,9	16,569985	637	580,3239	145,081	0,114212
10:26	41,8	43,7	33,2	1,9	4,9	31,319111	661	609,3977	152,3494	0,205574
10:36	42,2	44,7	33,1	2,5	4,9	41,105249	686	639,1788	159,7947	0,257238
10:46	42,4	45,1	34,4	2,7	5,4	44,345476	707	664,9897	166,2474	0,266744
10:56	42,8	45,7	33,7	2,9	5,4	47,54405	728	690,5238	172,6309	0,275409
11:06	42,6	45,7	33,4	3,1	4,9	50,841396	750	716,7403	179,1851	0,283737
11:16	42,9	45,9	34,7	3	4,9	49,156722	771	741,7355	185,4339	0,26509
11:26	43,3	46,9	34,9	3,6	4,9	58,8381	790	764,5219	191,1305	0,307843
11:36	43,7	47,2	35,6	3,5	5,4	57,130801	805	783,1208	195,7802	0,291811
11:46	43,5	47,3	34,4	3,8	4,9	62,039035	824	805,2962	201,3241	0,308155
11:56	43,8	47,7	35,8	3,9	5,4	63,590396	837	821,2869	205,3217	0,309711
12:06	44	48	35,2	4	6,3	65,161395	849	835,9499	208,9875	0,311796
12:16	44,2	48,1	35,7	3,9	5,8	63,497537	861	850,2662	212,5665	0,298718
12:26	44,7	48,4	36	3,7	5,8	60,153149	872	863,247	215,8118	0,27873
12:36	44,8	48,6	36,4	3,8	5,8	61,744976	882	874,8853	218,7213	0,2823
12:46	44,7	48,9	36,3	4,2	5,8	68,219442	890	884,1806	221,0451	0,308622
12:56	45,1	49,2	36	4,1	5,8	66,509734	893	888,1392	222,0348	0,299546
13:06	44,8	49,1	36,1	4,3	5,4	69,805314	894	889,7335	222,4334	0,313826
13:16	44,5	49,1	36,7	4,6	5,8	74,716532	894	889,9578	222,4894	0,335821
13:26	45,2	49,5	36,4	4,3	5,8	69,702906	894	889,8083	222,4521	0,313339
13:36	44,8	49,4	36,9	4,6	5,8	74,634371	894	889,2839	222,321	0,335705
13:46	44,5	48,8	36,8	4,3	6,7	69,882114	894	888,3809	222,0952	0,314649
13:56	44,9	49	37	4,1	6,3	66,558555	894	887,093	221,7733	0,30012
14:06	44,9	48,9	37,8	4	6,3	64,947083	889	880,459	220,1147	0,29506
14:16	45,2	49,3	37,2	4,1	5,8	66,485322	874	863,5614	215,8903	0,307959
14:26	44,8	49	37,7	4,2	6,3	68,194437	863	850,2697	212,5674	0,320813
14:36	45,4	49,4	37,7	4	5,8	64,828004	854	838,5838	209,646	0,309226
14:46	44,9	49	37,2	4,1	6,3	66,558555	845	826,5196	206,6299	0,322115
14:56	44,9	48,8	36,9	3,9	5,8	63,335016	832	810,1708	202,5427	0,3127
15:06	44,5	48,6	37	4,1	6,3	66,656192	818	792,4889	198,1222	0,33644
15:16	44,7	48,2	37,5	3,5	5,8	56,922463	803	773,4798	193,37	0,294371
15:26	44,7	48,3	36,7	3,6	6,3	58,538104	785	751,2364	187,8091	0,311689
15:36	44,7	48,1	37,6	3,4	5,8	55,306228	770	731,5082	182,877	0,302423
15:46	45,6	48,6	37,3	3	4,9	48,67459	744	701,0238	175,256	0,277734
15:56	45,7	48,5	37,7	2,8	6,3	45,429617	725	676,8523	169,2131	0,268476
16:06	45,4	48,2	37,2	2,8	5,8	45,479628	704	650,4816	162,6204	0,279667
16:16	45,1	47,4	36,7	2,3	6,7	37,433574	679	620,1314	155,0329	0,241456
16:26	45,3	47,3	36,6	2	6,3	32,544981	655	590,4361	147,609	0,220481

