CAPACITY AND TECHNOLOGY SELECTION VIA COST MODELLING IN TURKISH CEMENT INDUSTRY

by

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TURKISH CEMENT INDUSTRY

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ABSTRACT

Discounted Cash Flow and Net Present Value methods have been used for analyses in Turkish Cement Industry to provide valuable help for prospective investors in crucial aspects such as selecting proper technology, capacity etc.given the relevant data on equipment,raw material and production costs.

Both DCF and Net Present Value methods are heavily dependent upon compilation of relevant technological and economical data, hence a through market and literature survey has been conducted to establish a sound data base.Compiled economical data include costs of raw and operating materials, costs of individual equipment items as a function of capacity,past,present and future trends in cement consumption and production both in Turkey and abroad. As for technological information, main technological parameters such as electrical energy consumption per unit production etc, for each available technology and effects of efficient operation on these parameters have been compiled.

The compiled information has been evaluated via DCFROI and NPV methods utilizing a software package; Microsoft Works. Sensitivity analyses on important parameters have also been carried out.

Results indicate that a capacity of 1500 tons / clinker is the minimum to be employed in a new investment, regardless of the selected processing scheme. As for the proper processing scheme, selection between processes with and is highly dependent on the efficiency of actual plant oparation.

ÖZET

Çimento sanayiinde ekipman, hammadde ve üretim maliyetleri hakkında yeterli bilgi ışığında muhtemel yatırımcılara uygun teknoloji ve kapasite seçimi gibi kritik konularda yardım sağlayacak ekonomik analizler yapılmıştır.

Bu tür analizlerin başarısı,gerekli teknolojik ve ekonomik verilerin güvenirliliğine sıkı sıkıya bağlı olduğundan, öncelikle yoğun bir pazar ve literatür araştırması yapılarak güvenilir bir veri tabanı oluşturulmuştur.

Toplanan ekonomik veriler ham ve işletme malzemelerinin maliyeti, beher ekipman kalemlerinin kapasiteye bağlı maliyetleri,yurtta ve dünyada geçmiş, bugünkü ve gelecek çimento piyasa içerir. Teknolojik bilgi olarak,eldeki her teknoloji için birim üretim başına elektrik tüketimi gibi ana teknik parametreler, ve verimli ile - verimsiz işletimin bunlar üzerindeki etkileri toplanmıştır.

Toplanan bilgiler Türk Çimento Endüstrisinin ekonomik analizini yapmak üzere Microsoft Works yazılım paketi ile işlenmişlerdir. Önemli parametreler üzerinde duyarlılık analizleride yapılmıştır.

Sonuçlar yapılacak yeni yatırımlarda, seçilecek üretim prosesi ne olursa olsun klinker /gün olarak minimum 1500 ton'luk bir kapasite hedeflenmesi gerektiğini göstermektedir. Üretim prosesinin seçiminde, önkalsinasyon kullanan ve kullamayan sistemler arasındaki tercihin, işletme koşullarına son derece bağımlı olduğu görülmüştür.

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ACC	:Average Value of the Capital
APC	:Annual Production Cost
C	:Annual Cash Flow
Cn	:Cash flow for year n
D	:Depreciation
e	:Escalation Rate
FI	:Fixed Investment
GNP	:Gross National Product
i	:Interest Rate
I	:Investment
IRR	:Internal Rate of return
I/C	:Payback Period
n	:Years of Project Life
NPV	:Net Present Value
Pn	:Net Profit after taxes

CHAPTER I

INTRODUCTION AND OBJECTIVE

I.1.INTRODUCTION

In modern times one needs only to mention rainforced concrete walls and girders, tunnels,dams and roads to realize the dependence of present-day civilization upon cement products. The convenience, cheapness, adaptability, strength and durability of cement products have been the foundations of these tremendous structures.

According to ASTM Specification C 150-160 and C 175-61 Portland Cement has been defined as the product obtained by pulverizing clinker consisting essentially of hydraulic calcium silicates, to which no additions have been made subsequent to calcination other than water and /or untreated calcium sulfate, except that additions not to exceed 1.0 % of other materials may be interground with the clinker at the option of the manufacturer(1).

The manufacture of portland cement is unique in many respects. For example, no other active chemical is manufactured in such large quantities(2).

According to 1987 figures, Turkey is among the top twenty producers in the world(3).

Table 1.1 Top 20 Producers in the World

	Million Tons		Million Tons
1.CHINA	180.0	11.W.GERMAY	23.0
2.USSR	136.0	12.MEXICO	22.4
3.JAPAN	71.4	13.TURKEY	22.0
4.USA	71.1	14.POLAND	15.7
5.ITALY	36.9	15.TAIWAN	15.7
6.INDIA	36.5	16.IRAQ	13.0
7.S.KOREA	25.6	17.IRAN	12.2(*)
8.BRAZIL	25.5	18.ROMANIA	11.0(*)
9.FRANCE	23.4	19.CANADA	10.4(*)
10.SPAIN	23.0	20.CZECHOSLOVAKIA	10.2(*)

(*) 1986 Figures

The cement production and capacity utilization in major producer countries are given in Tables 1.2 and 1.3(4)

The production growth is significant in developing countries whereas in industrialized countries the production is stagnant and even experiences a decline.

Table 1.2 Annual production change in major cement producers.(milliontons)

	1980	1981	1982	1983	1984	1985	1986	1987
FRANCE	28.1	27.2	25.2	23.5	21.9	21.4	21.8	22.8
ITALY	41.9	42.1	40.2	39.8	38.3	37.2	35.4	37.7
G.BRITAIN	14.9	12.7	13.0	13.4	13.5	13.3	13.4	-
SPAIN	28.0	30.5	30.2	31.2	26.6	24.2	22.1	23.0
USA	67.9	62.8	57.2	63.9	63.9	70.3	71.1	67.4
JAPAN	88.0	84.4	80.4	90.5	80.0	81.7	71.3	71.6
TURKEY	12.9	15.1	16.0	13.9	15.7	17.7	21.1	22.0
W.GERMANY	34.6	31.4	30.1	30.0	29.9	26.0	27.0	25.0

It is interesting that,Turkey and Greece show the two biggest capacity usage among the EC countries.

I.2 CEMENT INDUSTRY IN TURKEY

The first portland cement plant in Turkey was founded by Asian Osmanli Company in Darica,Istanbul in 1910.A little later another plant in Eskihisar District began its operation.Thus these two plants at the edge of World War I brought Turkey's capacity to 40.000 t/yr(5)

Table 1.3 Capacity Utilization in European Community Countries

	% Capacity Usage
DENMARK	55
FRANCE	72
W.GERMANY	50
GREECE	80
IRELAND	46
ITALY	66
LUXEMBOURG	100
HOLLAND	62
ENGLAND	75
BELGIUM	n/a
SPAIN	61
PORTUGAL	70
TURKEY	81

In Turkey till the World War I there was not an important acceleration in cement production. In 1926, Ankara Cement Plant began its activity with a capacity of 15.000 tons of cement/yr.At that time the production capacity was 40.000 ton/yr.This was followed by a plant of 120.000 tons/yr.(made by F.L.Schmidt) in Kartal, Istanbul and another with the same capacity (MIAG made) and two other rotary kilns in Zeytinburnu,Istanbul.

Historically , the progress in Turkish Cement Industry should be considered in eight main stages.

a) Stage I: In 1910 - 1920 are there is not a certain cement policy . There is a fierce competition between the two plants mentioned before. A considerable amount of the demand is met by importation.

b) Stage II: During 1920 - 1930 the merger of two factories ended the competition .But this time , the import prices of cement threatened the domestic producers.

c) Stage III: During 1930 - 1935 the coordination among the cement plants enabled them to control the whole market. This was followed by an increase in prices.

d) Stage IV: During 1935-1950,a state policy in this industry was established for the first time. The prices were taken under control . The training of domestic labour and expertise formed a basis for the post-1950 contributions of Turkish Cement industry.

e) Stage V: The fifth stage represents a basic jump for Turkish Cement industry. In 1935 ,Turkish Cement industries inc. (Türkiye Çimento Sanayii T.A.Ş.)

was founded.This company ordered 15 new cement plants to outside contractors.The private industry also showed an acceleration by renewing and expanding the existing facilities.

In 1960 , although Turkey would export a limited amount of cement,this scene turned upside down between 1963 and 1970.And between these years importation began again.

f) Stage VI:Begining from 1970 Turkey became a cement exporter once again.Exportation reached its peak in 1981 and 1982 probably receiving help from the crisis in the Turkish construction sector which drastically dropped the domestic demand. Beginning from 1982,utilization of additive chemicals also increased considerably(3).

g) Stage VII:This stage contains the Fifth 5 Year Development Plan Period and reflects the effect of two major developments:

i) A significant increase in domestic demands as a consequence of goverment incetive plants for housing.

ii) A significent decrease in exports primarily due to the collapse of Middle East market and establishment of local cement industries in countries like Jordan,Iraq,Iran, Tunisia and Morocco which became exporters themselves(3).

The increase in domestic demand which started in 1984 compensated the bad effects of shrinking export markets and capacities freed from export duty were employed to meet the domestic demand.

The increase was due to the availability of certain funds established by the goverment as well as channelling of financial sources to Anatolian municipalities.

Primarily,the capacity usage in cement industry in 1983 rose from an average of 61.4 % to 78 % in 1987. Another important point is the new price policy of Ministry of Industry and Technology wwhich went into effect on 6.12.1985 (3). In this way a considerable amount of financial fund could have been created;which in turn caused a boost in investments.For the last five years,there have been quite a few investments like; pre-calcination , bottleneck recovering,restoration and modernization in the sector.

In the 5th 5 Year Development Plan Period,the main activities are the start - up of previously planned plants. Therefore in 1983 Adiyaman and Ladik,in1984 Ergani ,in 1985 Kurtalan ,in 1986 Şanliurfa , in 1988 Denizli began their operation. But there was not new construction in this stage to provide for the increasing demand.

In the 5th 5 Year Development Plan Period there is no tendency toward new investment. The reason is that a total new investment would cost 100x10 TL for a capacity of 10 ton annualy (1987 prices).In view of this,it is better to expand, modernize existing facilities for the desired capacity increase.Another point is that, as the firs time since 1969 importation began. Sudden demand increase especially in Marmara, Ege and Inner Anatolia forced the capacity usage fiercely(3).Also some sharp price increase in coal , electricity fuel and Kraft paper (all manufactured by the state) weakened sector's competition.

The main disadvantages of this stage are the costly items utilized as electricity , coal ,fuel and kraft paper and countries which are in need of immediate cash like Iran , Iraq,Syria also providing dumping on cement. This is an unfair competition in importation. Although some law has been constituted, there is little official enforcement to penalize such importation(6).

h) Stage VIII : This is the last and still continuing stage.In this period it is foreseen that the domestic cement demand increase will be 7.4% annually (7). The main aim is to decrease the import by domestic production. With this , importation will decrease with an annual rate of 9.6% finally reaching 900x10 tons in 1994.

In 1990 with the addition of a 3rd Blending Mill in Iskenderun,total production reached 24 million tons (8).

The main philosophy of our present time as well as the future will be that the demand should only be supplied by local production and importation should be employed only in case of necessity (3). The Middle East market will vanish and the Mediterranean market will shrink considerably. Exception is the Northern Cyprus market which is too small. It is necessary to plan new investments which can provide cement to more than one regions by being situated between them.Such investments are required in Central Anatolia.

Recently there is a tendency towards the privatization of existing plants to foreign groups,mainly to cement Francais of France.

I.3.SIGNIFICANCE AND OBJECTIVE OF PRESENT WORK

Cement industry represents a percentage of about 8% of Turkish manufacturing industries (8).It has also reached (more or less) the level of many major cement producers in the world. In the future,there will be great competition in the world markets. Extensive research and development studies are currently in progress for more energy efficient,thus more economical manufacturing technologies (9,10,11).

As the fixed investment is on the order of ten millions of dollars and the annual operating costs being not less , new investment decisions in the cement industry must be based on sector - specific ,reliable technological and economical analyses. For such an analysis , accurate estimates for fixed capital investment together with annual operating and other costs of cement plants are essential. How such expenses vary among available technologies , and how they are affected by production capacity should be carefully examined. Furthermore , the effects of changes in technology and production capacity on the feasibility should also be analyzed.

The objective of this study is to develop an economical model which will help prospective investors in crucial aspects such as selecting proper technology ,capacity are,given the relevant data on equipment,raw material and product costs. This model will be based on extensive market and technological surveys which will be combined and evaluated by proper economical criteria using a computer program developed for this purpose.

CHAPTER II

TECHNICAL BACKGROUND

II.1.BASIC ASPECTS OF CEMENT MANUFACTURING

There are no means of knowing when the discovery of a cementing material was first made , but it must have been discovered soon after the first intelligent use of fire.

Perhaps the earliest attempted explanation of the reactions by which certain rocks become cementitious on burning is that given by Vitruvius in the 1st century AD (12).

Cement contains four essential chemical elements; silicon , aluminium , iron and calcium. Usually these are reported as oxides (13). The raw materials for making Portland cement are generally a mixture of calcerous an argillaceous materials in such proportions as to provide proper chemical composition for sintering and burning.The chemical composition should be confined within narrow limits,as small variations in the ratios of the principal components of the mixture may be sufficient to alter the properties of the cement.

Main steps in cement manufacture may be given as:

1.Quarrying the components of raw material

2. Raw material crushing and grinding
3. Calcination ; Conversion of raw materials into clinker
4. Finishing;clinker ,clay and additive proportioning and cement grinding
5. Packaging and Shipping of Cement

A simplified flowsheet of the processes in a typical cement plant is shown in Fig (21).

II.1.1. QUARRYING,CRUSHING AND GRINDING OF RAW MATERIAL

The first step in blending the raw materials may be made at once in the quarry by the steam shovels, one ladle of stripping and two ladles of rock,or two cans of this rock and three of that. Through battery of crushers the rocks wrench their way until they are only marbles.Then they are dumped into huge bins (2).

The raw mixtures for producing kiln feed vary over a range from simple blends of limostone and cement rock to mixtures of limestone and iron blast - furnace slag etc. With sometimes the addition of silica from standstone and iron or which are relatively free from complex lime bearing materials. The unit operations prepare the raw materials in the necessary proportions and in the proper physical state of fineness and intimate contact so that the chemical conversions can

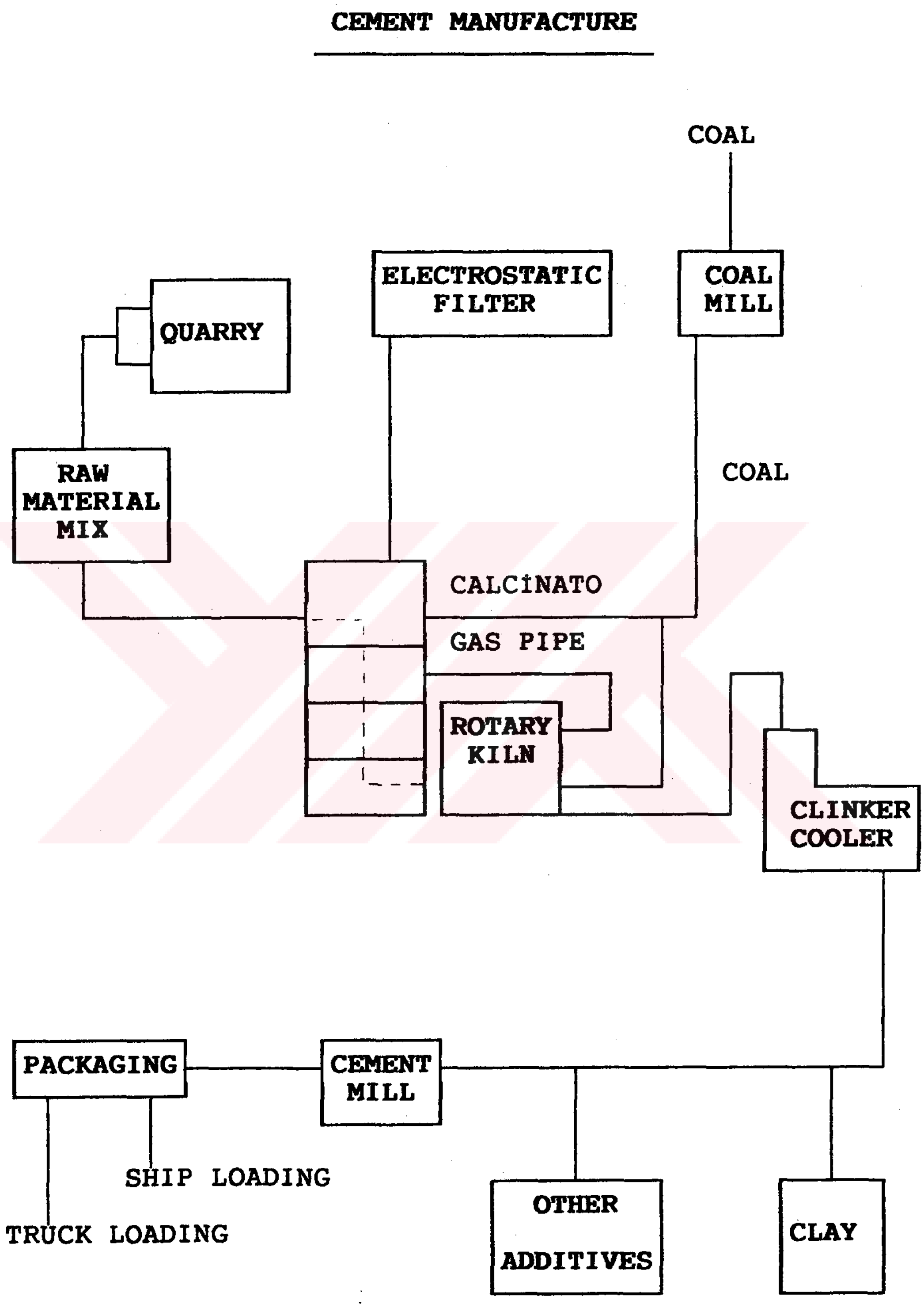


Figure 2.1 Flowsheet of cement manufacture

take place at the calcining temparature in the kiln to form,by double decomposition or neutralization , mainly the compounds given below.

Table 2.1 Composition of Oxides

Compound	C3S	C2S	C3A	C4AF
CaO	73.7	65.1	62.3	46.15
Si2	26.3	34.9	-	-
Al2O3	-	-	37.7	21.00
Fe2O3	-	-	-	32.85

C3S; Tricalcium Silicate,C2S;Dicalcium Silicate, C3A; Tricalcium Aluminate,C4AF; Tetracalcium Aluminoferrite

Table 2.2 Crusher types and their properties.

Type	Feed opening(m)	Capacities tons/yr
Jaw Crusher	2.0-2.5	1200
Gyratory Crusher	1.5-2.0	4500
Core Crusher	(similar to gyratory)	3000

The fineness of raw materials sometimes is measured ,in cement practice , as the percentage of material passing a No.100 sieve (linear openings 0.0058 and 0.0029 inch respectively). It is now more commonly measured by a turbidity or air-flow method and expressed as surface area in sq.cm.per gram.

The critical factors in the preparation of the raw mixture for the manufacture of portland cement are correct proportioning,fine grinding and intimate mixing (12).

In proportioning raw materials; the proper lime content is limited due to the low early strength produced when the lime is too low,and unsoundness when it is too high. There is no advantage in adding the extra lime unless it be brought into combination with the other constituents. If appreciable lime is left uncombined, it may cause expansion and cracking of the mortar or concrete.

This property may be tested by an accelerated test consisting of an exposure of a pat or bar of cement in steam or boiling water.If the specimen cracks, curls or expands unduly it is designated as "unsound", such cement is rejected by standart specifications.

When the lime content is raised too high, it becomes impossible to get alloy it into combination, regardless of the temperature of burning and the cement is unsound (12).

The silica and alumina as well as ferric oxide are likewise limited by the standard specifications not to exceed 5 % by weight because higher magnesia contents than that may be dangerous to the soundness of cement, especially at later stages.

It is necessary to direct the flow of rock that eventually finds its way into the kiln so that the desired composition shall be continuously and uniformly maintained. It is also important that the materials be finely pulverised and uniformly mixed. An area of lime particles may be so far removed from a region of some acidic component that these particles will remain in the mixture as free lime. Portland cement is not melted but only sintered,so some reaction has to take place by diffusion. Free lime remaining as a result of non-uniform mixing will be just as disastrous in producing unsoundness as similar free lime that might be left due to an excess of lime in the mixture.

II.1.2.CALCINATION AND CLINKER FORMATION

As the calcination section bears a special importance in the cement manufacture and the technological improvements in it sharply affects the efficiency of the whole plant, three systems;each one more developed than the previous are taken as basis. These are shown in fig.(2.2)

a)Processing Scheme A;Rotary kiln only.

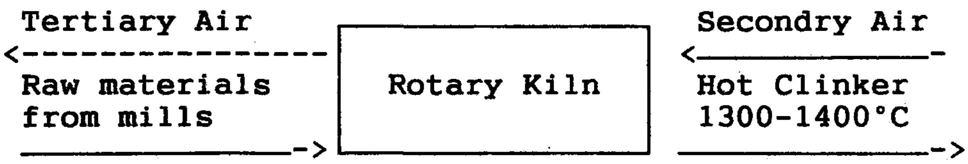
b)Processing Scheme B;Rotary kiln with preheater.

c)Processing Scheme C;rotary kiln and preheater with precalcinator.

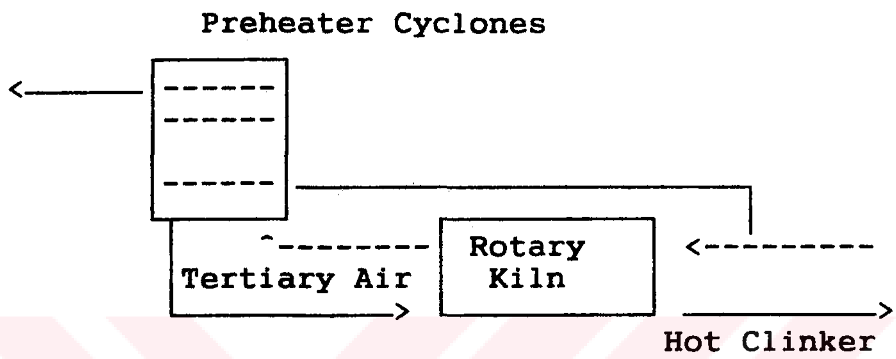
In processing Scheme A the raw mixture passes into rotary kilns whose speed of rotation varies from 30 to 110 revolutions per hour.Here the raw mixture is heated slowly to the sintering point. The clinker formation is higtly exothermic with the following reactions (1).

Most of the reactions in the kiln proceed in the solid phase, but toward the end, the important fusion occurs.The final product of calcination consist of hard granular masses from 3 to 20 mm.in size called clinker.

The water and carbon dioxide are driven off before the clinkering zone is reached.As the hotter zones are approached, chemical reactions described above take place between the constituents of the raw mixture. A rotary kiln comprises the steel shell, the refractory



Scheme A



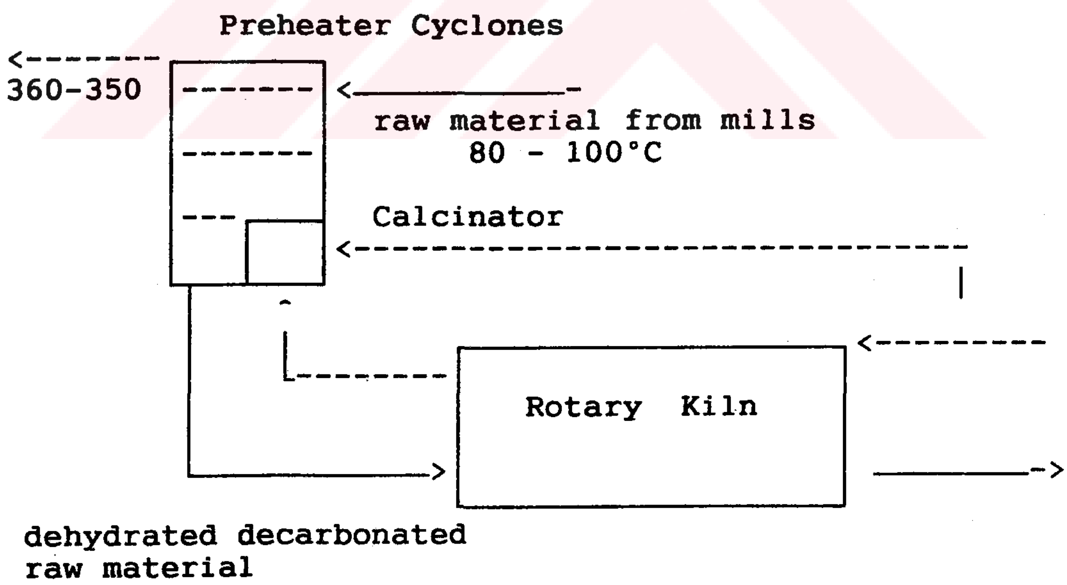


Figure 2.2 Process Schemes A,B and C

lining, any insulation that my be present between the lining and the shell,the front and the back housing the supporting structure, and the driving mechanism (13). In the kilns heat is provided by burning pulverized coal or more recently natural gas using preheated air from cooling the clinker.

Processing scheme B contains a rotary kiln with cyclone preheaters. In a conventional 4 staged preheater, raw materials carried downward by the means of a series of pipes and cyclones.Because of the global counter flow and the specific surface area of the material which is considerably high (approximately 10 times longer than that of a rotary kiln),the material temperature rises from 60 to 820C in a few seconds and it is decarbonized by half (25-30 % in average)(17).The cyclone preheaters cause a considerable pressure drop with four to five staged preheaters so the rotary kilns are operated as to have a pressure difference of 700 to 1000 mm Water Gauge.

Processing scheme C: It is known that presence of unburnt carbon leads to formation of reduction zones in the rotary kiln which in turn increases the flow of sulfur and alkalis, eventually leading to system shut down.

In order to prevent such undesirable consequences, precalcinators have been introduced which serve as burning chambers prior to rotary kiln. This way before combustion gases, decarbonized gases and materials are mixed rotary kiln outlet gas, a coal combustion of 80 % is realized. The presence of calcinators also provides calcination of raw material up to 90 %.

In order to increase the capacity, a cement producer adds a precalcinator which most probably causes a high pressure loss.This requires an additional parallel series of cyclones supplying the increasing gas volume.

Performance data shown in Table 2.4 is an example of such an improvement.

II.1.3.FINISHING,CEMENT GRINDING,PACKAGING AND SHIPPING

At the discharge or firing end of the kiln,the clinker must be properly quenched and cooled,and as much of the recovered heat as possible must be utilized in the combustion of the fuel. This is followed by clinker finish grinding and later by storage and packing.

Certain additives are added to clinker in order to:

1. Prevent cement to set or stiffen too rapidly upon mixing with water.
2. Increase grinding efficiency.

Table 2.3 Reactions in clinker formation

Temperature,C	Reaction	Heat Change
100	Evaporation of free water	Endothermic
500 and above	Evolution of combined H_2O from Clay	
900 and above	Crytallization of amorphous dehydration products ofClay	Exothermic
900 and above	Evolution CO_2 from $CaCO_3$	Endothermic
900 - 1200	Main reaction between lime and Clay	Exothermic
1250 - 1280	Commencement of liquid formation	Endothermic
1280 and above	Further formation of liquid and completion of formation of cement (compounds)	Probably endothermic on balance

Table 2.4 Performance data after the addition of calcinator (17).

Conversion	Before	Later
Kiln dimensions,m	4.55x68	4.55x68
Cooler inlet area,m	63.6	84.6
Production(test) tons/day	1529	4094
Kiln specific production tons/m/day	1.66	4.45
Cooler Specific Production tons/m/day	24.0	48.4
Coal Ash Content %	28.3	36.0
Heat Consumption Kcal/kg	824	765
Cyclones,kiln series m	2x3.95	2x3.95
"	3x600	3x600
Calciner m	-	2x5.25
"	-	4x760
Calcinator system m	-	6.6x19.0
m	-	597
tons/m/day	-	6.86
Retention Time,seconds	-	3.35
Kiln Series Outlet Temp.C	369	351
Calcinator Series Outlet Temp.C	-	322
Kiln Ser.Outlet Pres.mm WG	575	560
Calcinator Ser.Outlet Pres.mm WG	-	570

For these purposes, as the clinker passes to the mills it is mixed with a carefully adjusted amount of retarder consisting of gypsum ($CaSO_4.2H_2O$) or plaster ($CaSO_4.H_2O$) (12).

It is found that 25 to 75 percent of the gypsum could be replaced with natural anhydrite without adversely affecting either the setting times of the cement pastes or the strength or volume change characteristics of the concrete made from them. The addition of one percent talc was found to increase the grinding efficiency by about 6 percent, to have little effect upon the setting time or heat stability, but to reduce the compressive and flexural strengths by about 14 and 4 percent, respectively.

In addition to natural materials, some plants use blast furnace slag and precipitated calcium carbonate obtained as a by-product in the alkali and synthetic ammonium sulfate industry. Sand, waste bauxite and iron ore are sometimes used in small amounts to adjust the compositions of the mix. Gypsum (4 to 5 %) is added to regulate the setting time of the cement.

Cement is usually packed in two fold kraft paper packages weighing 50 kg. or in bigger plastic bags. It is transported by tractor-trailer trucks(15).

II.2. COMPARATIVE EVALUATION OF ALTERNATIVE PROCESSING SCHEMES

Processing Scheme A (rotary kiln only) has lost its place to the other two systems.First of all, Scheme A kilns are extremely long and have little capacities when compared to the Processing Schemes B and C.

Many Scheme A kilns do operate with coal and fuel oil.Upon conversion to system B, rotary kiln sizes shrink usualy two three times. As capacities are increased two to three times, mills should be employed for the additional raw meal. This is an extra investment.But the fuel consumption per kg of clinker may be saved at a rate of 20-30 %.Kiln revolution also increases upon conversion to Processing Scheme B.In B type kilns (kiln + preheater),cooler exhaust gas as well as preheater waste gas can be utilized in raw meal drying(17).

There are certain modifications in Processing Scheme B itself too.Many low efficiency cyclones may be replaced with high efficiency and low pressure difference cyclones. Main advantage are; a low power consumption of heat exchanger fan,higher capacity and a low heat consumption.

Such a kiln with modified cyclones has a specific load of 2.98 tons/m /day.But normally a calcinator kiln (Processing Scheme C) has a specific load of 4.0 tons/m /day (17).

In other words,if V is the rotary kiln volume required for a given capacity under Scheme C, corresponding kiln volumes to achieve the same capacity are 1.35 V and 3.5 V,respectively,for Scheme B and A.Kiln sizes are calculated utilizing these scaling factors in this study (18).

The restricting factors for high capacity are;pressure loss in the cyclones and the size of the calcinator.By the addition of calcinator and employing LP cyclones, any cement plant can reach higher capacities.Fixed investment costs are less than half of what would a rotary kiln with the corresponding capacity cost to investor(17).Therefore it can be said that,transition from Process Scheme B to C are highly recommended and feasible due to the above mentioned capacity increase.

A typical heat input to calcine one ton of clinker is given below for efficient and inefficient operations (18).

Table 2.5 Heat input for efficient and inefficient and operations

Systems	typical efficient op.		
	A	**B**	**C**
Specific Fuel Consumption (kj / kg)	4.827	3.466	3.547
Total gases leaving (i.e.going to I.D.fan) (Nm/kg.cl,standart cond.)	2.41	1.73	2.13
	typical inefficient op.		
Specific Fuel Consumption(kj/kg)	5164	3710	3792
Total gases leaving (i.e.going to ID fan) (Nm/kg.cl,standart cond.)	2.63	1.87	2.17

II.3 RECENT DEVELOPMENTS IN CEMENT TECHNOLOGY

The energy crisis of 1970's has introduced new burdens on manufacturing cost of cement. In many countries 50 % of the cost belongs to electricity and fuel.On the other hand, the crisis in construction sector led producers to compete fiercely in international cement markets. In addition, new enviromental regulations have also forced many producers to improve and modernize the on - going facilities.All these have become direct causes for the technological developments, as classified below.

II.3.1.THERMAL ENERGY

There has been special emphasis on reducing specific heat consumption per kg.of clinker in recent years.Introduction of a fifth cyclone stage or modified cyclone preheater designs are good examples.Depending on achievement of optimum operating conditions,specific heat consumption as low as 3139 kJ / kg clinker have been reported (3).

Pressure drop throughout the whole preheater cyclones has long been a design criteria. In order to attain a smaller pressure difference, an advanced preheater design with the following geometry is characterized:

1.A greater outlet / cyclone diameter ratio
2.Relatively small sized control pipe diameters
3.A big inlet gate

Such recent geometries led the pilot plants to succesfull results;namely 20-25 % reduction in pressure loss although the new cyclone diameter decreased by 25%

(17). In higher stages a greater separation efficiency is required. This fact reveals the need of a wider and longer central cylindrical pipe. The lower cyclone stages and refractory steel where the temperature is too high,experience a life less than one year.

In the new preheater geometry, a choice between four staged preheater with a pressure loss of 210 mm WG is possible (17). Keeping the nominal pressure difference same,the recent designed preheater requires a tower volume 20-30 % less than the conventional one.

Typical performance data of an old preheater kiln with two stages which is converted to 5 staged preheater kiln after shortening kiln tubing,addition of a preheater tower and planet type cooler;is shown below (17).

II.3.2.ELECTRICAL ENERGY

40 % electrical energy is consumed by size reduction units like crushers, grinders,seperators and mills (3). In Germany a radial crusher fed horizontally consumes 0.3-0.5 kwhr / ton energy versus the traditional hammer mill consumption of 1 kwhr/ton (3).

The cyclone seperators called "cyclopol"experience approximately 15 to 20 % less energy consumtion. In

Table 2.6 Performance data of an old preheater kiln after modernization

	Before	After
Kiln Dimensions	5.25x178	5.25x86
Cooler Type	UNAX	UNAX
Cooler Dimensions	10x1.95x19.8	9x2.55x25.2
Preheater	2 stage	2 stage
Cyclones	2x5.5+4x3.6	3x6.9+1x6.6+2x4.
Production Rate	1900	3000
Heat consumption (kcal/kg	905	707
Temperature,C		
Cyclone 5	-	832
Cyclone 4	-	730
Cyclone 3	-	596
Cyclone 2	710	459
Outlet Gas Temp. After preheater	440	287
Pressure mm WG	485	125
Energy Consumption Kiln+ID fans (kW)	11.3	9.9

densified - phase pneumatical conveyor where the principle is to carry the solid phase with minimum gas acceleration, system requires 50 % less air thus decreases the fixed investment (3).

II.3.3.INCREASE IN ADDDITIVE USAGE

One third of the world cement production consists of composite cement. The ash content in worldwide production is more than 40 million tons. In Mediterranean countries some arbitrary packing materials like silica dust and calcer dust are used as additives.

The additive usage has risen from 17.7 % in 1982 to 23.3 % in 1987.

II.3.4 MISCELLANEOUS

Recent advances in ceramic technology provided the use of chrome - magnesite bricks for their extensive strength against hostile conditions.Kiln - stops are among the main problems of this industry.Periklas-spinel technology (3) is a recent method in the production of certain chrome-magnesite bricks which are 2 to 3 fold more resistant than the conventional ones. In preheater inner surface zirconium - silicate based refractory materials are used.These decrease the shut downs and maintenance so that their high cost can be compensated.

II.4.CURRENT TECHNOLOGICAL LEVEL OF TURKISH CEMENT INDUSTRY

The wet kilns have been converted into dry kilns since 1965,in Turkey.Until 1973,the major objective of this conversion was to increase production, after that,fuel saving also became an important factor.

Presently, majority of, existing plants are operating with either processing scheme B or C,and modernization of the remaining plants which utilize scheme A is pending.

In Turkey most of the plants operate under the optimum production levels. The only exceptions are Mediterranean-Agean and Marmara coastal plants. Typical measures toward capacity increase which are widesprend in EC countries are also under construction or adaptation stages in Turkey.The advantage of trass cement (a mixture of volcanic tuff and lime,used as additive.) usage seems not to be realized by the authorities.

CHAPTER III

ECONOMICAL BACKGROUND

III.1.MARKET ANALYSIS

Recent developments in the international cement market can be summarized as follows:

Besides Taiwan and South Korea, who have recently experienced a decline in their exports, new exporters especially in North America have emerged. These countries are Mexico,Columbia and Venezuella.

From the point of demand,the dominancy in market shifts towards USA and North Africa from Middle East. Since 1984 Saudi Arabia has decreased its import from 12 million tons to 4.5 million tons in 1986.Kuwait,Iraq and Syria experience the same conditions.

In Turkey, export - import pattern has shown an alternating character due to a variety of reasons as explained in section(I.2). Between 1981 -1982 a peak level in exportation has been reached.

The main exporters and importers in the world are given in table (3.1).

Table 3.1 Main cement exporters and importers (3).

MAIN EXPORTERS (1987)		MAIN IMPORTERS (1986)	
Country	Exp.(1000tons)	Country	Imp.(1000tons)
GREECE	7018	USA	14.804
S.KOREA	4800	EGYPT	5.363
SPAIN	4748	S.ARABIA	4.500
MEXICO	4569	HONG KONG	4.134
JAPAN	4283	HOLLAND	3.075
CANADA	4200	CHINA	3.000
TAIWAN	3000	ALGERIA	2.472
RUSSIA	2800	SINGAPORE	2.103
ROMANIA	2000	W.GERMANY	1.814
FRANCE	1945	KUWAIT	1.750

But due to war and the emergence of cement industry in developing countries the exports could not be kept at the same level falling to a restricted level of 343.000 tons/year in Turkey.(Table 3

A small amount of 500.000 tons per year of exportation till 1995 is forecasted(3).This forecast is attributed to the following reasons:

a) The cement demand from Turkish Republic of Northern Cyprus

b) The need to continue the relationship between our present markets.

c) Compensation towards regional and seasonal demand fluctuations.

Table 3.2 Turkish Cement Export x 1000 tons

	82	83	84	85	86	87
Clinker	182	266	88	92	119	117
Cement	4.001	2.105	2.137	1.761	1.130	226

The variation of cement production per capita with GNP in Turkey is presented in figure (3.1)

For comparison purposes situations in USA, France and Japan are also given in figures (3.2) to (3.4).

Cement demand and domestic production in Turkey are presented in Table (3.3) (19).

In order to forecost the national demand up to 1995,figure (3.5) suggests that the following model can be used.