Table C.25. Daily data for 26.07.2005

Date	**26.07.2005**	**Without Polyurethane**								
Weather Condition		Clear								
Midday	**Φ (°)**	**δ (°)**		**V_{in} (m/s)**	**V_{out} (m/s)**		**P_{in} (kPa)**	**P_{out} (kPa)**		
13:18	38,46	19,378		3	2,3		0,025	0,01		
Time	**T_{in}**	**T_{out}**	**$T_{amb.}$**	**ΔT**	**Wind(m/s)**	**Q_{useful} (W)**	**I_o(W/m²)**	**I_β(W/m²)**	**Q(W)**	**η**
09:56	33,1	33,5	28,9	0,4	6,3	6,8181385	595	528,8152	132,2038	0,051573
10:06	37	37,6	29,5	0,6	6,7	10,084658	622	561,168	140,292	0,071883
10:16	38,6	39,7	29,4	1,1	6,3	18,367596	649	593,3571	148,3393	0,123822
10:26	38,9	40,6	29,6	1,7	6,7	28,32565	673	622,5997	155,6499	0,181983
10:36	39,2	41,1	30	1,9	6,7	31,612895	697	651,6046	162,9011	0,194062
10:46	39,2	41	30,3	1,8	6,7	29,954409	719	678,485	169,6213	0,176596
10:56	39,4	41,8	30,4	2,4	6,3	39,867864	740	704,1439	176,036	0,226476
11:06	39,2	42,2	31,8	3	5,8	49,816992	761	729,5206	182,3802	0,273149
11:16	40	43	32,3	3	7,2	49,674273	781	753,6525	188,4131	0,263645
11:26	39,9	42,9	31,6	3	7,2	49,692114	798	774,5815	193,6454	0,256614
11:36	40,3	43,4	32,3	3,1	6,3	51,265554	810	790,3108	197,5777	0,25947
11:46	40,6	43,6	32,3	3	6,7	49,567219	826	809,5984	202,3996	0,244898
11:56	40,8	44	32,3	3,2	6,7	52,814599	841	827,5801	206,895	0,255272
12:06	40,5	43,9	32,2	3,4	6,7	56,155958	854	843,2584	210,8146	0,266376
12:16	40,6	44,1	33	3,5	5,8	57,776377	863	854,6348	213,6587	0,270414
12:26	41,2	45,1	33,7	3,9	6,3	64,193794	872	865,6511	216,4128	0,296627
12:36	41,3	45,4	33,5	4,1	6,7	67,437	882	877,305	219,3263	0,307473
12:46	41,9	45,7	33,8	3,8	7,2	62,400847	891	887,609	221,9023	0,281209
12:56	41,8	45,8	34,3	4	6,3	65,685102	895	892,5675	223,1419	0,294365
13:06	41,7	45,7	34,5	4	6,3	65,708902	897	895,1596	223,7899	0,293619
13:16	41,8	45,8	34,2	4	6,3	65,685102	899	897,3795	224,3449	0,292786
13:26	41,1	45,7	34	4,6	6,3	75,647341	900	898,2282	224,5571	0,336874
13:36	41,7	46,2	35,6	4,5	5,8	73,855578	901	898,7014	224,6754	0,328721
13:46	41,6	46,1	35	4,5	6,3	73,882353	899	895,8048	223,9512	0,329904
13:56	42,2	46,6	36	4,4	5,8	72,096526	898	893,5236	223,3809	0,322752
14:06	42,5	46,5	35,2	4	7,2	65,518494	894	887,873	221,9683	0,295171
14:16	42,2	46,2	35,3	4	7,2	65,5899	878	869,9457	217,4864	0,301582
14:26	42	45,9	35,7	3,9	6,7	64,008167	870	859,5929	214,8982	0,297853
14:36	43	46,9	35,9	3,9	6,3	63,776091	860	846,8931	211,7233	0,301224
14:46	42,9	46,7	35,7	3,8	6,3	62,174728	848	831,8594	207,9649	0,298967
14:56	43,1	47,3	36,1	4,2	5,4	68,619454	837	817,4379	204,3595	0,335778
15:06	43,2	47,6	36,3	4,4	5,4	71,834672	824	800,6892	200,1723	0,358864
15:16	43,2	47,2	36,8	4	5,4	65,351861	806	778,7336	194,6834	0,335683
15:26	44,1	48	37,5	3,9	6,3	63,520752	787	755,4895	188,8724	0,336316
15:36	44,5	47,7	36,7	3,2	5,8	52,110067	765	729,0646	182,2662	0,285901
15:46	44,2	47,5	37,3	3,3	5,8	53,787615	744	703,3017	175,8254	0,305915
15:56	44	47,2	37,3	3,2	5,4	52,205305	723	677,2352	169,3088	0,308344
16:06	44	47,3	37,5	3,3	5,4	53,8269	701	649,9294	162,4824	0,331278
16:16	44	46,9	37,4	2,9	4,9	47,336949	677	620,4882	155,122	0,305159
16:26	44,2	46,8	37,8	2,6	5,4	42,432286	652	589,8752	147,4688	0,287737
16:36	43,8	46,4	37,2	2,6	5,8	42,49418	624	556,3396	139,0849	0,305527
16:46	43,9	46	36,6	2,1	5,8	34,34097	603	528,7764	132,1941	0,259777