$$\ln D = a + by$$

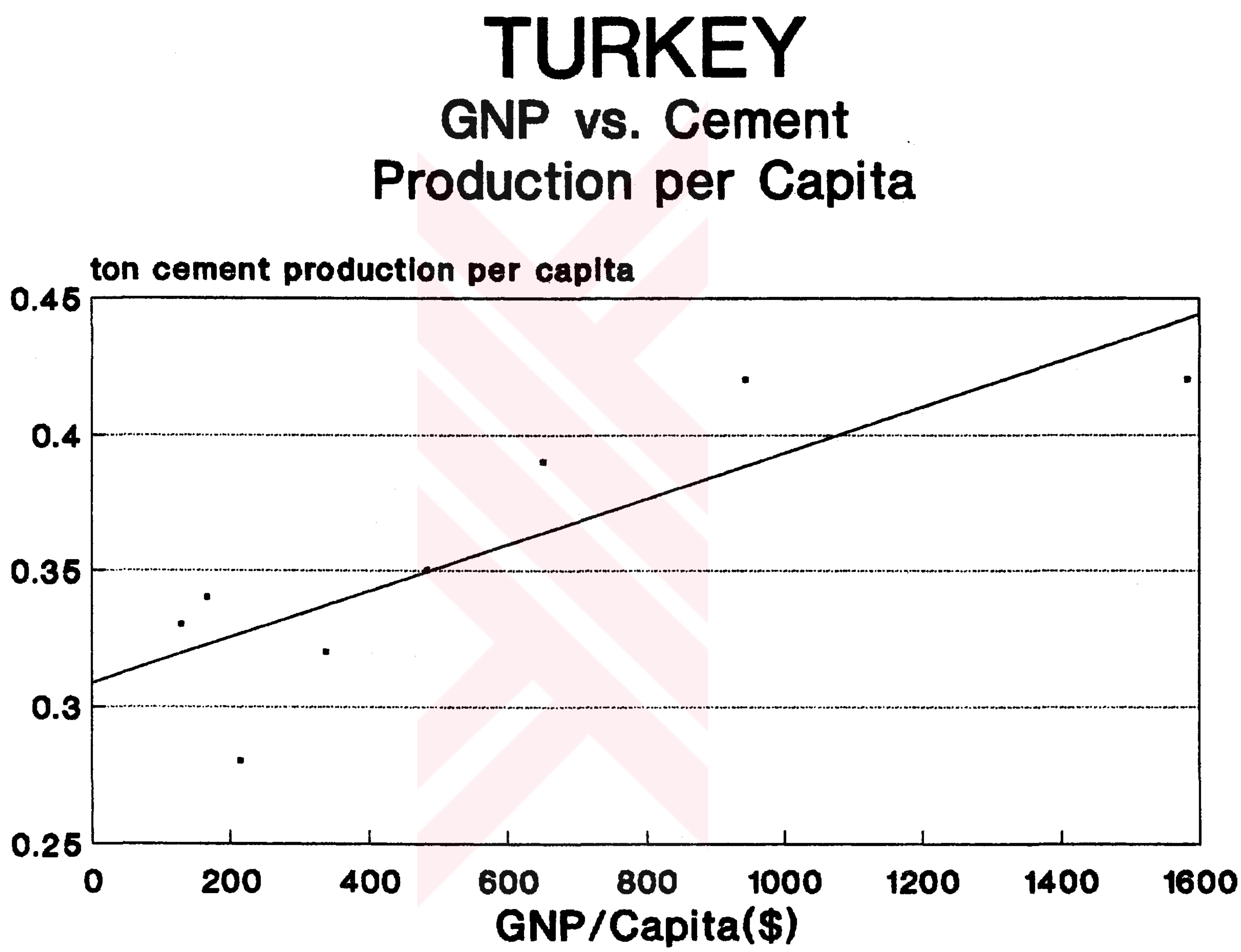


Figure 3.1 GNP versus Cement Production per Capita,Turkey

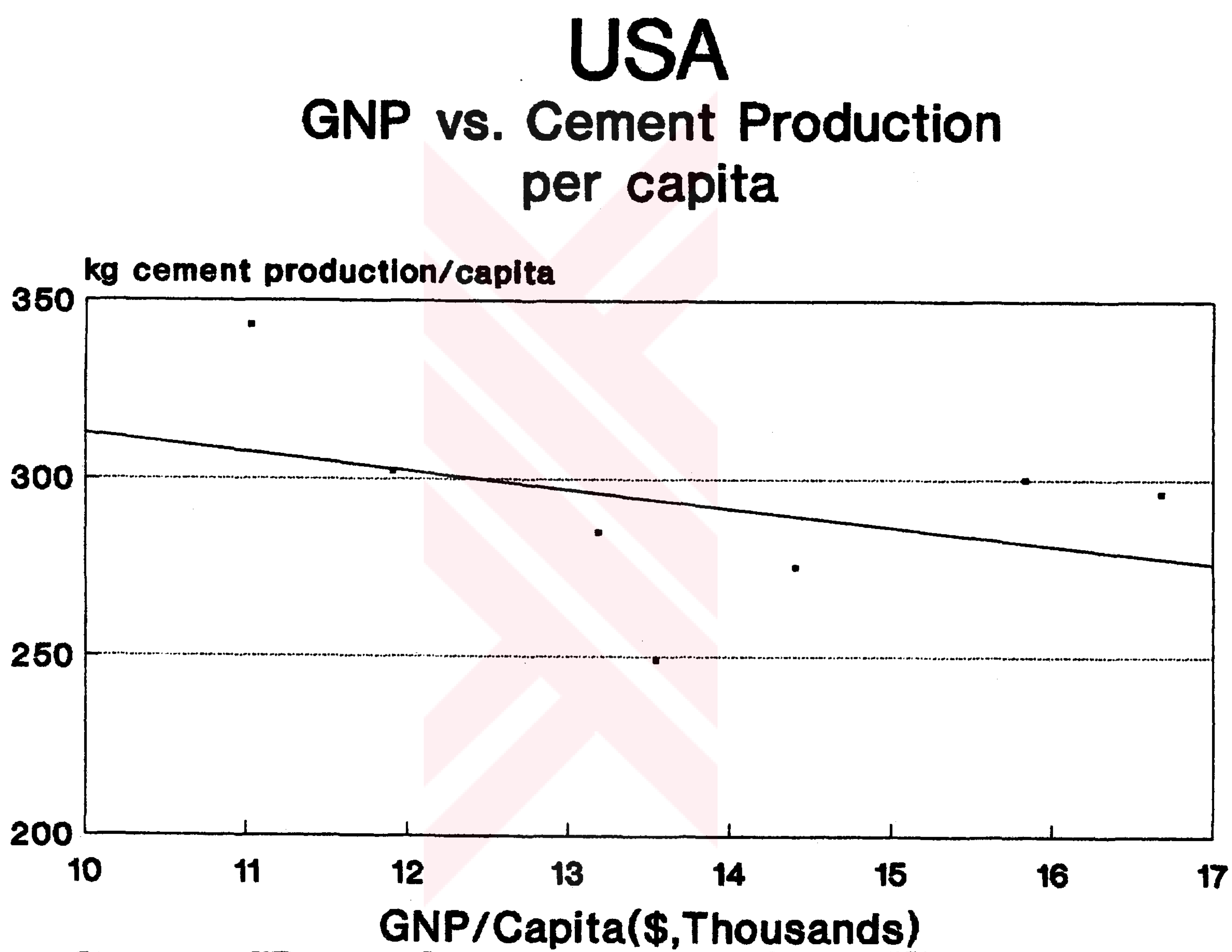


Figure 3.2 GNP versus Cement Production per Capita, USA

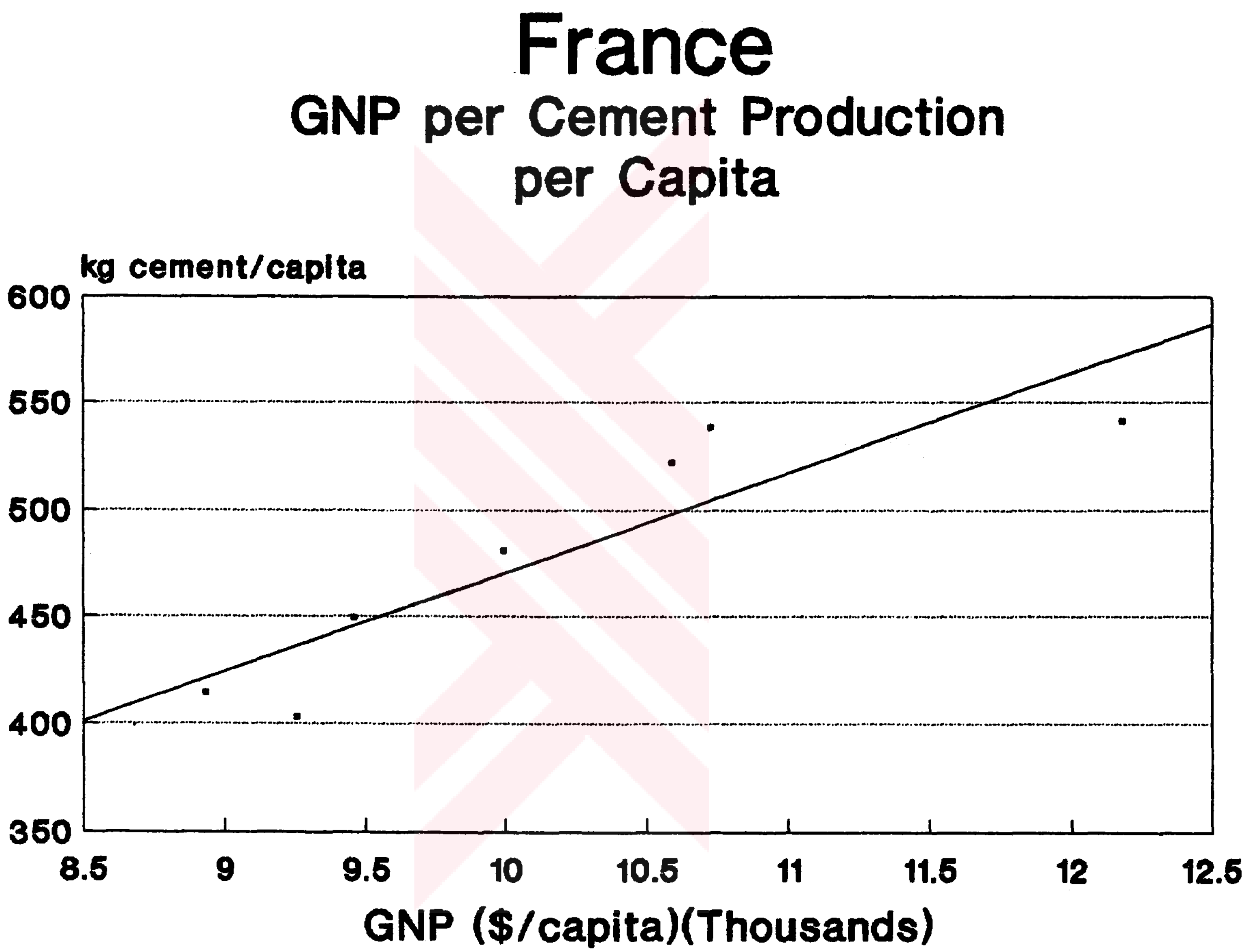


Figure 3.3 GNP versus Cement Production per Capita, France

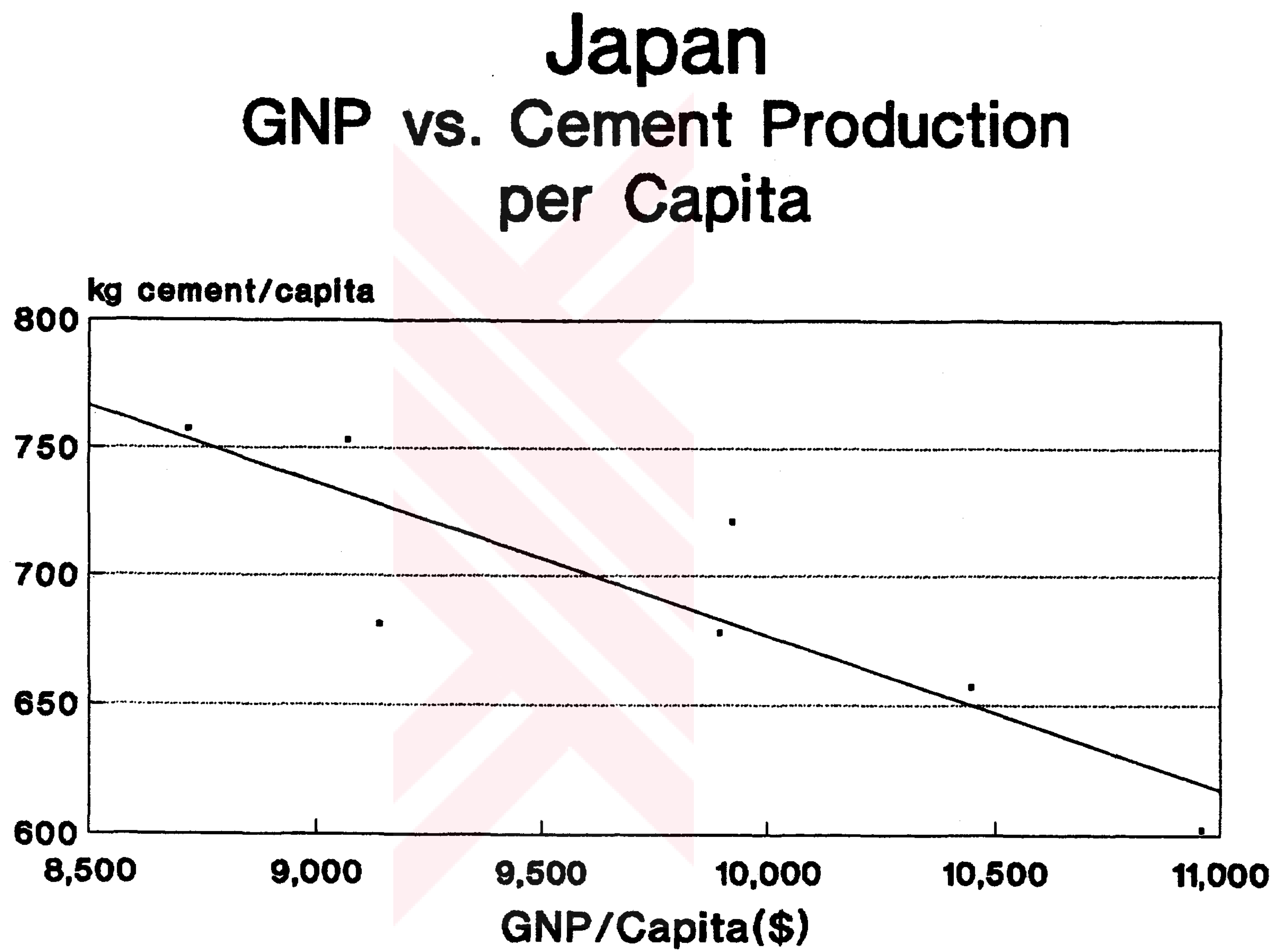


Figure 3.4 GNP versus Cement Production per Capita, Japan

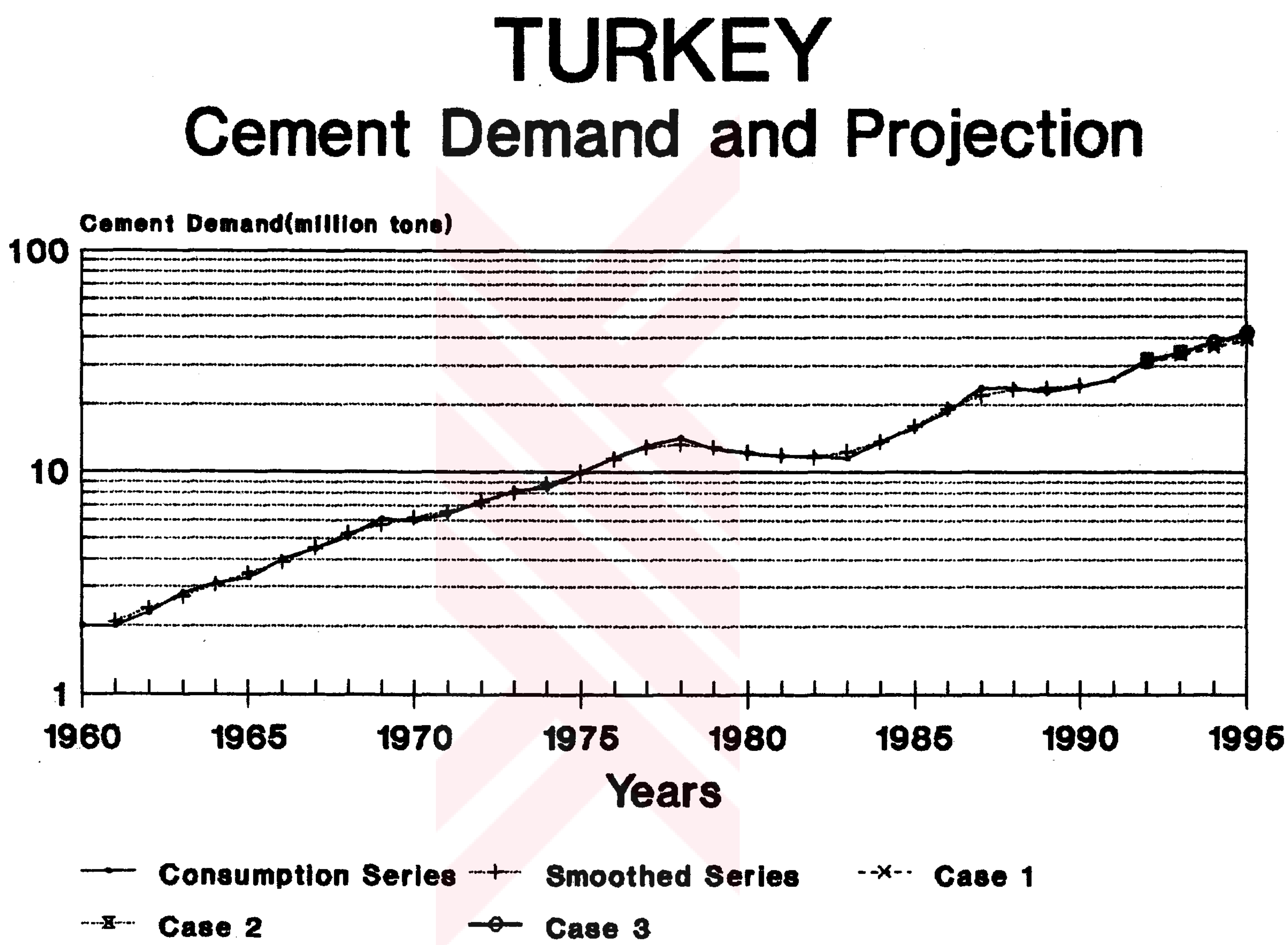


Figure 3.5 Cement Demand and Projection in Turkey

Table 3.3 Turkish Cement demand and production

(million tons)

YEARS	PRODUCTIONS	DEMAND
1960	2	2
1961	2	2
1962	2.3	2.3
1963	2.7	2.8
1964	2.9	3.1
1965	3.2	3.3
1966	3.8	4.0
1967	4.3	4.5
1968	4.7	5.1
1969	5.8	6.1
1970	6.4	6.0
1971	7.5	6.4
1972	8.4	7.3
1973	8.8	8.2
1974	9.0	8.5
1975	10.8	9.9
1976	12.4	11.5
1977	13.8	13.0
1978	15.3	14.1
1979	13.8	12.7
1980	12.8	12.1
1981	15.0	11.7

Table 3.3 Continued

YEARS	PRODUCTION	DEMAND
1982	15.7	11.7
1983	13.6	11.5
1984	15.7	13.6
1985	17.5	15.7
1986	20.0	18.7
1987	22.0	23.7
1988	22.6	24.0
1989	23.8	23.0
1990	24.7	24.2
1991	26.4	26.0

Where D is annual demand in million tons and y is year, represented by only the last two digits. Linear regression using (i) actual data between 1960 and the present,(ii)smoothed data between 1960 and the present, (iii) actual data between 1983 and the present produced the results presented in Table 3.4.

Cement Industry is generally considered as energy intensive,raw materials being abundant in nature, hence relatively cheap.The general structure of production cost of cement is given Table (3.5).

Table 3.4 Demand Projection up to 1995

YEAR	case 1 a=0.07868 b=-3.80427	case 2 a=0.08066 b=-3.9572	case 3 a=0.09866 b=-5.6306
	r=0.974	r=0.974	r=0.942
1992	31.03	31.94	31.40
1993	33.58	34.63	34.65
1994	36.31	37.54	38.24
1995	39.29	40.69	42.21

Table 3.5 Production cost of cement (3)

Component	**%**
Raw Material	7 %
Auxiliary and operating materials	10 %
Fuel	15 %
Electricity	20 %
Labour	10 %
Depreciation	25 %
General Expenses	3 %
Other	10 %

For comparison purposes, the structure of production cost of cement in Turkey is also presented in Table (3.6)

Table 3.6 Production cost of cement in Turkey,1988 (3).

Component	%
Raw material	7.4 %
Auxiliary and operating materials	10.8 %
Fuel	25.6 %
Electricity	24.2 %
Labour	5.6 %
Depreciation	11.2 %
General Expenses	3.7 %
Others	11.5 %

The main difference between two tables is observed in fuel and depreciation items.Fuel,as a cost item has decreased from 25 % to 15 % especially since 1987 in EC countries.Electricity also decreased from 24 % to 20 %. Both of these show that Turkish Cement Industry is suffering from high cost of energy which should be drawn below the current levels in the fortcoming years.

III.2.LOCATION ANALYSIS

In general, world trade in cement is shrinking primaly due to the fact that transportation costs prohibit transfer of cement over long distances. For instance, transportation by land for distances over 500 km, may add almost 10 % to the local price of cement.

Therefore, regional demand structure should be properly taken into account in selection new sites for cement plants. The capacity expansion projects at existing plants should also be evaluated on the same basis. Furthermore, the regional demand analysis should include neigboring countries as well since Iraq and Iran are expected to constitute a hot market in post war area.

Availability of cheap new material sources is also a significant factor affecting site selection. The erection of a plant in Denizli is a good example in this respect. Limestone cost is almost one half of the regular market price for this plant (29). Hence regional distribution of raw material sources should also be analysed prior to site selection.

III.3. PRICE ANALYSIS

As for market price of cement in Turkey, expect for a period between 1982 - 1986 a steady value exceeding 45 $ / ton is observed, figures (3.6) and (3.7).

According to the objectives stated in the Sixth 5-year Development Plan, an average annual increase of 8.2 % in production is foreseen and demand will be entirely supplied by domestic production.

The regional distribution of Turkish cement industry, is interest as indicators of where new investments in this industry will be realized. This information is provided in Table (3.7)

Table 3.7 Regional Distribution of Turkish Cement Production in 1988. (3).

Region	% Production	Number of Plants
Marmara	26.80	9
Aegean	12.29	4
Meditter	14.46	4
Blacksea	11.63	6
Central Anatolia	16.37	8
Eastern Anatolia	4.93	4
S.East.Anatolia	13.50	6
Total	100.00	41

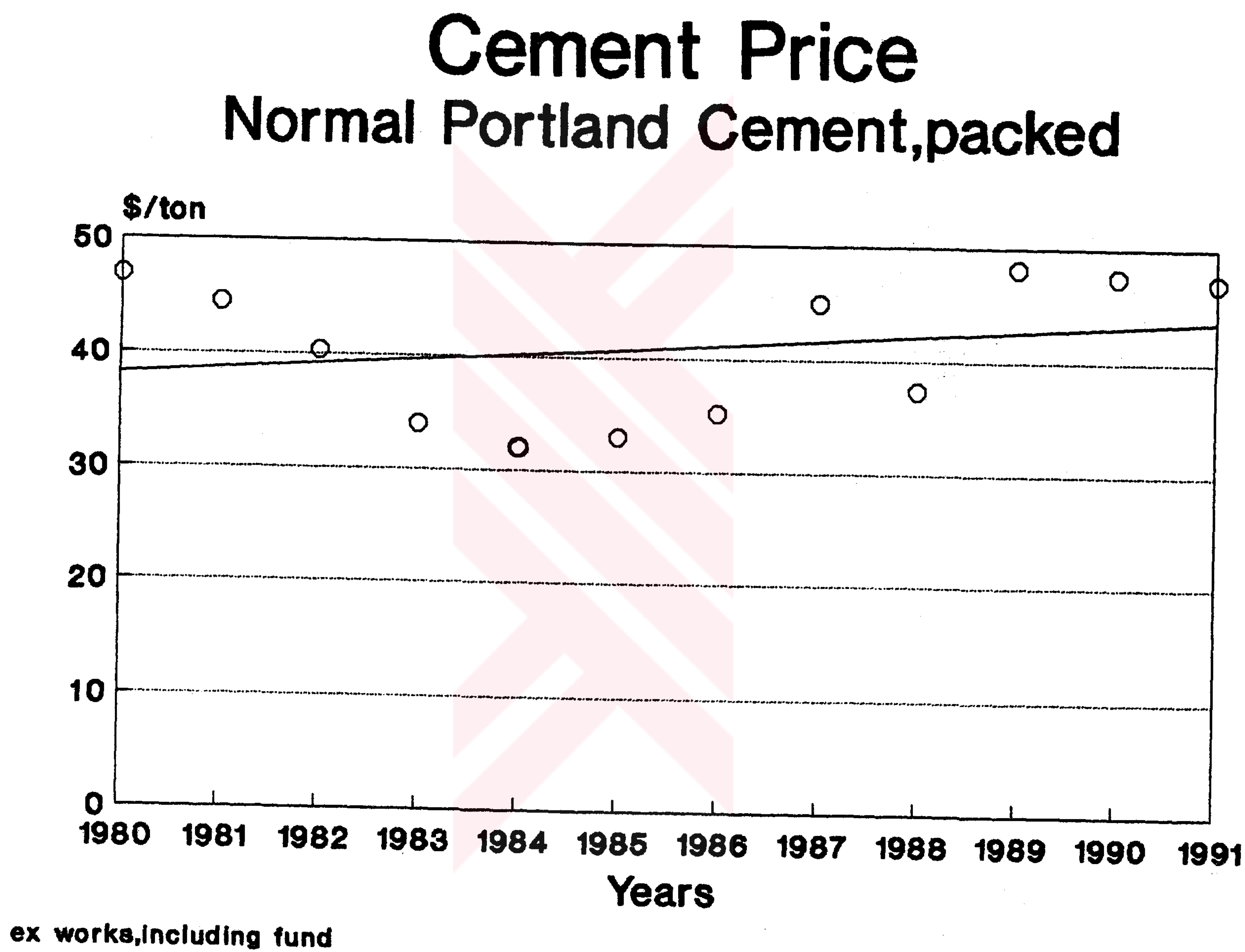


Figure 3.6 Normal Portland Cement Price

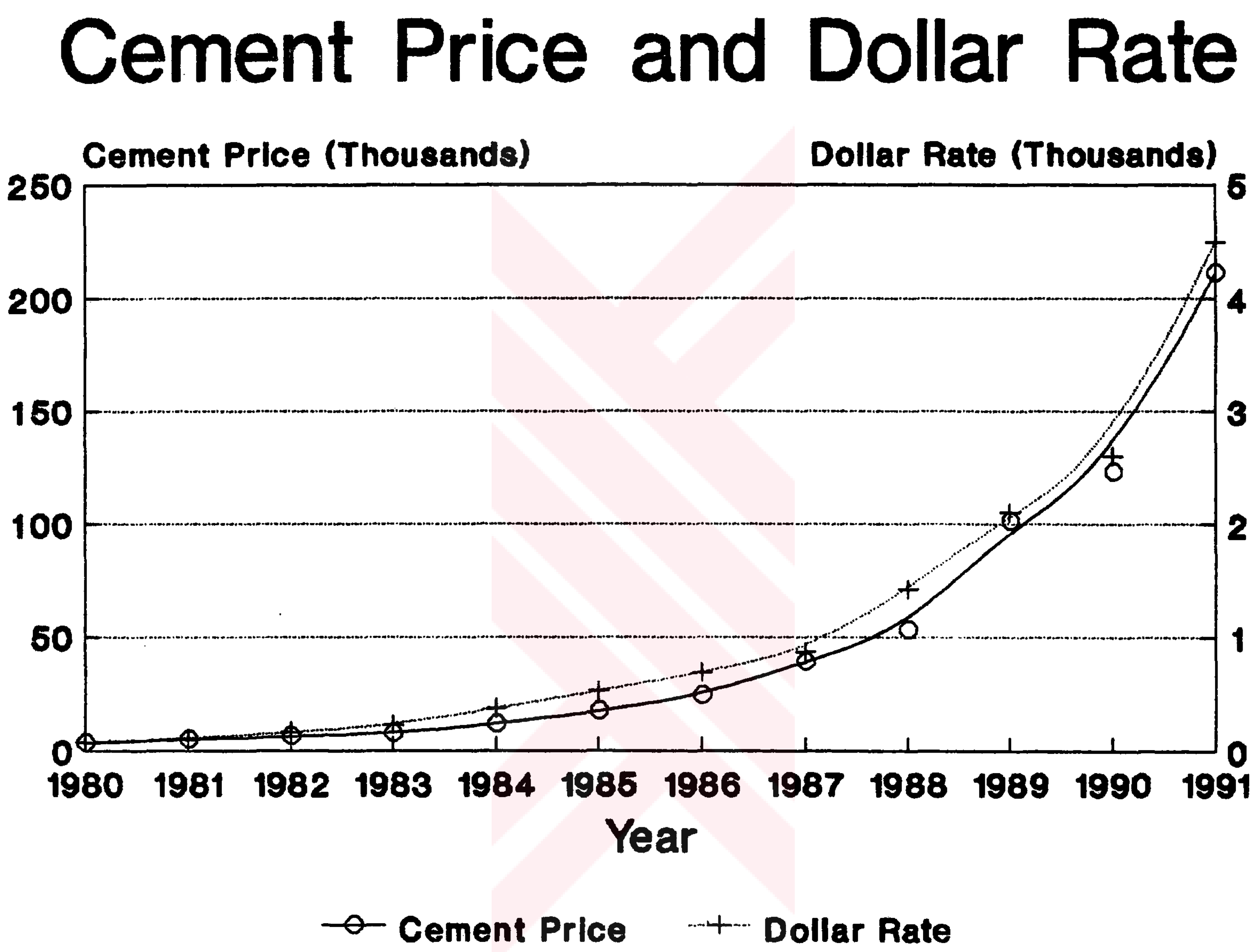


Figure 3.7 Cement Price and Dollar Rate

CHAPTER IV

METHODOLOGY

IV.1. GENERAL APPROACH

In order to conduct a successful economical evaluation one needs a reliable cost model of any given cement manufacturing plant together with cost models for raw materials and products which preferably include effects of trends in world markets as well.In evaluting all these,certain prameters;like inflation rate and its effect on labour, raw material cost, maintanence etc. should be estimated. Since the cost model of any manufacturing plant is strongly dependent on the selected processing scheme and capacity,sufficient information on available technologies is required.Costs of main equipment items and their dependence (if any) on capacity should also be known (21), and in the absence of accurate data, reliable estimation methods should be employed.

An extensive literature and market (domestic and foreign) survey was conducted to compile the relevant information and data. Then the cost models were developed and combined to obtain an overall perspective of the cement industry.All these models constitute the necessary input to an evaluation procedure via any suitable method.

Some of the most common economical analysis methods are the following:

1. Discounted Cash Flow Method
2. Payout Time Method
3. Net Present Value Method
4. Capitalized Cost Method

In the discounted cash method, the aim is to analyze the return on investment so as to compare to with the interest which will be paid for the capital. In the payout time method the objective is to determine the period in which the initial investment is recovered In the net present value method the value of the project at the end of its' useful life is computed utilizing a given rate of interest. Capitalized cost method is essentially a present worth comparison where economic lives are indefinitely long in the eyes of the analyst.

In the present study, discounted cash flow and net present value methods are utilized since they take time value of money into account. Although these two methods are philosophically different, governing equations are the same, i.e., same set of equations are used. However, in the discounted cash flow method, a rate of return which makes the present worth zero at the end of useful project life is found by an iterative method whereas in the other approach, present worth at the end of useful project life is calculated, given the interest rate. Both methods are necessary to analyze different situations encountered by prospective investors in cement industry. Therefore both are employed in this study.

The cement plant improvement reports, company bids for usually complete cement plants and books of recent advancements were the main sources in the compilation of technological data (1,3,17,22,23,24,25,26). The bids were used as a basis for cost modelling of main equipment items. In case of capacity dependence, the cost vs capacity coefficients (scale up coefficients) were utilized(15,21,24,27).

In compiling economical data, the main aim was to evaluate fixed investment and annual manufacturing cost components item by item. These items are expressed as a percentage of total physical cost (28,29,30,31,32,33, 34,35).

For a quick, yet accurate and detailed analysis of any given project under different economic scenarios and with alternative technologies,a computer programme was devoloped and employed to evaluate different projects and to perform sensitivity analysis on key technological and or economical parameters.In order to provide flexibility to the users,discounted cash flow and net present value methods were both included in this program.

Today,cement industry mainly relates with the cost of energy. The energy economy or specifically coal economization is at the highest level recently.Any potential increase in the coal prices will of course increase production cost of cement.This was the case in past with rotary kilns employing fuel oil for calcination.As a result, all the rotary kilns have been converted to coal combustion for the past 10-15 years. Consequently, any sharp change in the coal prices is expected to affect the clinker production cost considerably.

Another parameter is labour rate. It is expected to increase sharply in the coming years in Turkey. The effort for unification to EC must take Turkish annual earnings per capita from $ 1,500 in 1989 to $ 6,000 or $ 7,000 in about 5 to years. This difference may be significant from the point of cost in the coming years.

The technology will, except some details, remain the same for clinker and cement production. Only the chemical additives shall evidently experience significant improvements.

However minor alterations in avaible technologies may significantly affect thermal energy requirement per unit production.

Consequently,energy price,labour rates and energy per unit production are the primary selection for sensitivity analysis. Annual capacity utilization and different scale-up coefficients for certain equipment items (when in doubt) are also employed in the sensitivity analysis.

IV.2.DISCOUNTED CASH FLOW AND NET PRESENT VALUE METHODS

Discounting puts cash flows on equal footing or more precisely,evaluates each year's flow on an equal basis.It does this by means of the Discount or Present Value Factor, which is the reciprocal of the Compound Interest Factor,$(1+i)$,with i=interest rate,and n = the year in which the interest is compounded. Each cash value is evaluated by computing its present value.This is done by taking a cash flow of year n and multiplying it by the discount factor for the nth year.

$$\text{Present value of } Cn = Cn \left[\frac{1}{(1+i)^n}\right] \qquad (1)$$

In general cash flows are the funds generated b yan investment over the estimated life of a project.

$$Cn = Pn + D \qquad (2)$$

where Pn = net profit after taxes and

D = depreciation

The governing equation for discounted cash flow and net present value methods is:

$$NPV = Co + \frac{C1}{(1+i)} + \frac{C2}{(1+i)^2} + \ldots + \frac{Cn}{(1+i)^n} \qquad (3)$$

In the above equation, NPV = Net Present Value, Cn = Cash flow for year n and i = Interest rate, or rate of return , ROI / 100.

Cash flow for each year is the algebraic sum of revenues and the expenditures for that year. Revenues include annual total sales and depreciation. Coal consumption,electricity, raw and side materials,labour expenses,maintenance,depreciation (both for machines and buildings) and other general expenses as managerial, social, research and development,financial expenses etc. are among the main expense components.

If it is assumed that the investment is made in year 0{i.e.Co=I} and cash flows over the project life are constant equation (2) is simplified as below;

$$NPV = [\ C \sum_{n=1}^{n} \left(\frac{1}{1+i} \right)] - I \qquad (4)$$

The $\frac{1}{(1+i)}$ series in equation 4 is a geometric progression whose sum can be expressed as the single term:

$$\sum_{n=1}^{n} \frac{1}{(1+i)} = \frac{(1+i)^{n}-1}{(1+i)^{n}} \qquad (5)$$

When equation (5) is replaced in (4) the following

$$NPV = C \left[\frac{(1+i)^{n}-1}{i(1+i)^{n}} \right] - I \qquad (6)$$

In case, in equation (6), NPV is set equal to zero, the interest rate (IRR) that makes the future cash flows equal to the investment (the " breakeven " point) can be calculated;

$$I/C = \frac{(1+i)^{n}-1}{i(1+i)} \qquad (7)$$

Where; I = Capital investment, C=Annual cash flow, i=Rate of return (=IRR/100) and n = years of project life. The I/C is called as the payback period.

In case of an annual escalation rate applied to annual cash flows of equation(3), NPV will be as below:

$$NPV = Co \frac{C1(1+e)}{(1+i)} + \frac{C2(1+e)^2}{(1+i)^2} + \ldots + \frac{C(1+e)^n}{(1+i)^n} \quad (8)$$

Where, e=escalation rate

In order to extract meaningful and reliable information from a discounted cash flow or net present value analysis, accurate estimates of capital investment annual revenues and expenditures are essential. It is evident from the foregoing discussion that such analyses are also highly dependent on project life.

Questions arise as to what value of (i) should be the benchmark for investment decision ? In the NPV method, an (i) value greater then the benchmark is selected to see if NPV will be positive. In the IRR method, the calculated (i) must be greater than the selected benchmark for the investment to be accepted.

Usually, a company sets a minimum (i) as benchmark. This is known as the Average cost of the Capital (ACC).

In general,larger corporations select an ACC between 10 and 15 % (36).

IV.3.COMPUTER PROGRAM

In implementing the cost model of a cement plant,a computer program is employed.The program utilized in this work is a spreadsheet part of Microsoft Corporation`scomplete software package named Works; version 2.00 . In order to construct the cost model of a cement plant,all major equipments and accessories are listed.Each of them is scaled up to current capacity by the use of certain exponents.As the inputs,the operator should give current Marshall and Swift Index and current capacity as tons clinker per day.All the costs of equipment, accessories, their related installation costs as well as other fixed investment parameters, whose sum constitute the total fixed investment are computed.

A similar approach has been employed to astimate annual production costs which consist of different components such as labor,raw and auxiliary materials, coal and electricity.

In labour; an approximate value for wage and salary per person is given as input.Raw and auxiliary material sections utilize data from coal section where ash content, specific fuel consumption,heat value are given as input.

Once the data are given, related sections automatically give out the desired output,the sum of which constitute the total annual production cost.

The software package allows the oparator to print not only the whole cost picture but also separate tables or even just one compact table describing all the operations in brief.

Sample output and menu the computer program is provided in the Appendix.

CHAPTER V

COST ESTIMATION

V.1.CAPITAL INVESTMENT

Capital investment is the monetary outlay required for the erection of production facilities and their ultimate operation.There are two types of capital;fixed and working.

V.1.1.FIXED INVESTMENT

Fixed investment represents the investment in production facilities.In general 85 to 90 % of total capital is comprised of fixed capital.It may be defined as the total cost of processing installations, buildings, auxiliary services and engineering involved in the creation of a new plant. The first primary subdivision of fixed capital is the physical plant cost,which is the sum of all equipment, material and labor expenditures incurred in the actual construction of plant facilities.The direct plant cost is the sum of physical plant cost and engineering and project expenses (37,38).

A typical fixed investment structure for a solid processing plant is given below.

Table 5.1 Fixed investment structure for solid processing plant.(39,40)

Machine and Accessories	100
Pipes	14
Installation	43
Electrical Facilities	15
Buildings	35
Land and Yard Improvements	13
Side Services	20
Field Cost	6
Total Physical Cost	246
Engineering and Project	30
Direct cost	276
Contractor's Fee 7 %	19
Contingency 15 %	41
Fixed Capital	336
Working Capital	60
Capital Investment	396

In actual company bids which were used as sources of cost data in this study,a single price is quoted for the sum of machine and accessories, pipes, installation and electrical facilities items. Consequently, in the computer program items given in Table (5.1) are calculated as follows:

$$\text{Machines and Accessories} = \frac{100}{172} \times \text{(Quoted Price)}$$

$$\text{Installations} = \frac{43}{100} \times \text{Machine and Accessories}$$

$$\text{Pipes} = \frac{14}{172} \times \text{Machines and Accessories}$$

$$\text{Electrical Eq} = \frac{15}{100} \times \text{Machines and Accessoriors}$$

Engineering +Project0=0.058 x Machines and Accessoriors

Analysis of actual plant cost data revealed that estimation of field cost as suggested in Table (5.1) yields unrealistically high figures for Turkey. Similarly ,land and yard improvement are not expected to exceed half of the field cost in Turkey.

Consequently , estimation of these two items are modified as described below ın order to conform with the actual situation in Turkey: Land cost is taken as $ 250.000 as a maximum. Construction is considered to be fıve times greater than land cost while land and yard improvements cost is taken as half of the land cost ,namely $ 125.000. Machines and accesssories (most of them being in General Equipment Items) of all the unit operations in a typical cement plant are given below.

A) Longitudinal and Circular Blending Bed for Lime
Stone
Belt Conveyors
Stackers
Electrial Equipment for stackers
General equipment (rails with accessories, chutes, pipes)

B) Raw Material Grinding Plant
Belt Conveyors
Roller Mill

General Equipment (Magnetic seperators , fans, hot gas generator,compensators,chutes,pipes, erection device etc.)

C) Raw Meal Transport
Conveyors

D) Raw Meal Blending
(Aeration System

E) Kiln Feed
(aeration System,discharge apparatus)

F) Preheater,Kiln,Cooler
Dopol Preheater
Calciner
Rotary Kiln

Grate Cooler

General Equipment (fan,coal dust firing,air duct, aeration unit)

G) Cement Grinding Plant

Grinders

Gen.Eq.(metal detector,oven belt magnetic seperator etc.)

H) Coal Grinding

Roller Mill

Gen.Eq.(Screw conveyor, erection device,fan,throttle etc.)

I) Coal Dosing Plant

Coal dust silo , silo cone , compressors , pipes,discharge apparatus,cellular feeder etc.)

J) Measuring and Control System

Control and Panel Instrumentation

Costs of various equipments and their accessories were scaled up to the desired level by using certain exponents as listed in Table 5-2

With the structure as described above, one will have to know the current Marshall and Swift Index and desired capacity.With these two,all the main items of fixed capital can be computed.

Table 5.2 Scale-up exponents for main equipments.

Equipment	Exponents	
	Ref(21)	Ref(27)
Belt conveyor	0.90	from graph
Conveyors	0.65	0.76
Rotary Kiln		0.48
Fluid Bed Calciners	0.60	from graph
Cyclone Separators	0.64	"
Instrumentation	0.60	"
Ball Mills	0.65	"
Roller Mills	0.65	0.70
Air Coollers	0.80	from graph
Grinders	0.65	"
General Equipment	0.68	"
Storage Tanks	0.30	
Electrofilter	0.68	

In the computer program , two main conversions are made to calculate machine and accessories. First , the costs are brought from a 1987 basis to the present time This is done by Marshall and Swift Cost Indexes.User enters the current index and gets the current costs of a reference capacity. Then a scale-up procedure is applied to each equipment by means of certain exponents

(21,27).Many other methods and exponents are given in the literature(27,28,29,30,31,32,33,38,39,40,41,42,44)

V,1.2. WORKING CAPITAL

Working capital may be defined as the funds necessary for the normal conduct of business (39). In general it will be found to be an amount equal to 10 to 15% of the fixed-capital investment or 25% of the annual product sales value. It includes raw material stocks, in-process inventory,product inventory,extended credit and funds available for the payment of wages and other expenses (available cash).

In this study working capital is calculated as 15% of total fixed capital investment. In the computer program another option is available where working capital can be estimated item by item as described in Table(5-3)

V.2. ANNUAL MANUFACTURING COSTS

The annual manufacturing costs contain direct production costs, such as raw and operating materials,labour,coal,electricity and other expenses and indirect costs such as depreciation,taxes and general expenses.

Table 5.3. Components of Working Capital (40)

ITEM	ESTIMATION
Raw Material Stock;depends upon raw material quantity, values,availability,sources material demand and preservation conditions.	1-2months of raw material
Product Stock;depends on whether the material is consumed throughout the whole year or not.	1 month's Production cost
Product Customer's Account;an amount of capital equivalent to the goods sold to customers	Sales of one month
Cash demand ;required for wages, services and materials	Prodction expenses of 1 month

V.2.1. RAW AND OPERATING MATERIALS

These include limestone , marn-clay as main inputs and lime as the side raw material. The ash content of the coal is added as raw meal into the rotary kiln. In the computer program raw meal is assumed to be 80% limestone and 20% marn and clay.At this point , the raw meal contains 1.22 tons of limestone and 0.32 tons marn and clay per each ton of clinker.

Given a certain type of coal with a known ash content , the corresponding amount of ash to be added into raw meal and thus the theoretical amounts of raw meal components can be corrected accordingly.

Limestone,marn-clay and lime prices are brought up to date by taking the prices in 1988 as a basis (3).

Table 5.4. Raw and operating material prices

Raw Materials		
Limestone	1.64	$/ton
Marn-Clay	1.11	$/ton
Lime	6.72	$/ton

Table 5.4 Continued

Operating Materials		
Pebbles	0.92	$/kg
silpep	0.92	$/kg
plate	4.04	$/kg
Magnesite Brick	0.40	$/kg
Alumina Brick	0.43	$/kg
Paper Bag	0.12	$/kg
Grease Oil	1.08	$/kg

V.2.2. LABOUR

As a non equipment item , labour has been calculated on average annual salary. To this , certain funds,security and sick leave costs are added. As labour hours scale-up exponent,0.25 is used (21).

Avoiding confusion due to a wide range of wage and salaries for various worker status,an average value of $4500 on annual basis (1991) is taken per each worker. Sick leave and others are calculated by taking 15% of total annual wages and salaries.

V.2.3. COAL

The available coal's calorific value and specific fuel consumption are also given as input. By these two, the amount of coal per each ton of clinker is determined. Knowing unit price of coal ,production cost due to coal consumption can easily be calculated.

V.2.4. ELECTRICITY

The distribution of electrical energy consumption among principal units of cement plants is given below

World standard is around 110-115 kw/hr per ton of clinker produced.

Table 5.5 Distribution of electricty consumption in a cement plant (Kwhr/ton clinker)

System	A	B	C
Rotary Kiln	24.26	20.81	21
Cyclone Fans	9	9	9
Others	82	82	82
Auxiliary Facilities	3	3	3

V.2.5 DEPRECIATION

In this study an annual average of 10 % is taken as the depreciation rate. Recently accelerated depreciation is also utilized in industry.An investment can be completely depreciate in four years according to tax regulations.This is no doubt,an advantage in small and middle sized plants.But in an investment with the magnitude of ten millions of dollars, accelerated depreciation causes all the investment to be depreciated in the first few years and in the succeeding years cousing big expansion in before-tax revenues.From book-keeping point of view, accelerated depreciation also reflects the first years of investment as being in loss.This situation is not desirable for tax offices.Due to all these,accelerated depreciation is not found to be suitable for cement case.

V.2.6.GENERAL AND OTHER EXPENSES

After electricity,labour,coal, raw and operating materials in the operating costs are computed, general expenses and other costs are found.General expenses are considered to be 4 % and others as 11 % of annual operating costs. So 15 % of operating costs are estimated from a real calculation of 85 % portion.

V.2.7.ANNUAL TOTAL SALES

Total sales are found by multiplying annual cement capacity with the cement price per ton. The price as well as capacity are given as input.

CHAPTER VI

RESULTS AND DISCUSSION

The result of internal Rate of Return Analysis for various capacities, Breakeven Capacity Analysis for various interest rates and various other scenarios are presented either in graphical or tabular from in this chapter and in Appendix. In these analyses, useful life of a typical cement plant is taken as nine years (45).

The operating material prices as well as other important technological parameters employed in the analyses are given in Table (6.1)

Table 6.1 Operating material prices and other technological parameters.

Lime	6.72	$/ton
Pebble	0.92	$/kg
Silpeps	0.92	$/kg
Plate	4.04	$/kg
Magnesite Brick	0.40	
Alumina Brick	0.43	
Grease Oil	1.08	
Paper Bag	0.12	$/piece

Table 6.1 Continued.