Table C.26. Daily data for 27.07.2005

Date	27.07.2005	Without Polyurethane								
Weather Condition		Clear								
Midday	Φ (°)	δ (°)		V_{in} (m/s)	V_{out} (m/s)		P_{in} (kPa)	P_{out} (kPa)		
13:18	38,46	19,148		3	2,3		0,025	0,01		
Time	T_{in}	T_{out}	$T_{amb.}$	ΔT	Wind(m/s)	Q_{useful} (W)	I_o(W/m²)	I_β(W/m²)	Q(W)	η
09:57	33,2	33,5	29	0,3	6,7	5,1127133	574	512,9507	128,2377	0,039869
10:07	36,9	38	29,9	1,1	6,3	18,478734	601	545,0243	136,2561	0,135618
10:17	38	39,9	30,9	1,9	5,8	31,748435	628	576,9644	144,2411	0,220107
10:27	38,2	40,5	31,2	2,3	5,4	38,377629	652	605,9719	151,493	0,253329
10:37	38,7	41,3	31,5	2,6	5,4	43,282938	675	633,828	158,457	0,273153
10:47	38,6	41,3	31,2	2,7	4,9	44,955693	696	659,5571	164,8893	0,272642
10:57	38,9	41,7	31,3	2,8	5,8	46,562453	717	685,0229	171,2557	0,271888
11:07	39,4	42,5	32,5	3,1	5,8	51,431475	744	716,0019	179,0005	0,287326
11:17	40	43,4	32,1	3,4	5,4	56,257068	766	741,9525	185,4881	0,303292
11:27	40,2	43,8	32,6	3,6	5,4	59,502074	785	764,7261	191,1815	0,311233
11:37	40	43,9	33,5	3,9	4,5	64,472178	800	783,2943	195,8236	0,329236
11:47	40,3	44,2	33,5	3,9	4,9	64,402589	814	800,5544	200,1386	0,32179
11:57	40,3	44,4	34	4,1	4,9	67,680899	827	816,4983	204,1246	0,331567
12:07	39,7	43,8	33,4	4,1	5,4	67,827214	840	832,1096	208,0274	0,326049
12:17	39,9	44	33,6	4,1	4,9	67,778444	851	845,4032	211,3508	0,320692
12:27	39,9	44,2	33,7	4,3	5,4	71,059134	861	857,3601	214,34	0,331525
12:37	40,2	44,5	34,5	4,3	4,9	70,982406	869	866,9769	216,7442	0,327494
12:47	40,9	45,1	35,1	4,2	4,5	69,169257	875	874,2433	218,5608	0,316476
12:57	41,3	45,8	34,9	4,5	4,5	73,962675	881	881,1525	220,2881	0,335754
13:07	40,9	45,4	34,5	4,5	4,9	74,069763	883	883,7001	220,925	0,335271
13:17	41	45,5	35,5	4,5	4,9	74,042992	883	883,8821	220,9705	0,335081
13:27	40,8	45,2	34,6	4,4	4,9	72,463032	882	882,6993	220,6748	0,32837
13:37	40,9	45,2	34,9	4,3	5,4	70,803354	881	881,1525	220,2881	0,321413
13:47	41	45,3	34,9	4,3	4,5	70,777773	878	877,2407	219,3102	0,322729
13:57	41,5	45,8	35,6	4,3	4,9	70,649861	877	874,9582	218,7396	0,322986
14:07	41,3	45,6	35,2	4,3	5,4	70,701028	871	867,3179	216,8295	0,326067
14:17	41,3	45,4	35,6	4,1	4,5	67,437	859	853,3506	213,3376	0,316105
14:27	41,6	45,9	36	4,3	4,5	70,624277	850	842,0157	210,5039	0,335501
14:37	41,6	45,7	35,7	4,1	5,4	67,363821	838	827,3586	206,8397	0,325681
14:47	41,9	45,9	36	4	4,5	65,661303	826	812,3561	203,089	0,323313
14:57	41,8	45,9	36	4,1	4,9	67,315033	813	796,0228	199,0057	0,338257
15:07	41,8	45,7	36	3,9	5,4	64,054577	799	778,3645	194,5911	0,329175
15:17	41,8	45,4	35,5	3,6	4,9	59,15943	782	757,4502	189,3626	0,312414
15:27	41,8	45,2	35,6	3,4	4,9	55,893024	765	736,2117	184,0529	0,303679
15:37	42,1	45,3	36	3,2	4,9	52,567121	747	713,6849	178,4212	0,294624
15:47	42,1	45,3	36,3	3,2	5,4	52,567121	726	687,9863	171,9966	0,305629
15:57	42,1	45	35,7	2,9	4,9	47,664835	705	661,9982	165,4995	0,288006
16:07	42,2	44,9	36,2	2,7	4,9	44,377605	681	632,9247	158,2312	0,280461
16:17	42,4	44,7	36,2	2,3	4,5	37,803145	657	603,6076	150,9019	0,250515
16:27	42,6	44,9	36	2,3	4,5	37,775776	634	574,9508	143,7377	0,26281
16:37	42,9	44,2	31,8	1,3	4	21,36699	607	542,4409	135,6102	0,157562

Table C.27. Daily data for 28.07.2005

Date	**28.07.2005**	**Without Polyurethane**								
Weather Condition		Mostly Sunny								
Midday	**Φ (°)**	**δ (°)**		**V_{in} (m/s)**	**V_{out} (m/s)**		**P_{in} (kPa)**	**P_{out} (kPa)**		
13:18	38,46	18,912		3	2,3		0,025	0,01		
Time	**T_{in}**	**T_{out}**	**$T_{amb.}$**	**ΔT**	**Wind(m/s)**	**Q_{useful} (W)**	**$I_o(W/m^2)$**	**$I_\beta(W/m^2)$**	**Q(W)**	**η**
10:05	36,4	37,5	30,1	1,1	6,7	18,511415	642	582,839	145,7098	0,127043
10:15	37,6	39,2	29,4	1,6	6,3	26,787829	482	443,3953	110,8488	0,241661
10:25	37,4	39	30,5	1,6	6,3	26,806847	684	636,6283	159,1571	0,16843
10:35	38,7	41	31,3	2,3	5,8	38,309264	687	646,115	161,5288	0,237167
10:45	39,2	41,8	32,6	2,6	5,8	43,205646	694	658,7808	164,6952	0,262337
10:55	39,5	42,1	32,2	2,6	6,3	43,159266	596	570,4494	142,6124	0,302633
11:05	37,6	39,6	31,8	2	5,4	33,461012	539	519,7051	129,9263	0,257538
11:15	39,4	42,2	31,9	2,8	5,8	46,47921	744	722,0802	180,5201	0,257474
11:25	39,6	42,9	32,3	3,3	5,8	54,690763	772	753,6228	188,4057	0,290282
11:35	40,7	43,8	33,3	3,1	6,3	51,191801	806	790,8674	197,7168	0,258915
11:45	39,6	42,6	33,3	3	6,3	49,745635	854	841,7623	210,4406	0,236388
11:55	40,3	43,1	33,2	2,8	5,8	46,32935	906	896,5482	224,137	0,206701
12:05	39,7	42,6	33	2,9	6,3	48,078825	879	872,8017	218,2004	0,220342
12:15	40,9	43,8	34,1	2,9	6,3	47,871855	896	892,2721	223,068	0,214607
12:25	40,7	43,8	32,9	3,1	5,4	51,191801	457	456,2059	114,0515	0,448848
12:35	39,6	41	32,6	1,4	5,8	23,281227	548	548,1291	137,0323	0,169896
12:45	39,4	41	32,6	1,6	5,4	26,616629	436	436,7733	109,1933	0,243757
12:55	39,6	40,5	32,4	0,9	5,4	14,97988	392	393,1318	98,28296	0,152416
13:05	39,7	41,9	33,6	2,2	5,4	36,519379	849	852,0436	213,0109	0,171444
13:15	42,3	45,5	35,2	3,2	4,5	52,529042	861	864,3333	216,0833	0,243096
13:25	42,4	46,5	35,7	4,1	4,9	67,168655	863	866,2351	216,5588	0,310164
13:35	42,1	46,6	36	4,5	4	73,748472	865	867,7818	216,9455	0,33994
13:45	42,4	47	37	4,6	3,6	75,29152	864	865,9608	216,4902	0,347783
13:55	42,5	47,6	36,8	5,1	4,9	83,369152	862	862,7778	215,6945	0,386515
14:05	42,7	47,9	36,7	5,2	5,4	84,926471	854	853,2355	213,3089	0,398138
14:15	42,9	48,3	36,8	5,4	5,4	88,096453	840	837,3655	209,3414	0,420827
14:25	43,3	48,1	36,7	4,8	5,4	78,279388	830	825,1547	206,2887	0,379465
14:35	43	48,2	36,9	5,2	5,8	84,833621	820	812,6038	203,151	0,417589
14:45	43,3	48,3	37,1	5	5,8	81,511268	807	796,7454	199,1864	0,409221
14:55	43,5	47,8	36,8	4,3	5,8	70,138082	794	780,5584	195,1396	0,359425
15:05	43,4	47,6	36,9	4,2	5,8	68,544462	780	763,0584	190,7646	0,359314
15:15	43,6	48,5	37,1	4,9	4,9	79,808125	764	743,2798	185,8199	0,429492
15:25	43,4	48,3	36,5	4,9	6,3	79,866459	751	726,083	181,5207	0,439985
15:35	43,5	48,5	37,5	5	5,4	81,451743	741	711,3982	177,8495	0,457981
15:45	44,1	47,8	37	3,7	5,8	60,285302	718	683,8983	170,9746	0,352598

Table C.28. Daily data for 29.07.2005

Date	**29.07.2005**	**With Polyurethane**								
Weather Condition		Clear								
Midday	**Φ (°)**	**δ (°)**		**V_{in} (m/s)**	**V_{out} (m/s)**		**P_{in} (kPa)**	**P_{out} (kPa)**		
13:17	38,46	18,6705		3	1,7		0,23	0,015		
Time	**T_{in}**	**T_{out}**	**$T_{amb.}$**	**ΔT**	**Wind(m/s)**	**Q_{useful} (W)**	**$I_o(W/m^2)$**	**$I_\beta(W/m^2)$**	**Q(W)**	**η**
09:57	35,5	37,5	29,9	2	5,8	25,649362	558	503,466	125,8665	0,203782
10:07	38,6	41,2	31,1	2,6	5,8	32,944432	586	536,3065	134,0766	0,245713
10:17	39,6	43,1	31,9	3,5	6,7	44,118672	611	566,2776	141,5694	0,31164
10:27	40,3	44,5	31,9	4,2	5,8	52,74284	637	597,0181	149,2545	0,353375
10:37	40,6	45,5	32,3	4,9	5,4	61,389157	662	626,6573	156,6643	0,391852
10:47	41,1	46,6	33,8	5,5	5,4	68,707019	683	652,2953	163,0738	0,421325
10:57	41,1	47,4	33,2	6,3	5,8	78,586679	705	678,6475	169,6619	0,463196
11:07	41,5	47,5	33,2	6	5,8	74,776542	724	701,858	175,4645	0,426163
11:17	41	48,3	33,6	7,3	6,3	90,928546	744	725,7716	181,4429	0,501141
11:27	42	48,8	33,6	6,8	6,3	84,469624	763	748,4449	187,1112	0,451441
11:37	42	49	31,5	7	5,8	86,922325	782	770,8471	192,7118	0,451048
11:47	42	49,2	31,8	7,2	4,9	89,373213	796	788,0266	197,0066	0,453656
11:57	42,2	49,6	33,9	7,4	5,8	91,755261	809	803,8985	200,9746	0,456551
12:07	42,1	50,3	32,8	8,2	5,4	101,56333	822	819,4524	204,8631	0,495762
12:17	42,8	51,3	34,7	8,5	5,4	104,95179	832	831,6905	207,9226	0,504764
12:27	43,3	51,9	35,1	8,6	5,4	105,97223	842	843,5969	210,8992	0,502478
12:37	43,3	52,6	35,6	9,3	5,4	114,45041	851	854,1686	213,5421	0,535962
12:47	43,5	52,6	35,5	9,1	5,8	111,94787	859	863,3998	215,8499	0,518638
12:57	43,6	53,1	35,5	9,5	5,8	116,73952	862	867,2603	216,8151	0,538429
13:07	43,9	53,5	36,1	9,6	5,4	117,8161	871	876,8111	219,2028	0,537475
13:17	43,9	53,4	36	9,5	5,8	116,61038	873	878,9662	219,7415	0,530671
13:27	43,8	53,8	36,6	10	5,8	122,67979	876	881,7733	220,4433	0,556514
13:37	43,7	53,7	35,9	10	5,8	122,72511	879	884,2207	221,0552	0,555179
13:47	43,7	53,7	36,6	10	5,8	122,72511	877	881,2762	220,3191	0,557034
13:57	44,4	53,8	37,2	9,4	5,8	115,19121	875	877,9686	219,4921	0,524808
14:07	44,6	53,9	36,9	9,3	5,4	113,90255	868	869,2834	217,3209	0,524122
14:17	44,5	54,3	37	9,8	6,7	119,95972	860	859,243	214,8108	0,558444
14:27	44,3	54	37	9,7	6,3	118,84554	849	845,8574	211,4644	0,562012
14:37	44,8	53,5	36,8	8,7	5,8	106,59342	837	831,1353	207,7838	0,513002
14:47	45,1	53,9	37,5	8,8	4,5	107,67904	829	820,0284	205,0071	0,525245
14:57	45,6	54,5	38,3	8,9	5,4	108,6808	817	804,5995	201,1499	0,540298
15:07	45,5	54,2	38,1	8,7	5,8	106,3174	799	782,9315	195,7329	0,543176
15:17	46,4	54,2	37,6	7,8	6,3	95,159948	785	764,8548	191,2137	0,497663
15:27	45,9	53,9	38,6	8	6,3	97,744999	768	743,5137	185,8784	0,525854
15:37	46,1	53,5	38,4	7,4	6,3	90,447666	751	721,8386	180,4597	0,501207
15:47	45,9	53,3	38	7,4	5,8	90,514747	730	696,0033	174,0008	0,520197
15:57	46,2	53,5	39	7,3	4,9	89,208856	708	668,9293	167,2323	0,533443
16:07	46	52,6	37,6	6,6	5,4	80,819109	686	641,5719	160,393	0,503882