Capacity Utilization	330 days/year
Electricity	0.0538 $/kwhr
Coal	33 $/ton
Heat Value of Coal	23.012 kj/kg
Heat Consumption(per ton of clinker)	taken from Table 2.5
Selling Price of cement	46 $/ton

VI.1.GENERAL REMARKS

NPVS at various interes rates and different capacities shown in Tables (6.2),(6.3), and (6.4)

From fig. (6.1) of fixed investment versus Capacity, exponent for Processing Scheme A is found to be 0.58 and 0.59 for schemes B and C.

This a significant departure from literature (27) where reported capacity exponents for cement plants are approximately unity. It is highly probable that such exponents have been based on rough estimates and detailed cost models similar to the one developed in this study have not been utilized.

In fig (6.2) Interest Rate versus Break-even Capacity is shown. Scheme B and C experience lower break-even capacities than scheme A at the same interest rate. As the interest rate increases the difference between Processing Scheme A, B and C increases.

Break-even Capacities versus Interest Rate analysis drives us to the fact that 1500 tons clinker/day is a minimum capacity to be employed if an internal rate of return of 0.15 is expected.

In fig (6.3) Capacity versus Annual Production Cost is shown.This shows that Annual Production Costs are almost proportional with capacity changes.Ratio of Fixed Investment to Annual Production costs are given as 1.32,1.38,1.38 for processing schemes A, B and C respectively.

System A must also be rejected from the point of production costs since B and C are 7 % below than the annual production cost of processing scheme A.

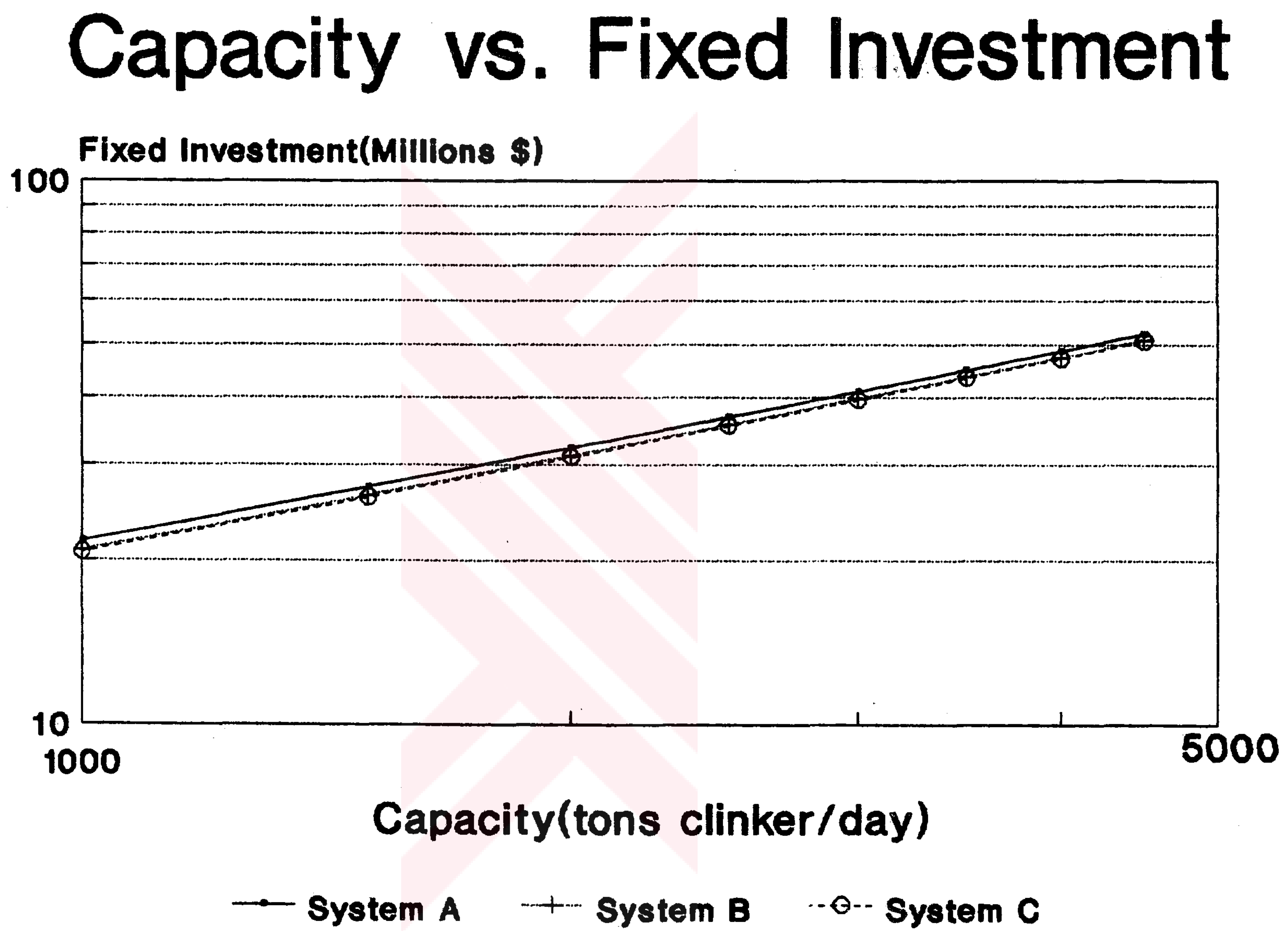


Figure 6.1 Fixed Investment versus Capacity

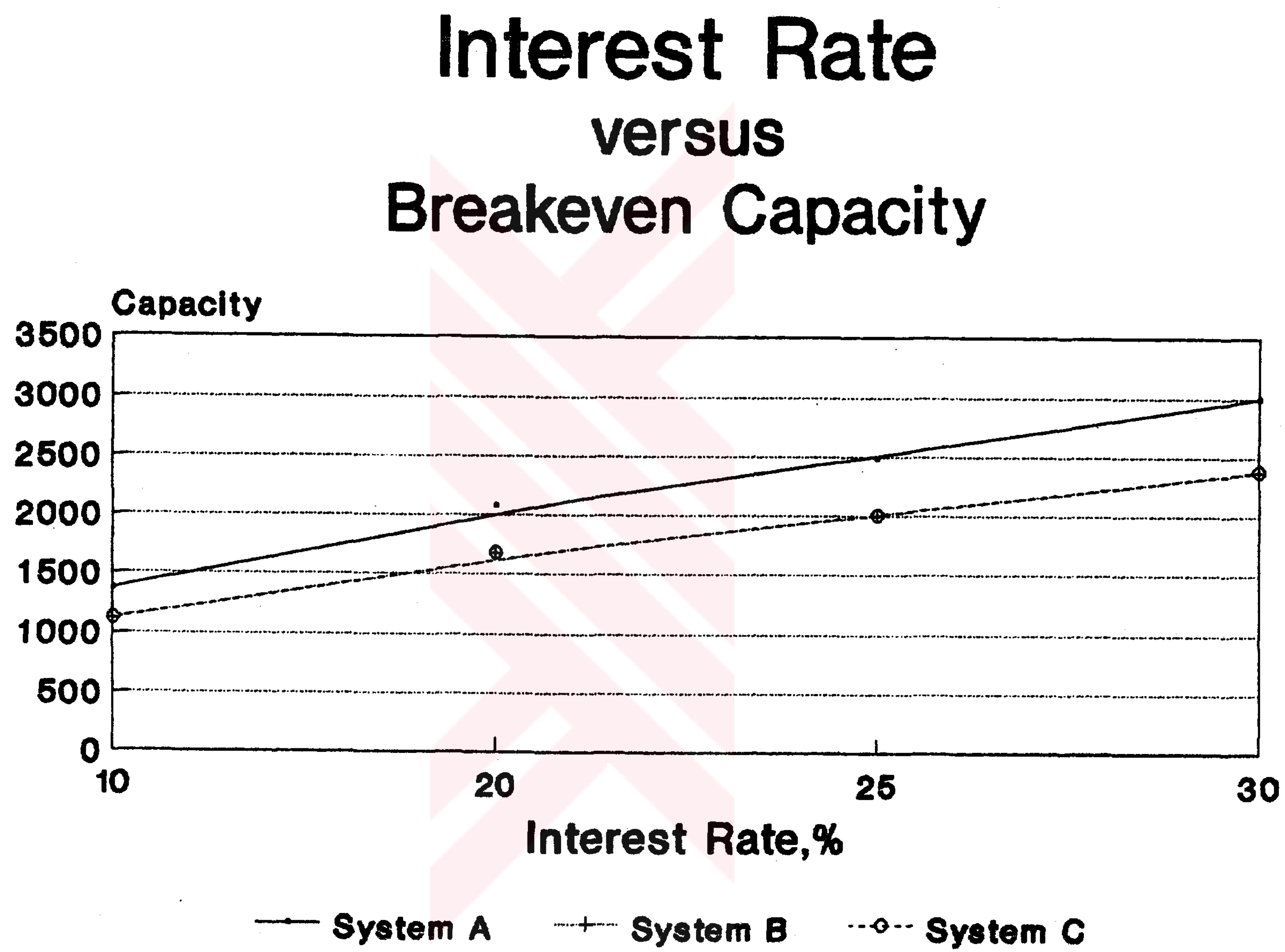


Figure 6.2 Interest Rate versus Breakeven Capacity

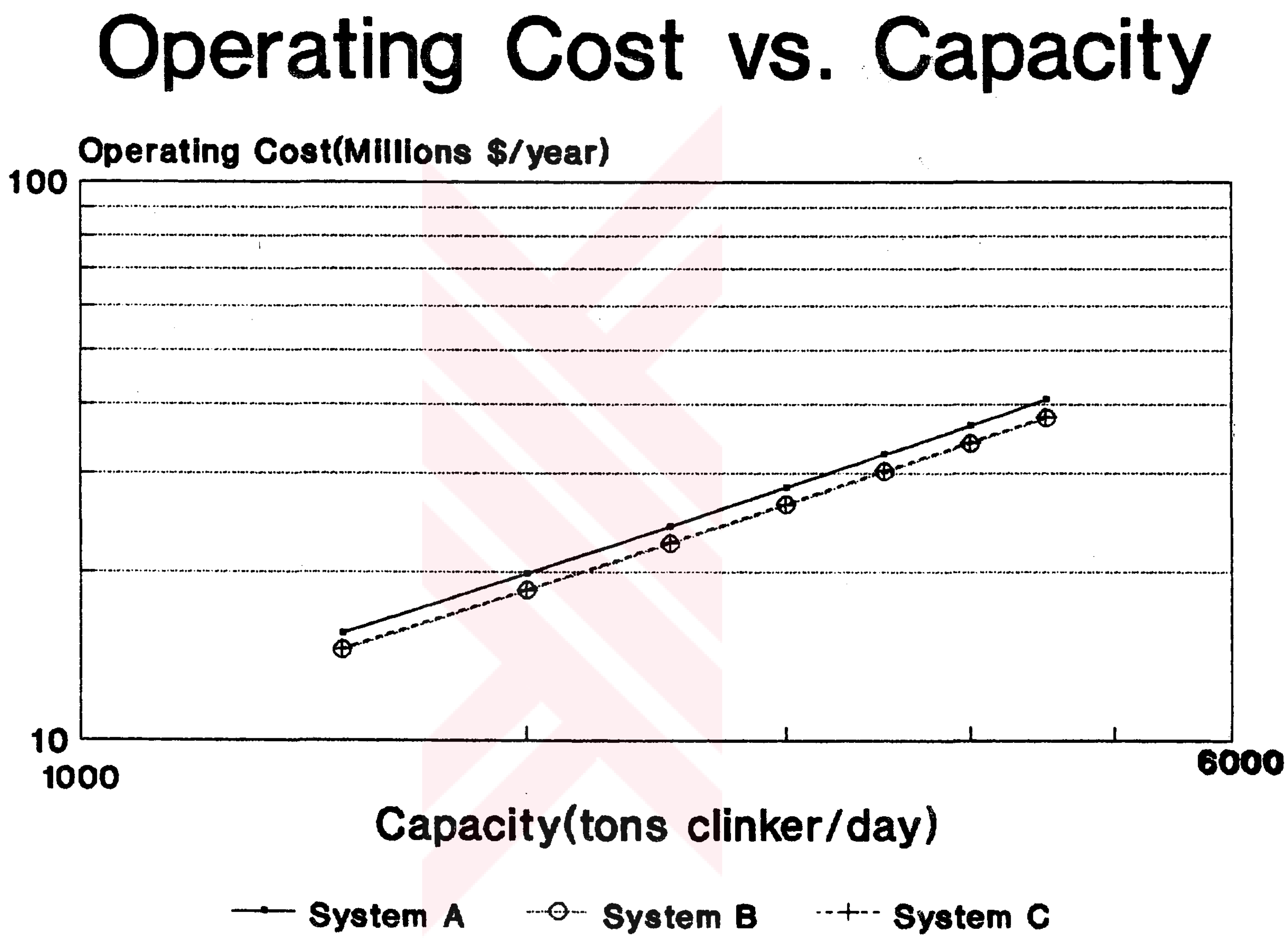


Figure 6.3 Operating Cost versus Capacity

Table 6.2 NPVs for different capacity and different rates of return for processing scheme A.

	Rates of Return			
Capacity tons clinker/day	r/0.1	0.15	0.20	0.25
1500	1.39	-2.45	-	-
2000	8.83	3.33	-0.88	-4.18
2500	16.91	9.73	4.22	-0.09
3000	25.36	16.48	9.68	4.36
3500	34.20	23.62	15.50	9.15
4000	43.32	31.01	21.57	14.19
4500	52.67	38.63	27.86	19.45

Table 6.3 NPVs for different capacity and different rates of return for processing scheme B.

	Rates of Return			
Capacity tons clinker/day	r/0.1	0.15	0.20	0.25
1500	5.70	1.41	-1.88	-
2000	14.32	8.23	3.35	-0.10
2500	23.50	15.59	9.52	4.77
3000	33.08	23.33	15.85	10.01
3500	43.07	31.46	22.55	15.59
4000	53.31	39.83	29.50	21.42
4500	87.4	68.89	54.70	43.60

Table 6.4 NPVs for different capacity and different rates of return for processing scheme C .

Capacity tons clinker/day	Rates of Return r/0.1	0.15	0.20	0.25
1500	5.67	1.41	-1.85	-
2000	14.20	8.15	3.51	0.11
2500	23.36	15.49	9.46	4.74
3000	32.92	23.22	15.78	9.97
3500	42.74	31.20	22.36	15.44
4000	52.89	39.50	29.23	21.21
4500	86.92	68.51	54.38	43.34

Table 6.5 IRR Values As Percent

Capacity (tons clinker per day)	A	B	C
2000	18.8	25.0	25.1
2500	25.0	31.7	31.8
3000	30.0	37.9	38.0
3500	35.0	43.2	43.4
4000	37.3	47.8	47.9
4500	44.0	69.1	69.2

The annual production cost of cement based on the computer results and the typical profile proposed by DPT in 1987 are tabulated in Table 6.6

Table 6.6 Contribution of different cost items to Annual Production Cost.

Item	Present Work	Reference(3)
Raw Material	9 %	7.4 %
Auxiliary and op. Material	17 %	10.8 %
Fuel	23 %	25.6 %
Electricity	22 %	24.2 %
Labour	8 %	5.6 %
Depreciation	6 %	11.2 %
General Expenses	4 %	3.7 %
Others	11 %	11.5 %

The comparison between two profiles reveal that two items,namely auxiliary and operating materials and labour have larger shares in the present model whereas depreciation weighs less.Increase in usage of additives and sophisticated equipment is the trend in recent developments in cement sector, and labour rates are expected to experience a real increase in the near future.Hence the present model is in accordance with recent and anticipated trends.

VI.2.SENSITIVITY ANALYSIS

The reference case for sensitivity analysis is chosen as 4000 tons clinker/day productions capacity.

Rotary kiln scale up exponent is taken as 0.48 All the scenarios are compared with this references capacity as discussed below. Results are summarized in Table (6.7)

Table 6.7 Result of Various Scenarios

SCENARIO		A	B	C
Capacity 4000 tons clinker/day	NPV APC FI	31.01 36.64 48.66	39.83 33.99 47.40	39.50 34.18 47.16
Change in Rotary Kiln Exponent e=0.48->0.60	NPV APC FI	28.77 36.74 50.64	39.17 34.02 47.92	39.16 34.19 47.43
10 % Increase in limestone Price	NPV APC FI	30.10 36.96 48.66	38.89 34.32 47.40	39.16 34.50 47.16
10 % Decrease in limestone Price	NPV APC FI	31.92 36.32 48.66	40.72 33.67 47.40	40.42 33.86 47.16

Table 6.7 Continued

SCENARIO		A	B	C
Limestone Pric Decreasing to $ 1.11/ton	NPV APC FI	33.95 35.60 48.66	42.77 32.95 47.40	42.47 33.14 47.16
10 % Increase in Electrical Consumption	NPV APC FI	28.39 37.55 48.66	37.07 34.95 47.40	36.79 35.14 47.16
5 % Decrease in Electrical Consumption	NPV APC FI	32.32 36.18 48.66	41.17 33.51 47.40	40.88 33.70 47.16
5 % Increase In Electrical Consumption	NPV APC FI	29.70 37.09 48.66	38.46 34.47 47.40	38.13 34.66 47.16
Escalation Rates	E.0.08 C.0.05	20.08	29.79	29.37
	E.0.08 C.0.08	16.84	27.50	27.03
	E.0.05 C.0.08	19.52	30.32	29.85
Capacity Utilization 90 %	FI APC	21.35 48.66 38.54	29.50 47.40 31.16	29.25 47.16 31.32
80 %	APC	11.80 30.45	19.13 28.33	18.95 28.47
70 %	APC	2.20 27.36	8.83 25.50	8.72 25.62
Labour		24.97	33.79	33.46
A Efficient B and C Inefficient	NPV APC FI	31.01 36.64 48.66	38.09 34.54 47.49	37.86 34.73 47.18
A and B Eff. C Inefficient	NPV APC FI	31.01 36.64 48.66	39.83 34.54 47.40	37.86 34.73 47.18
A and C Eff. B Inefficient	NPV APC FI	31.01 36.64 48.66	38.09 34.54 47.49	39.50 34.18 47.16

VI.2.1.LABOUR

In sensitivity analysis an annual escalation rate of 0.16 is taken in order to bring wage and salaries to $ 1700 per person (monthly basis) at the end of eight years.This is a must for entering EC by 2000. Number of workers and staff are taken as 450.Management costs are later added in general expenses. The current monthly wage and salary is taken as $ 483 per person.

With such an escalation rate Scheme A's NPV drops by 20 % while B and C drop by 15 %.

VI.2.2.KILN EXPONENT

As the exponent is changed from 0.48 to 0.60 NPV decreases by just 1 % for system C,while 8 % for Scheme A.There is no effect on APC (Annual Production Costs) while a substantial increase in fixed investment is observed.

Processing Scheme A is more sensitive since rotary kiln accounts for a larger portion in the fixed investment.

VI.2.3.LIMESTONE

Limestone price may exhibit large fluctuations depending on plant site.10 % deviation in limestone price causes 3 % deviation in NPV,1 % deviation in APC while keeping fixed investment constant for all schemes.

VI.2.4.ELECTRICITY

A total consumption of 115 kwhr/ton clinker and $ 0.0538/kwhr electricity are taken as basis.

An increase of 5 % in electricity consumption decreases NPV by 4 to 5 percent, while 10 % increase in electricity decreases NPV by 7 % in Systems B and C,and 9 % in Scheme A.

At 5 % decrease in electrical consumption NPV increase is 3 to 4 %, APC decrease 2 % while fixed investment is not affected.

VI.2.5.FUEL PRICES

Coal used has an ash content of 18 % and a heating value of 23.012 kj/kg coal Scheme A is the most sensitive system when escalation rates for coal and electricity are both 1.08 The decrease for scheme A is 46 % in NPVs.

For the three different sets of escalation rates Scheme A experiences the most sensitive reaction compared to Schemes B and C.In all scenarios,Scheme B has a slightly greater NPV than C.

VI.2.6.CAPACITY UTILIZATION

At 90 % capacity utilization,NPV decrease for A is 32 % while for schemes B and C it is 26 %,for 80 % utilization the decreases are more steep;being 62 % for A and 52 % for B and C,70 % utilization significant at scheme A where there is a NPV fall of 93 % while 78 % for B and C is observed. Annual production cost falls 9 %,17 % and 26 % successively,being at minimum at 70 % capacity utilization.

VI.2.7 EFFICIENT AND INEFFICIENT OPERATIONS

When a is efficient,B and C are inefficient,scheme B is the best in NPV s among them.Both APC and FI for B are greater than those of scheme C.

When A and B are efficient while C is inefficient,B has the bigger NPV than C has. In APCs;C is higher than scheme B. In fixed investment,C seems to be better than B.When A and C are efficient while B is inefficient,from NPVs,APC and fixed investment points of view,C is better than B.In all scenarios scheme A is observed to be consistently less feasible.

VI.2.8 SELLING PRICE

NPV becomes zore when cement selling price is \$37 / ton for scheme B and C,and \$39 / ton cement for scheme A.These, therefore may be named as breakeven prices when capacity is 4000 tons clinker / day.

VI.3.MODERNIZATION

As mentioned previously, many of the old plants operating under scheme A have already converted to scheme B or C,and the question facing a small number of remaining ones is the following: Which scheme is preferrable? A variety of options are available, since capacity increase may also accompany the conversion.Here the key is the selected new capacity and whether additional investment is required for other equipment to handle the capacity increase. If a considerable capacity increase is foreseen, the conversion becomes equivalent to generating a new production line.

Then the selection between B and C is almost the same as the selection for e new plant whose capacity is equal to the increase in capacity.whenever additional investment for other equipment is undesirable, and capacity is to be expanded utilizing the existing facilities,conversion to C should be preferred since the extra investment in a calciner is less than 10 % per cent of the total investment in a preheater and calcinator system.

The case of an existing new plant operating under scheme B is more interesting:In this case,conversion to scheme C will be accompanied by a considerable increase in capacity which will require additional investment in other equipment as well. In this case the remaining useful life of the existing plant should also be taken into account.

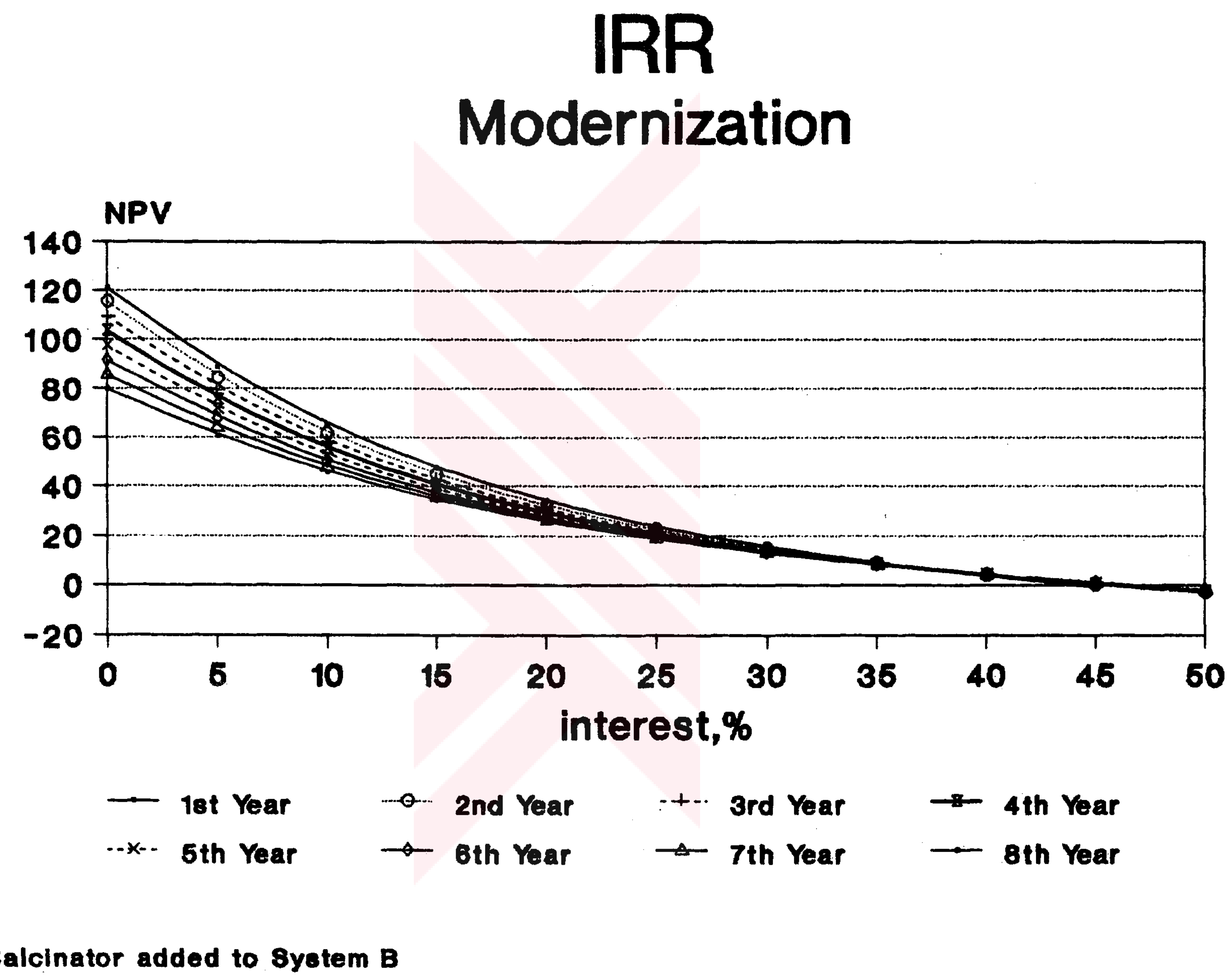


Figure 6.4 Sensitivity Analysis for Modernization of Preheater Kiln to Calcinator Kiln

CHAPTER VII

CONCLUSION

Results presented in the previous chapter demonstrate that energy costs account for almost half of the annual production cots of cement.When investment is included as a cost item by using the capital recovery factor,energy still accounts for more than one third of the total cost as shown in Table 7.1.

Table 7.1. Components of annual production cost

Fixed Invesment	24 (%)
Raw Material	7 (%)
Electricity	17 (%)
Coal	17 (%)
Labour	6 (%)
Operating Material	14 (%)
Depreciation	4 (%)
General Expenses	3 (%)
Other	8 (%)

Furthermore, sensitivity analysis reveals that share of energy in the annual production cost may be as high as 35 to 40 % in case of real increases in energy prices.Consequently,feasibility of any investment in the cement sector is highly sensitive to energy prices and therefore this sector should be attributed a high uncertainty factor in decision making.

The large magnitude of the initial investment, for a new cement plant,coupled with the forementioned high uncertainty factor, renders new investment in this sector extremely difficult. On the other hand, the following question must be answered; In view of the present demand and supply structure and forecasts, are new cement plants actually required in Turkey in the near future?

Demand projections presented in Chapter 3 reveal that production should reach at least 40 million tons by 1995 if all domestic demand is to be supplied by domestic means. A crude approximation assuming a capacity increase by a factor of 1.35 for all existing plants (by switching to precalcinator technology) shows that there will be a production deficit by 1995.

Consequently, it is concluded that existing production lines will not be sufficient to meet the demand and new production lines must be installed. If possible, all these new lines should be erected on the existing sites in order to reduce the overhead costs.If new plants sites are sought for socio-economic reasons, Eastern and Southeastern Anatolia regions should be given priority in view of the existing regional distribution and the discussion in section III.2.

Unfortunately, selection between processes with or without precalcinators is not straight forward. Sensitivity analyses have shown that actual implementation of either process is as important as the initial investment decision: Processes with and without precalcinators establish superiority over one another depending on how efficient the actual plant operation is. Since it is always possible to switch to precalcinators with an accompanying capacity increase,processes with preheaters only may be the best choice for new plants.

Cement plants have been under constant criticism as a major source of pollution.High cost of electricity has often been used by many establishments as an excuse for not operating existing electrofilters. The results of this study clearly show that such excuses are invalid,electrofilters contribute only less than 2 % to the total electrical energy consumption in a cement plant, hence their effect on the total product cost is negligible. Although electrofilters indeed account for a considerable share in the fixed investment, environmental considerations impose that they should be considered as indispensable parts of any new investment and once installed,they can be operated continously, without seriously affecting overall production costs.

Finally,it should be emphasized that the present structure of cement cost in Turkey may be significantly altered if labour rates experience a real increase and reach a level compatible with EC countries. Sensitivity analyses indicate that labor's share may increase up to 20 %,but investment in cement production will still be feasible within reasonable margins.

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A P P E N D I C E S

APPENDIX I

File Edit Print Select Format Options View Window Help

MALIYET.WKS

	A	B	C
2	Marshall & Swift Index no(Referance):	813	
3	Marshall& Swift Index no(Current):	926	
4	(Values,DM)		
5	Machines & Accessories		
6	A.Longitudinal & Circular Blending Bed for lime stone/pyrite		
7	Belt Conveyors)Referance:	329,112	
8	)Current:	502,402	
9	Stackers,Reclaimers)R:	3,095,072	
10	)C:	4,200,962	
11	General Equipment{Rails,Chutes etc.})R:	762,976	
12	)C:	1,050,298	
13	B.Raw Material Grinding		
14	Belt Conveyors)R:	34,489	
15	)C:	52,648	
16	Roller Mill)R:	6,172,058	
17	)C	8,377,375	
18	Gen. Equipment{separators,fans)R:	1,555,384	

C1 NL (F1=HELP)

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File Edit Print Select Format Options View Window Help

MALIYET.WKS

	A	B	C
20	C.Raw Meal Transport		
21	Conveyors)R:	229,028	
22	)C:	310,862	
23	D.Raw Meal Blending	0	
24	Gen. Equipment{Aeration System)R:	377,450	
25	Discharge apparatus})C:	519,591	
26	E.Kiln Feed		
27	Gen.Equipment{Proportioning feeder,)R:	241,614	
28	conveyor pipe,etc.})C:	332,601	
29	F.Preheater,Kiln,Cooler,Electrofilter	System A	System B
30	Electrofilter)R:	2,091,555	1,669,433
31	)C:	2,543,476	2,030,146
32	Preheater)R:	2,020,981	
33	)C:	2,730,228	
34	Calciner)R:	195,075	
35	)C:	258,627	
36	Rotary Kiln)R:	4,431,747	

C19 NL (F1=HELP)

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MALIYET.WKS

	A	B	C
38	)C:with preheater, four stage	6,405,220	
39	)C:with preheater+calciner	5,553,318	
40	Grate Cooler)R:	1,558,573	
41	)C:	2,269,986	
42	Gen.Equipment(clinker crusher)R:	1,395,287	
43	fan,etc.))C:	1,920,725	
44	G.Cement Grinding		
45	High Pressure Grinders)R:	7,391,348	
46	)C:	10,032,326	
47	Gen. Equipment(detectors,feed)R:	259,086	
48	hoppers,etc.))C:	356,653	
49	Cement Silo,Loading Systems)R:	4,555,966	
50	)C:	6,040,215	
51	G.Coal Grinding Plant		
52	Roller Mills)R:	1,356,140	
53	)C:	1,840,698	
54	Gen.Equipment(Screw conveyor,chain)R:	492,192	

C37 NL (F1=HELP)

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File Edit Print Select Format Options View Window Help

MALIYET.WKS

	A	B	C
56	H.Coal Dosing		
57	Gen.Eq.(Dust silo,silo cone,)R:	855,269	
58	screw compressor,pipes etc.))C:	1,177,346	
59	I.Measuring & Control System		
60	Control Panel&Instrumentation)R:	289,702	
61	)C:	384,082	
62	TOTAL,System A,including some utiliary	54,865,081	
63	System B	53,353,019	
64	System C	53,068,188	
65		SYSTEM A	SYSTEM B
66	Machines and Accessories	19,936,439	19,386,998
67	Installation	8,572,669	8,336,409
68	Pipes	1,622,733	1,578,011
69	Electrical Equipment	2,990,466	2,908,050
70	Construction	1,250,000	1,250,000
71	Land and Yard Improvement	125,000	125,000
72	Utilities	3,987,288	3,877,400

C55 NL (F1=HELP)

Press ALT to choose commands, or F2 to edit.

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MALIYET.WKS

	A	B	C
74	Total Physical Cost	38,734,595	37,711,869
75	Engineering & Project	1,156,313	1,143,833
76	Direct Cost	39,890,909	38,855,701
77	General Expenses,7%	2,792,364	2,719,899
78	Contingencies,15%	5,983,636	5,828,355
79	Fixed Plant Investment	48,666,909	47,403,956
80	Operating Capital 15%	7,300,036	7,110,593
81	Total Capital	55,966,945	54,514,549
82			
83	Table 1.CAPACITY		
84	Annual Capacity,Tons Clinker/year	1,320,000	
85	# of Working Days	330	
86	Daily Capacity,Tons clinker/day	4,000	
87			
88	Table 2-a.Electricity		
89		System A	System B
90	Rotary Kiln,KWhr/ton clinker	24.26	20.81

C83 NL (F1=HELP)

Press ALT to choose commands, or F2 to edit.

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MALIYET.WKS

	A	B	C
92	Others(KWhr/tons clinker)	82	
93	Lighting,Air,Side Facilities,KWhr/t. cl.	3	
94	Price per unit KWhr,$	0.0538	
95	Annual Electricity Consumption,$/year	7,755,648	8,150,035
96	Table 3.Labour		
97	# of Workers and Staff	450	
98	Average Annual Salary,$	5,800	
99	Total Wages and Salaries,annual,$	2,480,884	
100	Security,Sick Leave etc.	372,133	0
101	Total	2,853,017	
102			
103	Table 5.COAL		
104	Coal Type		
105	Ash (%)	18.0	
106		System A	System B
107	Specific Fuel Consumption,kJ/Kg clinker	4,827	3,466
108	Heat Value,kJ/kg coal	23,012	

C101 NL (F1=HELP)

Press ALT to choose commands, or F2 to edit.

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MALIYET.WKS

	A	B	C
110	Ash added to Raw Material,tons/year	39,871	28,629
111	Addition as Limestone,tons/year	31,897	22,903
112	Addition as Marn and Clay,tons/year	7,974	5,726
113	Price,$/tons coal	33	
114	Annual Coal Expense,$/year.		
115	System A	9,229,446	
116	System B	6,627,151	
117	System C	6,782,027	
118			
119	PRODUCTION COST		
120			
121	A] Direct Production Expenses		
122	Raw Materials,$/year	3,178,646	3,195,891
123	a)Limestone,$/ton	1.64	
124	b)Marn-Clay,$/ton	1.11	
125	Utiliary Material,Lime,$/tons	6.72	
126	Limestone,tons	1,657,703	1,666,697

C119 NL (F1=HELP)

Press ALT to choose commands, or F2 to edit.

File Edit Print Select Format Options View Window Help

MALIYET.WKS

	A	B	C
128	Lime,tons	54,996	
129	OPERATING MATERIAL	kg/ton cement	Value $/kg.
130	Pebbles	0.200	0.92
131	Silpeps	0.170	0.92
132	Plate	0.130	4.04
133	Magnesite Brick	0.680	0.40
134	Alumina Brick	0.500	0.43
135	Paper Bags,pieces/ton c. and $/piece	23.1	0.12
136	Grease Oil	0.05	1.08
137	Operating Materials,$/year	6,103,213	
138			
139	B] Fixed Production Expenses		
140	Machines 10%		Depreciation
141	System A	1,993,644	2,024,894
142	System B	1,938,700	1,969,950
143	System C	1,928,350	1,959,600
144	Buildings 2.5%	31,250	

C137 NL (F1=HELP)

Press ALT to choose commands, or F2 to edit.

File Edit Print Select Format Options View Window Help

MALIYET.WKS

	A	B	C
146	General Expenses	1,465,641	1,359,965
147	Others	4,030,512	3,739,904
148	{General expenses,management,clinical services,security,wages paid to ma		
149	Distribution and Sale Expenses}		
150	(Expenses for Sale Offices,Salesmen,Transportation and advertisement.)		
151			
152		System A	System B
153	TOTAL OPERATING COST	36,641,015	33,999,125
154			
155		System A	System B
156	OPERATING CAPITAL		
157	Sales Price,$/ton cement	46	
158	Annual Cement Production,tons	1,374,912	
159	Annual Sales,$/year	63,245,952	
160	1.Raw Material Stock	264,887	266,324
161	2.Materials under Process	1,526,709	1,416,630
162	3.Mamul mallarin Stoku	3,053,418	2,833,260

C156 NL (F1=HELP)

Press ALT to choose commands, or F2 to edit.

File Edit Print Select Format Options View Window Help

MALIYET.WKS

	A	B	C
164	5.Cash Flow Demand	3,053,418	2,833,260
165			
166			
167			
168			
169			
170			
171			
172			
173			
174			
175			
176			
177			
178			
179			
180			

B174 NL (F1=HELP)

Press ALT to choose commands, or F2 to edit.

File Edit Print Select Format Options View Window Help

DCF.WKS

	A	B	C	D	E
3	Fixed Investment,$:			35.59	
4	interest:	0.15			
5	Total Operating Costs				
6	Investment Interval	1	2	3	4
7	Capital,$	-47.16			
8	Raw Materials	-3.19	-3.19	-3.19	-3.19
9	Operating Materials	-6.10	-6.10	-6.10	-6.10
10	Electricity	-8.16	-8.16	-8.16	-8.16
11	Coal	-6.78	-6.78	-6.78	-6.78
12	Labour	-2.85	-2.85	-2.85	-2.85
13	Depreciation	-1.95	-1.95	-1.95	-1.95
14	General Expenses	-1.36	-1.36	-1.36	-1.36
15	Others	-3.76	-3.76	-3.76	-3.76
16	Annual Sales,Mio$/year	63.15	63.15	63.15	63.15
17	Corporate Tax	-13.92	-13.92	-13.92	-13.92
18	Cash Flow	-32.08	15.08	15.08	15.08
19	Discounted Cash Flow	-32.1	13.1	11.4	9.9

C4 NL (F1=HELP)

Press ALT to choose commands, or F2 to edit.

File Edit Print Select Format Options View Window Help

DCF.WKS

	F	G	H	I	J	K	L
3							
4							
5							
6	5	6	7	8	9		
7							
8	-3.19	-3.19	-3.19	-3.19	-3.19		
9	-6.10	-6.10	-6.10	-6.10	-6.10		
10	-8.16	-8.16	-8.16	-8.16	-8.16		
11	-6.78	-6.78	-6.78	-6.78	-6.78		
12	-2.85	-2.85	-2.85	-2.85	-2.85		
13	-1.95	-1.95	-1.95	-1.95	-1.95		
14	-1.36	-1.36	-1.36	-1.36	-1.36		
15	-3.76	-3.76	-3.76	-3.76	-3.76		
16	63.15	63.15	63.15	63.15	63.15		
17	-13.92	-13.92	-13.92	-13.92	-13.92		
18	15.08	15.08	15.08	15.08	15.08		
19	8.6	7.5	6.5	5.7	4.9		

L4 NL (F1=HELP)

Press ALT to choose commands, or F2 to edit.

FIXED INVESTMENT

Marshall & Swift Index no(Referance):	813		
Marshall& Swift Index no(Current):	926		
(Values, DM)			
Machines & Accessories			
A. Longitudinal & Circular Blending Bed for lime stone/pyrite			
Belt Conveyors>Referance:	329,112		
>Current:	502,402		
Stackers, Reclaimers>R:	3,095,072		
>C:	4,200,962		
General Equipment(Rails, Chutes etc.)>R:	762,976		
>C:	1,050,298		
B. Raw Material Grinding			
Belt Conveyors>R:	34,489		
>C:	52,648		
Roller Mill>R:	6,172,058		
>C	8,377,375		
Gen. Equipment(separators, fans >R:	1,555,384		
hot gas generators, compensators) >C:	2,141,111		
C. Raw Meal Transport			
Conveyors>R:	229,028		
>C:	310,862		
D. Raw Meal Blending	0		
Gen. Equipment(Aeration System >R:	377,450		
Discharge apparatus) >C:	519,591		
E. Kiln Feed			
Gen. Equipment(Proportioning feeder, >R:	241,614		
conveyor pipe, etc.) >C:	332,601		
F. Preheater, Kiln, Cooler, Electrofilter	System A	System B	System C
Electrofilter >R:	2,091,555	1,669,433	1,923,073
>C:	2,543,476	2,030,146	2,338,590
Preheater>R:	2,020,981		
>C:	2,730,228		
Calciner>R:	195,075		
>C:	258,627		
Rotary Kiln>R:	4,431,747		
>C:without preheater+calciner	10,134,180		
>C:with preheater, four stage	6,405,220		
>C:with preheater+calciner	5,553,318		
Grate Cooler>R:	1,558,573		
>C:	2,269,986		
Gen. Equipment(clinker crusher >R:	1,395,287		
fan, etc.) >C:	1,920,725		
G. Cement Grinding			
High Pressure Grinders>R:	7,391,348		
>C:	10,032,326		
Gen. Equipment(detectors, feed >R:	259,086		
hoppers, etc.) >C:	356,653		
Cement Silo, Loading Systems>R:	4,555,966		
>C:	6,040,215		
G. Coal Grinding Plant			
Roller Mills>R:	1,356,140		
>C:	1,840,698		
Gen. Equipment(Screw conveyor, chain >R:	492,192		
conveyor, fan, throttle flap etc.) >C:	677,542		
H. Coal Dosing			
Gen. Eq. (Dust silo, silo cone, >R:	855,269		
screw compressor, pipes etc.) >C:	1,177,346		
I. Measuring & Control System			
Control Panel&Instrumentation>R:	289,702		
>C:	384,082		
TOTAL, System A, including some utiliary	54,865,081		
System B	53,353,019		
System C	53,068,188		
	SYSTEM A	SYSTEM B	SYSTEM C
Machines and Accessories	19,936,439	19,386,998	19,283,499
Installation	8,572,669	8,336,409	8,291,904
Pipes	1,622,733	1,578,011	1,569,587
Electrical Equipment	2,990,466	2,908,050	2,892,525
Construction	1,250,000	1,250,000	1,250,000
Land and Yard Improvement	125,000	125,000	125,000

Utilities	3,987,288	3,877,400	3,856,700
Land Cost	250,000	250,000	250,000
Total Physical Cost	38,734,595	37,711,869	37,519,215
Engineering & Project	1,156,313	1,143,833	1,137,726
Direct Cost	39,890,909	38,855,701	38,656,941
General Expenses, 7%	2,792,364	2,719,899	2,705,986
Contingencies, 15%	5,983,636	5,828,355	5,798,541
Fixed Plant Investment	.48,666,909	47,403,956	47,161,468
Operating Capital 15%	7,300,036	7,110,593	7,074,220
Total Capital	55,966,945	54,514,549	54,235,689

Table 1. CAPACITY

Annual Capacity, Tons Clinker/year	1,320,000
# of Working Days	330
Daily Capacity, Tons clinker/day	4,000

Table 2-a. Electricity

	System A	System B	System C
Rotary Kiln, KWhr/ton clinker	24.26	20.81	21
Cyclone Fans, KWhr/ton clinker	9		
Others(KWhr/tons clinker)	82		
Lighting, Air, Side Facilities, KWhr/t. cl.	3		
Price per unit KWhr, $	0.0538		
Annual Electricity Consumption, $/year	7,755,648	8,150,035	8,163,467

Table 3. Labour

# of Workers and Staff	450	
Average Annual Salary, $	5,800	
Total Wages and Salaries, annual, $	2,480,884	
Security, Sick Leave etc.	372,133	0
Total	2,853,017	

Table 5. COAL

Coal Type

	System A	System B	System C
Ash (%)	18.0		
Specific Fuel Consumption, kJ/Kg clinker	4,827	3,466	3,547
Heat Value, kJ/kg coal	23,012		
Coal Amount, tons/year	276,883	198,815	203,461
<u>Ash added to Raw Material, tons/year</u>	39,871	28,629	29,298
Addition as Limestone, tons/year	31,897	22,903	23,439
Addition as Marn and Clay, tons/year	7,974	5,726	5,860
Price, $/tons coal	33		
<u>Annual Coal Expense, $/year.</u>			
System A	9,229,446		
System B	6,627,151		
System C	6,782,027		

PRODUCTION COST

A] Direct Production Expenses			
Raw Materials, $/year	3,178,646	3,195,891	3,194,864
a)Limestone, $/ton	1.64		
b)Marn-Clay, $/ton	1.11		
Utiliary Material, Lime, $/tons	6.72		
Limestone, tons	1,657,703	1,666,697	1,666,161
Marn and Clay, tons	414,426	416,674	416,540
Lime, tons	54,996		
OPERATING MATERIAL	kg/ton cement	Value $/kg.	
Pebbles	0.200	0.92	
Silpeps	0.170	0.92	
Plate	0.130	4.04	
Magnesite Brick	0.680	0.40	
Alumina Brick	0.500	0.43	
Paper Bags, pieces/ton c. and $/piece	23.1	0.12	
Grease Oil	0.05	1.08	
Operating Materials, $/year	6,103,213		

B] Fixed Production Expenses		
Machines 10%		Depreciation
System A	1,993,644	2,024,894
System B	1,938,700	1,969,950
System C	1,928,350	1,959,600
Buildings 2.5%	31,250	

	System A	System B	System C
General Expenses	1,465,641	1,359,965	1,367,350
Others	4,030,512	3,739,904	3,760,212

(General expenses, management, clinical services, security, wages paid to managers, staff, office expenses etc.
Distribution and Sale Expenses)
(Expenses for Sale Offices, Salesmen, Transportation and advertisement.)