Table C.29. Daily data for 01.08.2005

Date	01.08.2005	With Polyurethane								
Weather Condition		Clear								
Midday	Φ (°)	δ (°)		V_{in} (m/s)	V_{out} (m/s)		P_{in} (kPa)	P_{out} (kPa)		
13:17	38,46	17,913		3	1,7		0,23	0,015		
Time	T_{in}	T_{out}	$T_{amb.}$	ΔT	Wind(m/s)	Q_{useful} (W)	I_o(W/m²)	I_β(W/m²)	Q(W)	η
10:18	37,3	44,3	31,2	7	6,3	88,41154	638	599,1085	149,7771	0,590287
10:28	39,6	44,7	32,4	5,1	7,2	64,10258	663	629,285	157,3212	0,407463
10:38	40,4	46,2	32,8	5,8	6,3	72,599082	688	659,2617	164,8154	0,440487
10:48	40,4	46,8	31,7	6,4	6,7	80,022418	718	693,8676	173,4669	0,461312
10:58	41,2	47,3	32,7	6,1	7,2	76,091863	737	717,6289	179,4072	0,424129
11:08	41,4	48,3	32,7	6,9	7,6	85,883674	757	742,0756	185,5189	0,462938
11:18	41,8	48,7	33,6	6,9	7,2	85,758695	774	763,2868	190,8217	0,449418
11:28	41,9	49,2	32,9	7,3	6,3	90,631038	792	785,1832	196,2958	0,461706
11:38	42,4	50	33,3	7,6	7,2	94,131868	809	805,7916	201,4479	0,467277
11:48	42,1	49,8	32,9	7,7	6,7	95,457632	823	823,1006	205,7752	0,463893
11:58	41,9	50,1	33,8	8,2	7,6	101,63761	837	840,0898	210,0225	0,483937
12:08	42,4	50,8	33,5	8,4	7,2	103,88829	848	853,7416	213,4354	0,486744
12:18	42,3	51,6	34,6	9,3	6,3	114,87174	860	868,0703	217,0176	0,52932
12:28	42,8	51,9	35,1	9,1	5,8	112,23648	870	880,0501	220,0125	0,510137
12:38	43,1	52,5	35,3	9,4	6,3	115,74494	879	890,682	222,6705	0,519804
12:48	43,5	52,6	35,1	9,1	6,7	111,94787	881	893,8731	223,4683	0,500956
12:58	43,1	52,9	35,1	9,8	6,3	120,58145	886	899,757	224,9392	0,536062
13:08	43,7	53,3	35,7	9,6	6,3	117,90311	893	907,3256	226,8314	0,519783
13:18	43,5	53,4	35,8	9,9	5,8	121,61001	889	903,3669	225,8417	0,538475
13:28	42,6	52,9	35,9	10,3	5,8	126,85024	888	902,1048	225,5262	0,562463
13:38	43,1	53	36,5	9,9	5,4	121,78945	890	903,5363	225,8841	0,539168
13:48	43,6	53,7	37,5	10,1	5,8	123,97524	891	903,5921	225,898	0,548811
13:58	43,9	53,9	36,8	10	5,4	122,63447	893	904,2923	226,0731	0,542455
14:08	43,6	53,3	37,1	9,7	5,4	119,15324	883	892,4808	223,1202	0,534032
14:18	44,3	53,8	37,2	9,5	6,7	116,43817	880	887,3861	221,8465	0,524859
14:28	44,6	54,1	37,5	9,5	6,3	116,30901	871	875,8743	218,9686	0,531168
14:38	44,3	54	37,5	9,7	4,9	118,84554	855	856,9871	214,2468	0,554713
14:48	44,9	53,6	37,9	8,7	5,8	106,55399	841	839,7814	209,9454	0,507532
14:58	45,6	53,8	39	8,2	5,8	100,26296	825	820,253	205,0632	0,488937
15:08	45,1	53,2	38	8,1	5,8	99,242153	813	804,3601	201,09	0,493521
15:18	45,1	52,9	38,8	7,8	6,3	95,619541	798	785,1432	196,2858	0,487144
15:28	45,3	53	37,9	7,7	5,8	94,341306	780	762,6404	190,6601	0,494814
15:38	46,1	52,7	38,5	6,6	5,8	80,789196	754	732,0439	183,011	0,441445
15:48	46,6	53,2	39	6,6	5,8	80,639624	737	709,9005	177,4751	0,454371
15:58	46,5	52,9	39	6,4	5,8	78,254017	717	684,5289	171,1322	0,457272
16:08	45,7	52	38,3	6,3	5,4	77,273994	692	654,1024	163,5256	0,47255
16:18	46,4	51,7	38,7	5,3	5,4	64,960243	668	624,3699	156,0925	0,416165
16:28	46	51,2	37,9	5,2	5,8	63,84062	643	593,4465	148,3616	0,430304

Table C.30. Daily data for 02.08.2005

Date	02.08.2005	With Polyurethane								
Weather Condition		Clear								
Midday	Φ (°)	δ (°)		V_{in} (m/s)	V_{out} (m/s)		P_{in} (kPa)	P_{out} (kPa)		
13:17	38,46	17,65		3	1,7		0,23	0,015		
Time	T_{in}	T_{out}	$T_{amb.}$	ΔT	Wind(m/s)	Q_{useful} (W)	I_o(W/m²)	I_β(W/m²)	Q(W)	η
10:03	32,4	34,3	30,3	1,9	8,9	24,63735	580	536,9184	134,2296	0,183546
10:13	38,4	41,6	32,4	3,2	7,2	40,532517	597	559,6971	139,9243	0,289675
10:23	40,1	44	32,3	3,9	6,7	49,037269	625	592,5624	148,1406	0,331018
10:33	40,9	45,4	32,3	4,5	7,6	56,357428	655	627,2319	156,808	0,359404
10:43	41,3	46,7	33,4	5,4	7,2	67,42113	680	656,9798	164,2449	0,410491
10:53	41,3	47,8	33,6	6,5	5,8	80,993205	703	684,5936	171,1484	0,473234
11:03	41	47,9	33,7	6,9	5,4	86,008643	724	710,026	177,5065	0,484538
11:13	41,7	48,6	34,2	6,9	6,7	85,78994	741	731,2634	182,8158	0,46927
11:23	41,4	48,9	34,2	7,5	6,3	93,249935	759	753,2014	188,3003	0,495219
11:33	41,9	49,3	34,6	7,4	6,7	91,855802	773	770,8738	192,7184	0,476632
11:43	42,3	49,9	35,1	7,6	6,3	94,16629	790	791,2411	197,8103	0,476043
11:53	42,7	50,9	34,6	8,2	5,8	101,34048	809	813,3375	203,3344	0,498393
12:03	42,8	51,2	34,9	8,4	5,8	103,73609	827	834,1557	208,5389	0,497442
12:13	43,3	51,6	35,3	8,3	6,3	102,33193	841	850,6464	212,6616	0,481196
12:23	42,8	51,5	35,3	8,7	6,7	107,38183	850	861,7611	215,4403	0,49843
12:33	43,2	52,3	35	9,1	6,7	112,07157	859	872,5462	218,1366	0,513768
12:43	43,1	52,3	35,2	9,2	7,2	113,32396	868	883,0027	220,7507	0,513357
12:53	42,9	52,2	36	9,3	6,7	114,61895	878	894,1476	223,5369	0,512752
13:03	43,2	52,6	36	9,4	8	115,70235	883	899,8645	224,9661	0,51431
13:13	43,6	52	35,1	8,4	7,6	103,43165	888	905,2385	226,3096	0,457036
13:23	43,8	52,5	36,1	8,7	8,5	106,98767	890	907,2076	226,8019	0,471723
13:33	43,9	53,3	36,3	9,4	7,6	115,4042	890	906,7885	226,6971	0,509068
13:43	44,2	52,8	36,6	8,6	8	105,62153	887	902,9632	225,7408	0,467889
13:53	44,2	53	36,6	8,8	7,6	108,03797	882	896,754	224,1885	0,481907
14:03	44	53	36,8	9	7,6	110,53416	878	891,2117	222,8029	0,496107
14:13	44,6	52,7	36,7	8,1	7,2	99,42569	872	883,2862	220,8216	0,450254
14:23	44,5	53	37,5	8,5	6,7	104,29708	862	870,9634	217,7409	0,478996
14:33	44,5	53,9	37,6	9,4	6,3	115,1486	854	860,3148	215,0787	0,535379
14:43	44,5	53,1	37,8	8,6	7,6	105,50462	847	850,3092	212,5773	0,496312
14:53	44,7	53,5	38,1	8,8	7,2	107,83858	835	834,9232	208,7308	0,51664
15:03	44,7	52,9	38,2	8,2	8	100,59743	823	819,1847	204,7962	0,491208
15:13	45,5	53,2	37,8	7,7	6,7	94,271511	809	801,101	200,2753	0,47071
15:23	45	52,7	37,6	7,7	7,6	94,445992	791	778,7221	194,6805	0,485133
15:33	45,3	53,1	38,4	7,8	7,6	95,548842	775	757,9781	189,4945	0,50423
15:43	45,9	53,2	38,7	7,3	6,7	89,308118	756	733,9611	183,4903	0,486719
15:53	45,5	52,6	38,4	7,1	7,2	87,022212	737	709,6129	177,4032	0,490533
16:03	45,8	52,1	38,1	6,3	7,6	77,245443	715	682,0565	170,5141	0,453015
16:13	46	51,8	38,2	5,8	8	71,127995	692	653,2498	163,3124	0,435533
16:23	45,6	51,2	37,3	5,6	7,6	68,802189	667	622,2788	155,5697	0,44226
16:33	45,8	50,8	37,8	5	7,6	61,453182	644	592,8856	148,2214	0,414604