	System A	System B	System C
TOTAL OPERATING COST	36,641,015	33,999,125	34,183,750

OPERATING CAPITAL	System A	System B	System C
Sales Price, $/ton cement	46		
Annual Cement Production, tons	1,374,912		
Annual Sales, $/year	63,245,952		
1. Raw Material Stock	264,887	266,324	266,239
2. Materials under Process	1,526,709	1,416,630	1,424,323
3. Mamul mallarin Stoku	3,053,418	2,833,260	2,848,646
4. Musteriye Bagli Mal	5,270,496	5,270,496	5,270,496
5. Cash Flow Demand	3,053,418	2,833,260	2,848,646

Capacity,t. cement/year	1,372,800	Capacity:	4000						
Price per ton cement,$	46		NPV••9 years						
Fixed Investment,$:			35.59						
interest:	0.15								
Total Operating Costs									
Investment Interval	1	2	3	4	5	6	7	8	9
Capital,$	-47.16								
Raw Materials	-3.19	-3.19	-3.19	-3.19	-3.19	-3.19	-3.19	-3.19	-3.19
Operating Materials	-6.10	-6.10	-6.10	-6.10	-6.10	-6.10	-6.10	-6.10	-6.10
Electricity	-8.16	-8.16	-8.16	-8.16	-8.16	-8.16	-8.16	-8.16	-8.16
Coal	-6.78	-6.78	-6.78	-6.78	-6.78	-6.78	-6.78	-6.78	-6.78
Labour	-2.85	-2.85	-2.85	-2.85	-2.85	-2.85	-2.85	-2.85	-2.85
Depreciation	-1.95	-1.95	-1.95	-1.95	-1.95	-1.95	-1.95	-1.95	-1.95
General Expenses	-1.36	-1.36	-1.36	-1.36	-1.36	-1.36	-1.36	-1.36	-1.36
Others	-3.76	-3.76	-3.76	-3.76	-3.76	-3.76	-3.76	-3.76	-3.76
Annual Sales,Mio$/year	63.15	63.15	63.15	63.15	63.15	63.15	63.15	63.15	63.15
Corporate Tax	-13.92	-13.92	-13.92	-13.92	-13.92	-13.92	-13.92	-13.92	-13.92
Cash Flow	-32.08	15.08	15.08	15.08	15.08	15.08	15.08	15.08	15.08
Discounted Cash Flow	-32.1	13.1	11.4	9.9	8.6	7.5	6.5	5.7	4.9
Cumulative Cash Flow	-32.08	-18.97	-7.57	2.35	10.97	18.47	24.99	30.66	35.59