Table C.31. Daily data for 03.08.2005

Date	**03.08.2005**	**With Polyurethane**								
Weather Condition		Clear								
Midday	**Φ (°)**	**δ (°)**		**V_{in} (m/s)**	**V_{out} (m/s)**		**P_{in} (kPa)**	**P_{out} (kPa)**		
13:17	38,46	17,382		3	1,7		0,23	0,015		
Time	**T_{in}**	**T_{out}**	**$T_{amb.}$**	**ΔT**	**Wind(m/s)**	**Q_{useful} (W)**	**$I_o(W/m^2)$**	**$I_\beta(W/m^2)$**	**Q(W)**	**η**
09:58	33,6	35,6	31,1	2	8,9	25,821102	568	524,5499	131,1375	0,196901
10:08	39	41,9	32	2,9	8,9	36,673558	594	555,9066	138,9767	0,263883
10:18	41	44,7	32,7	3,7	7,6	46,388572	625	591,8471	147,9618	0,313517
10:28	41,6	46	32,3	4,4	7,6	54,975575	652	623,9025	155,9756	0,352463
10:38	41,7	46,3	31,6	4,6	6,3	57,432814	667	644,2171	161,0543	0,356605
10:48	41,8	47,1	32,4	5,3	7,2	66,06461	689	670,9962	167,7491	0,39383
10:58	42,1	47,9	34,2	5,8	6,7	72,152679	709	695,5816	173,8954	0,41492
11:08	42,6	49,3	35,1	6,7	6,3	83,060537	729	719,9099	179,9775	0,461505
11:18	42,8	49,8	34	7	7,2	86,668699	754	748,9503	187,2376	0,462881
11:28	43,2	50,4	35	7,2	7,6	88,981881	774	772,7962	193,1991	0,460571
11:38	43	50,5	34,7	7,5	8	92,706447	795	797,3874	199,3468	0,465051
11:48	43,3	51,3	35,2	8	7,2	98,687554	809	814,677	203,6693	0,484548
11:58	43,7	51,7	35,4	8	7,6	98,542578	824	832,6696	208,1674	0,473381
12:08	43,8	52,2	36,7	8,4	6,7	103,35553	838	849,3498	212,3374	0,486751
12:18	43,9	52,8	36,3	8,9	7,2	109,3665	848	861,6602	215,4151	0,507701
12:28	44	53,1	36,6	9,1	7,6	111,7417	860	875,6829	218,9207	0,510421
12:38	44,6	53,6	37,1	9	6,7	110,28945	869	886,3292	221,5823	0,497736
12:48	44,8	53,8	36,1	9	7,6	110,20788	875	893,5837	223,3959	0,49333
12:58	44,4	53,6	36,3	9,2	8	112,78202	879	898,4579	224,6145	0,502114
13:08	44,6	53,9	37,1	9,3	8	113,90255	881	900,9473	225,2368	0,505701
13:18	44,9	53,9	36,9	9	8	110,16709	882	902,0726	225,5181	0,488507
13:28	44,7	54,3	37,2	9,6	6,3	117,46805	876	895,698	223,9245	0,524588
13:38	44,6	54,4	37	9,8	5,8	119,9153	871	890,0093	222,5023	0,53894
13:48	44,8	54,5	37	9,7	6,7	118,62573	871	889,089	222,2723	0,533696
13:58	44,9	54,5	37,3	9,6	5,8	117,38103	869	885,7795	221,4449	0,530069
14:08	44,8	54,4	38,3	9,6	6,7	117,42454	858	872,9605	218,2401	0,538052
14:18	44,9	54,2	38,3	9,3	7,2	113,7761	850	862,8659	215,7165	0,527434
14:28	45,4	54,4	38,4	9	6,7	109,96312	839	849,3961	212,349	0,517841
14:38	45,8	54,6	38,9	8,8	6,7	107,39983	833	840,6462	210,1615	0,511035
14:48	45,5	54,5	38,6	9	6,3	109,92233	820	824,4892	206,1223	0,533287
14:58	45,8	54,5	39,8	8,7	5,8	106,1991	807	808,0064	202,0016	0,525734
15:08	46	54,3	39	8,3	6,3	101,31638	794	791,1896	197,7974	0,512223
15:18	46,2	53,9	38,4	7,7	6,3	94,027208	776	769,0722	192,268	0,489042
15:28	45,9	53,4	39,7	7,5	5,4	91,720923	760	748,6255	187,1564	0,490076
15:38	46,2	53,6	38,9	7,4	5,8	90,414124	744	727,8448	181,9612	0,496887
15:48	46,3	53,4	38,8	7,1	5,4	86,764778	726	704,7733	176,1933	0,492441
15:58	46,7	53,4	40,4	6,7	5,4	81,815882	706	679,442	169,8605	0,481665
16:08	46,3	52,7	39,4	6,4	5,8	78,312032	681	649,0294	162,2574	0,482641
16:18	46,6	52,5	39,3	5,9	5,8	72,180534	658	620,2735	155,0684	0,465476
16:28	46,6	51,5	37,4	4,9	5,4	60,057583	632	588,4463	147,1116	0,408245

Table C.32. Daily data for 04.08.2005

Date	**04.08.2005**	**With Polyurethane**								
Weather Condition		Clear								
Midday	**Φ (°)**	**δ (°)**		**V_{in} (m/s)**	**V_{out} (m/s)**		**P_{in} (kPa)**	**P_{out} (kPa)**		
13:17	38,46	17,108		3	1,7		0,23	0,015		
Time	**T_{in}**	**T_{out}**	**$T_{amb.}$**	**ΔT**	**Wind(m/s)**	**Q_{useful} (W)**	**$I_o(W/m^2)$**	**$I_\beta(W/m^2)$**	**Q(W)**	**η**
09:58	35,6	36,8	31,2	1,2	2,7	15,40589	573	531,6326	132,9081	0,115914
10:08	41	44,6	35,6	3,6	2,7	45,142974	605	568,7462	142,1866	0,317491
10:18	42,6	47,4	36,1	4,8	2,7	59,712562	628	597,2738	149,3185	0,399901
10:28	43,1	48,6	36,7	5,5	2,7	68,208933	648	622,6895	155,6724	0,438157
10:38	43,4	49,7	36,9	6,3	2,7	77,93049	679	658,495	164,6238	0,473385
10:48	43,5	50,2	36,9	6,7	2,2	82,787409	700	684,4304	171,1076	0,483832
10:58	44	51	36,5	7	2,2	86,288184	723	712,081	178,0202	0,48471
11:08	44,5	52	37,5	7,5	1,8	92,196765	738	731,5757	182,8939	0,5041
11:18	44,8	53	37,4	8,2	2,7	100,56027	767	764,7092	191,1773	0,526005
11:28	44,7	53,3	38,1	8,6	2,2	105,42667	767	768,6158	192,1539	0,548657
11:38	45	53,9	37,9	8,9	1,8	108,92284	806	811,3367	202,8342	0,537004
11:48	45,7	54,8	38,2	9,1	2,2	111,04056	816	824,6468	206,1617	0,538609
11:58	45,4	55	37,5	9,6	2,2	117,16345	829	840,661	210,1653	0,557482
12:08	45,9	55,4	38,4	9,5	2,2	115,74921	840	854,3296	213,5824	0,541942
12:18	46,2	55,9	37,8	9,7	2,2	118,01013	852	868,6978	217,1744	0,543389
12:28	46,2	56,3	38,3	10,1	1,8	122,78494	859	877,6439	219,411	0,559612
12:38	46,6	56,8	39,1	10,2	1,3	123,79252	867	887,2815	221,8204	0,558075
12:48	46,8	57	39	10,2	2,2	123,70001	869	890,444	222,611	0,555678
12:58	47,6	57,4	39,8	9,8	2,2	118,58238	869	891,2163	222,8041	0,532227
13:08	47,3	57,8	39,9	10,5	2,2	127,02874	874	896,7812	224,1953	0,566599
13:18	47,5	58,1	39,7	10,6	2,7	128,11836	878	900,9866	225,2467	0,568791
13:28	47,4	58,2	39,3	10,8	2,7	130,53568	884	906,906	226,7265	0,575741
13:38	47,1	57,7	40,4	10,6	2,2	128,31065	882	904,2765	226,0691	0,567573
13:48	47,5	58,1	39,8	10,6	2,2	128,11836	869	890,0393	222,5098	0,575787
13:58	47,4	57,6	39,6	10,2	2,7	123,42248	867	886,7386	221,6846	0,556748
14:08	48	58,3	39,8	10,3	2,2	124,32886	866	884,1105	221,0276	0,562504
14:18	47,6	58,1	39,7	10,5	2,7	126,88588	858	873,9894	218,4973	0,58072
14:28	46,9	57,4	38,9	10,5	3,1	127,21921	844	857,4345	214,3586	0,593488
14:38	46,4	56,7	38,5	10,3	2,7	125,07622	834	844,6228	211,1557	0,592341
14:48	45,9	55,9	38,4	10	3,1	121,72793	815	822,3911	205,5978	0,592068
14:58	46,2	55,6	38,7	9,4	3,1	114,42426	804	807,9252	201,9813	0,566509
15:08	46,4	55,6	39	9,2	3,1	111,94799	784	784,1107	196,0277	0,571083
15:18	46,8	55,6	39,5	8,8	2,7	107,00089	770	765,9989	191,4997	0,558752
15:28	47,3	55,8	40	8,5	3,1	103,21824	757	748,5374	187,1343	0,551573
15:38	48,1	56,3	40,4	8,2	3,1	99,333555	738	724,8154	181,2038	0,548187
15:48	47,7	55,9	39,6	8,2	2,7	99,482291	715	696,8946	174,2236	0,571003
15:58	46,9	54,5	39,4	7,6	2,7	92,582138	682	659,0649	164,7662	0,5619
16:08	46,7	53,9	39,2	7,2	2,7	87,839952	659	630,7426	157,6856	0,557057
16:18	46,7	53,6	38,8	6,9	2,7	84,22687	634	600,2822	150,0706	0,561248