A P P E N D I X   II

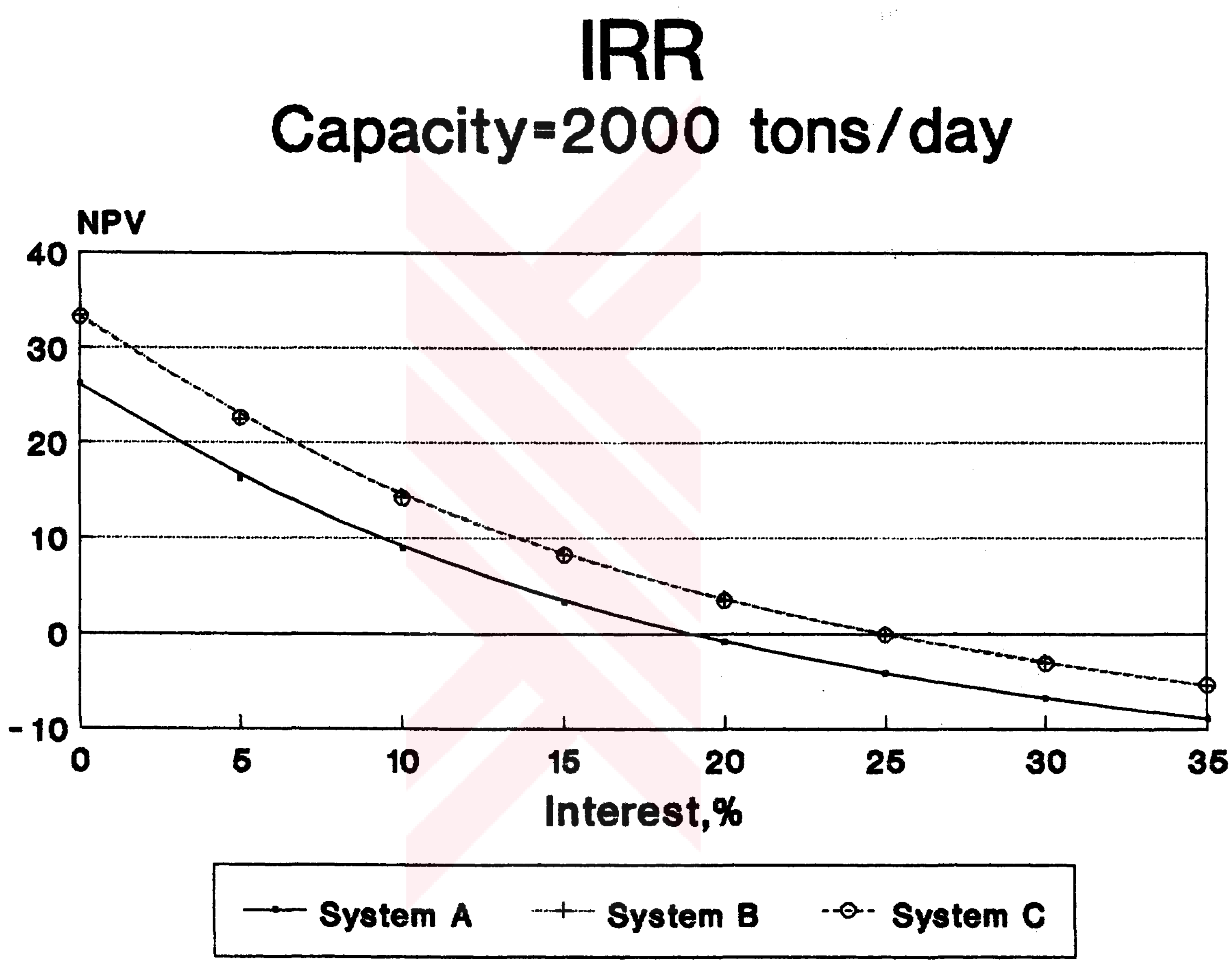


Figure A.II .1 IRR versus NPV for capacity=2,000 tons clinker/day

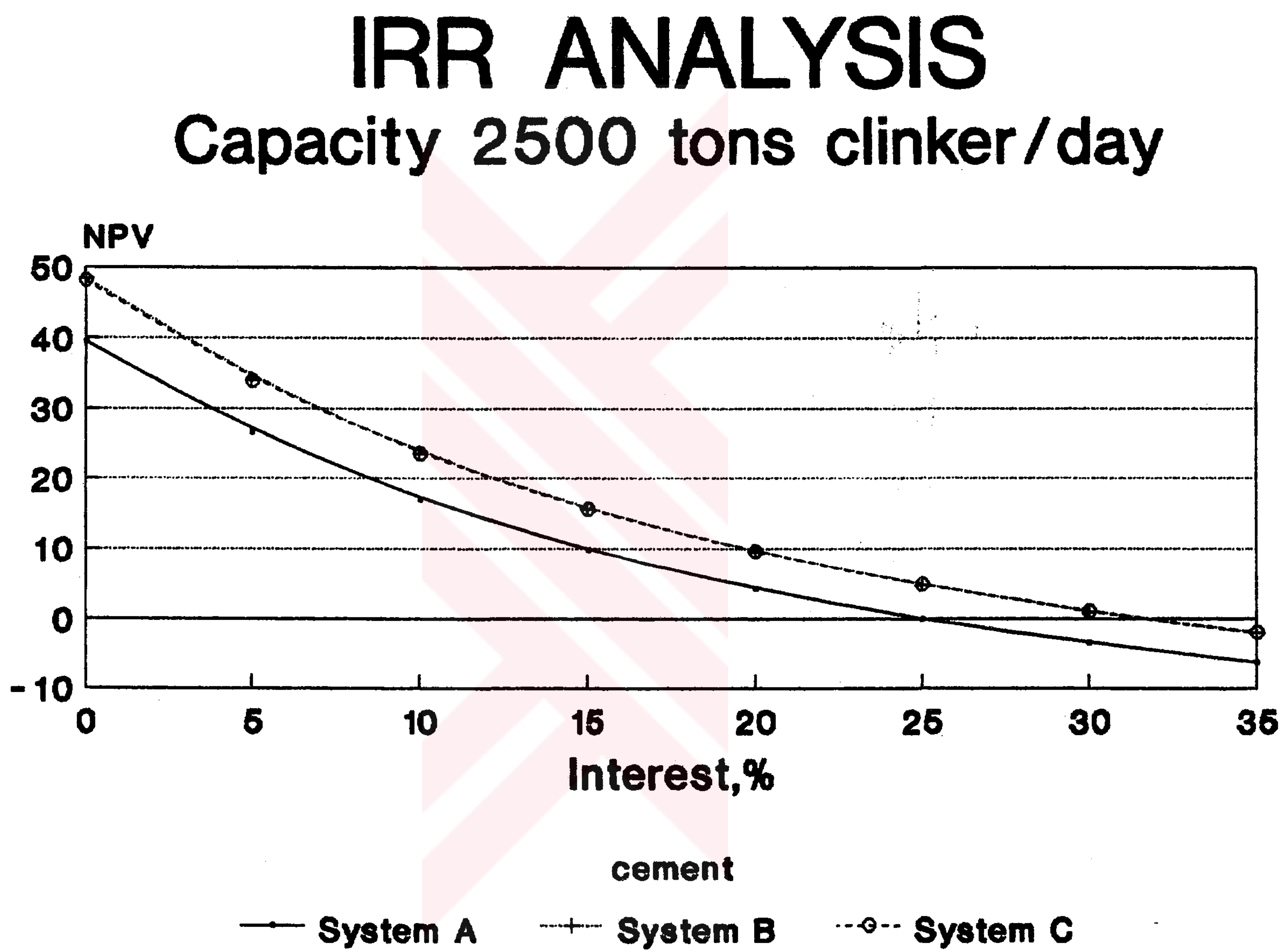


Figure A.II .2 IRR versus NPV for capacity=2,500 tons clinker/day

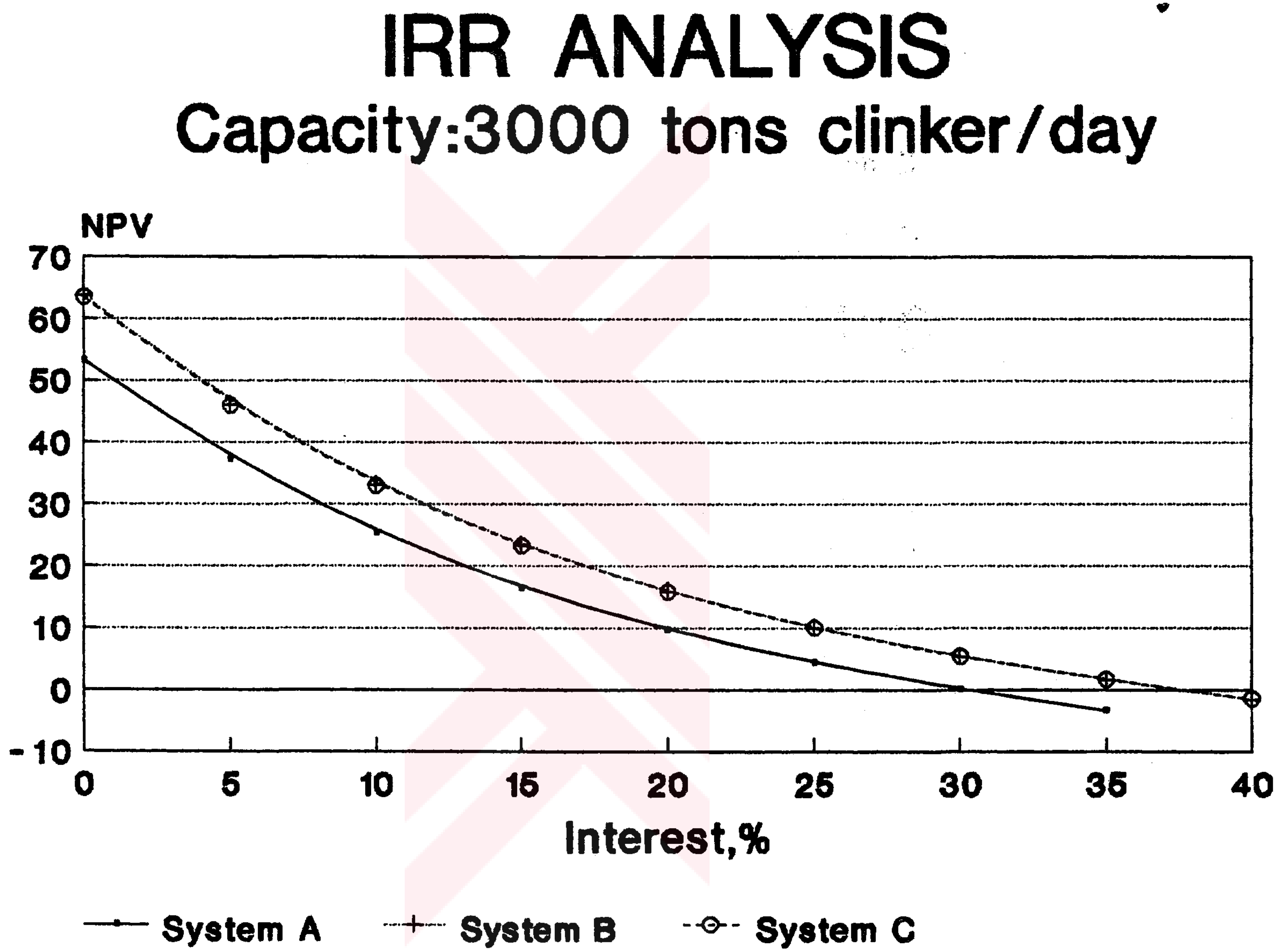


Figure A.II .3 IRR versus NPV for capacity= 3,000 tons clinker/day

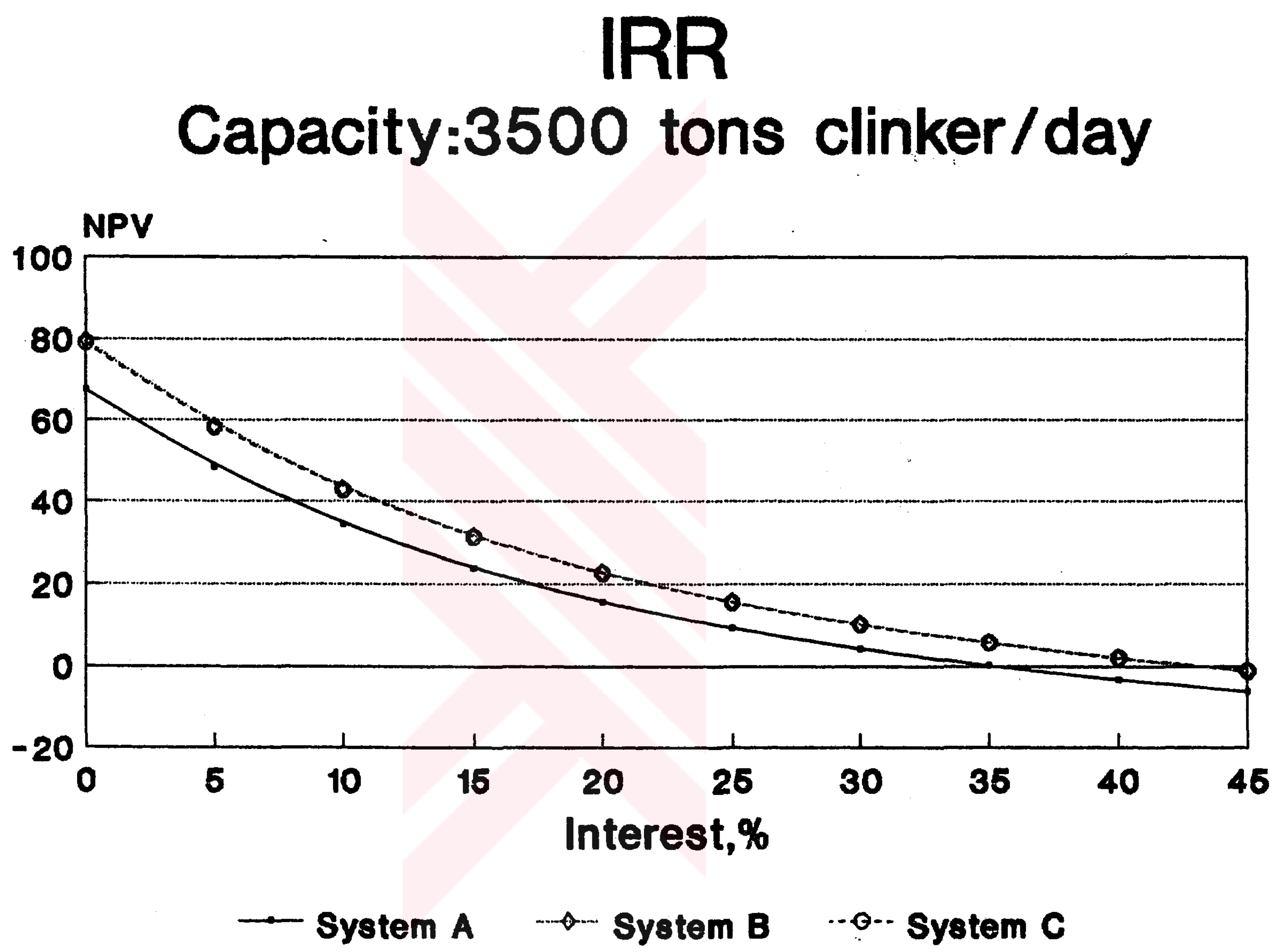


Figure A.II .4 IRR versus NPV for capacity=3,500 tons clinker/day

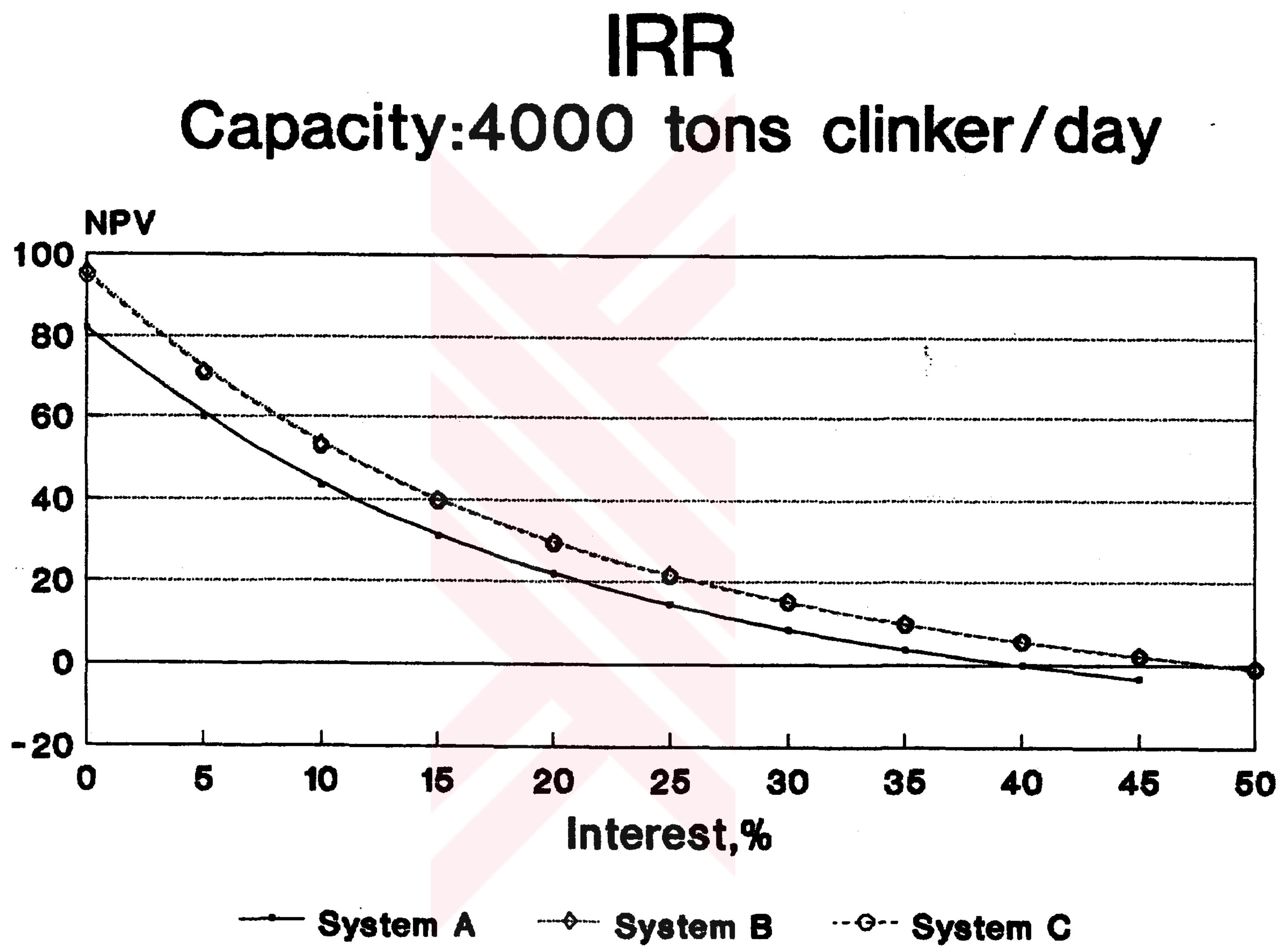


Figure A.II .5 IRR versus NPV for capacity=4,000 tons clinker/day

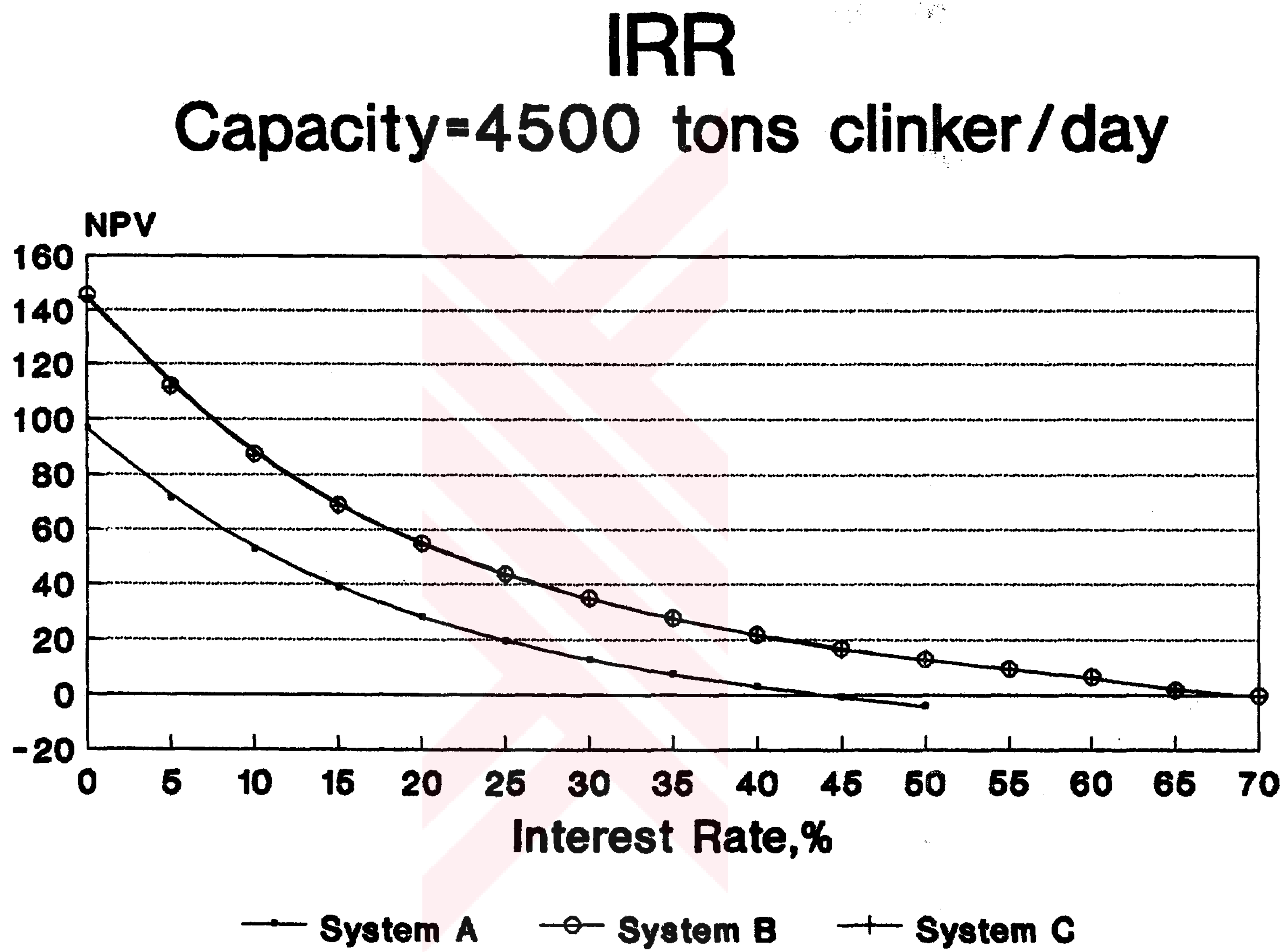


Figure A.II .6 IRR versus NPV for capacity=4,500tons clinker/day

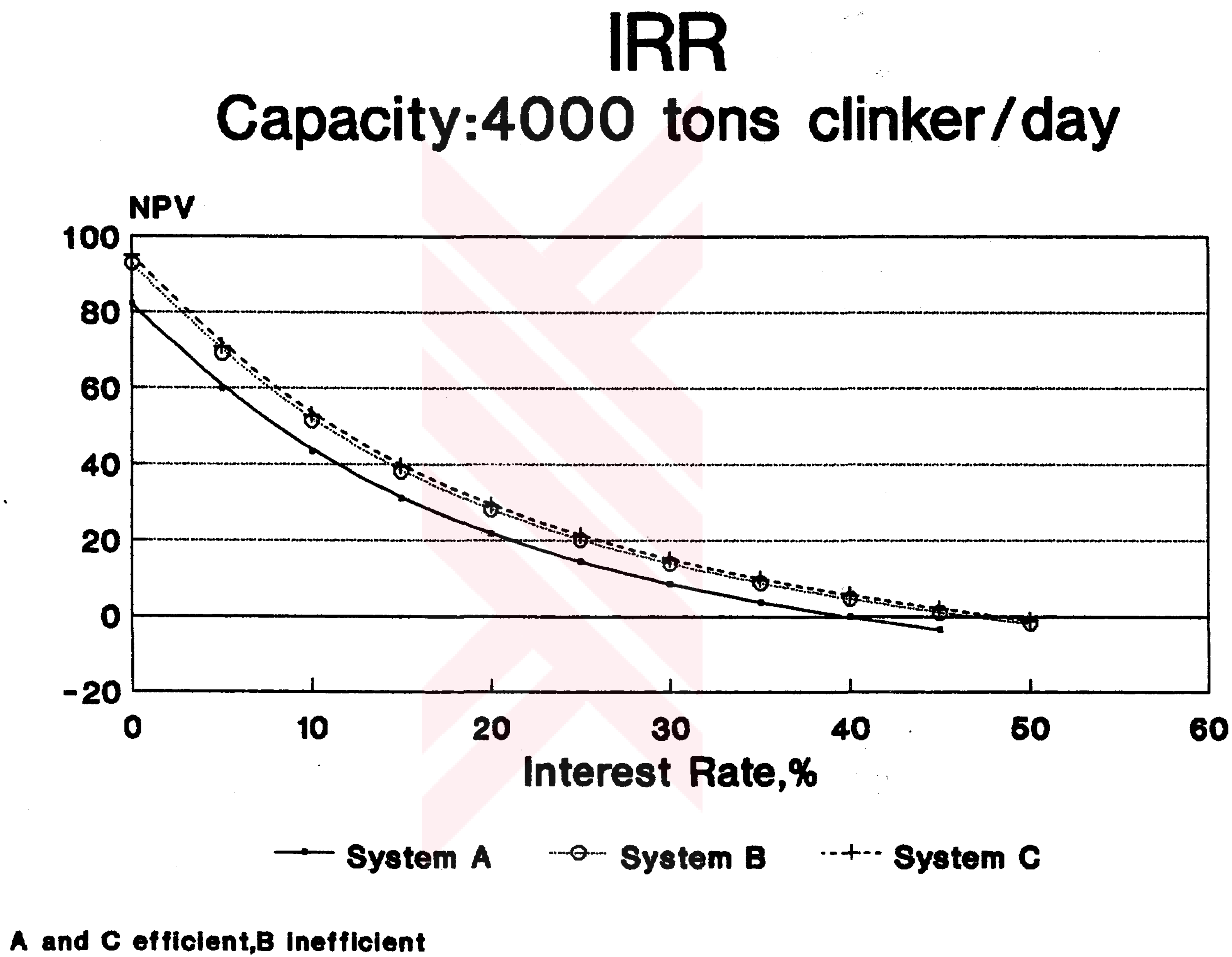
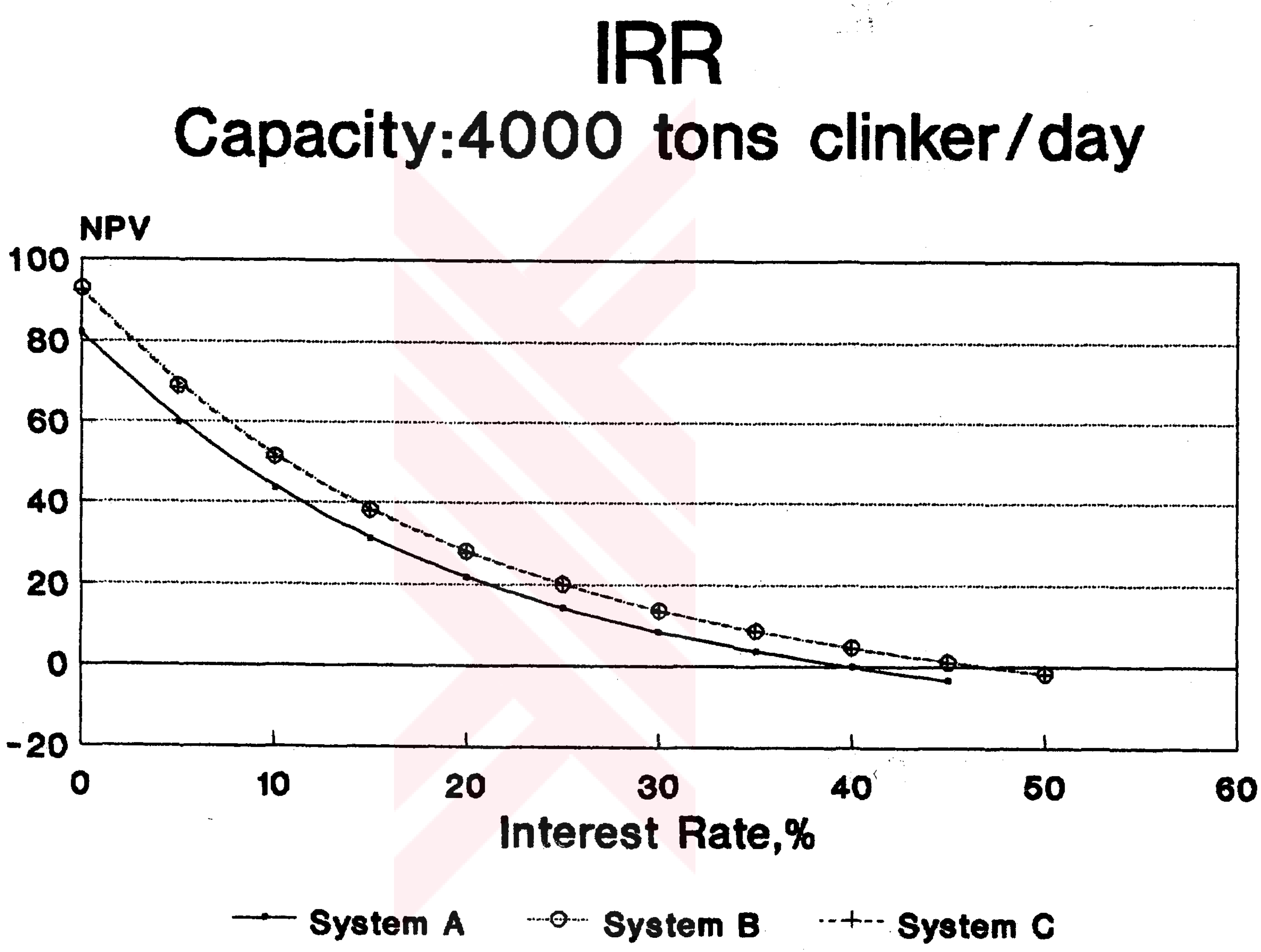


Figure A.II .7 Sensitivity Analysis for Systems A and C efficient,B inefficient



A efficient,B and C inefficient

Figure A.II .8 Sensitivity Analysis for Systems A efficient,B and C inefficient

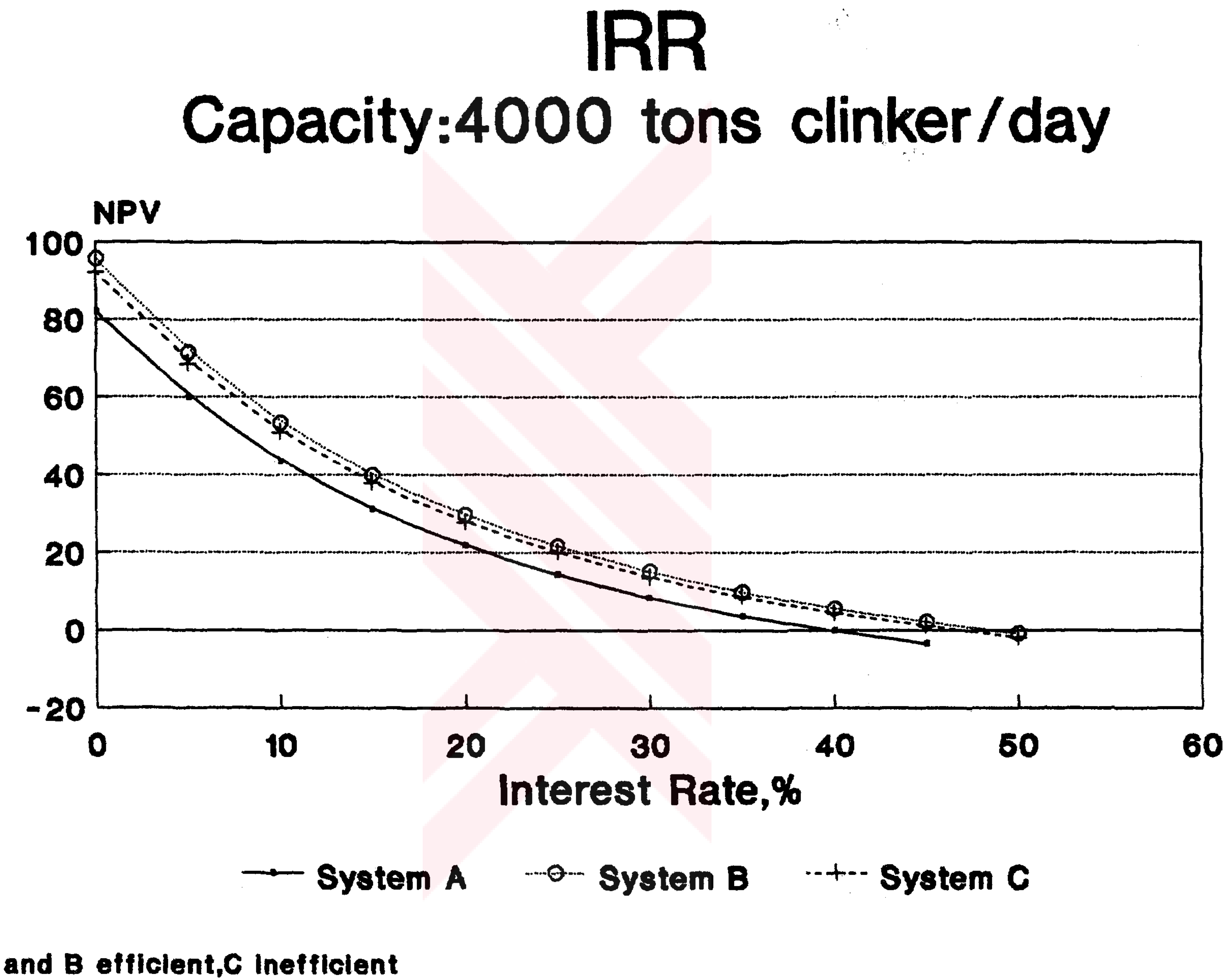


Figure A.II .9 Sensitivity Analysis for Systems A and B efficient, C inefficient

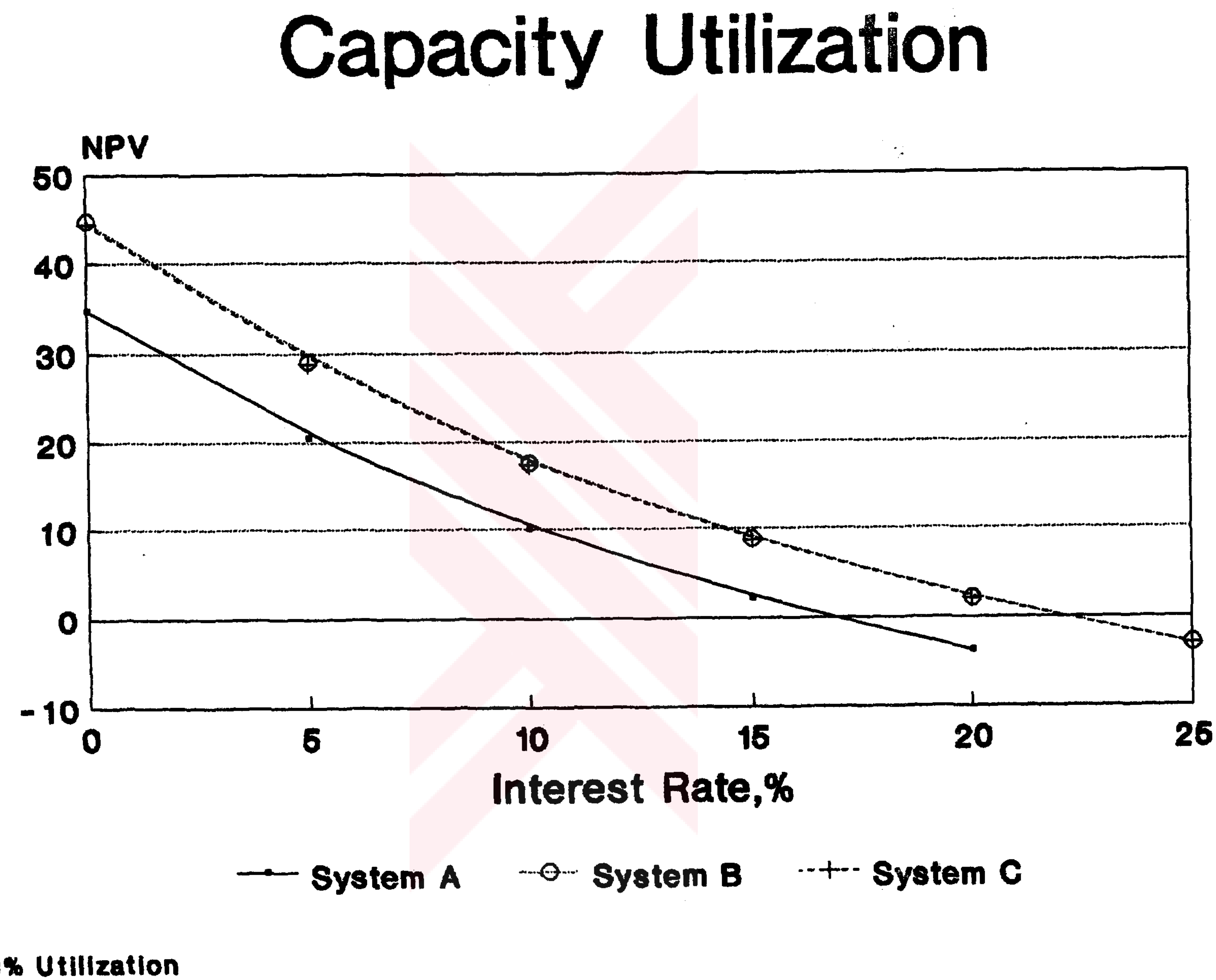


Figure A.II .10 Sensitivity Analysis at 70% Capacity Utilization

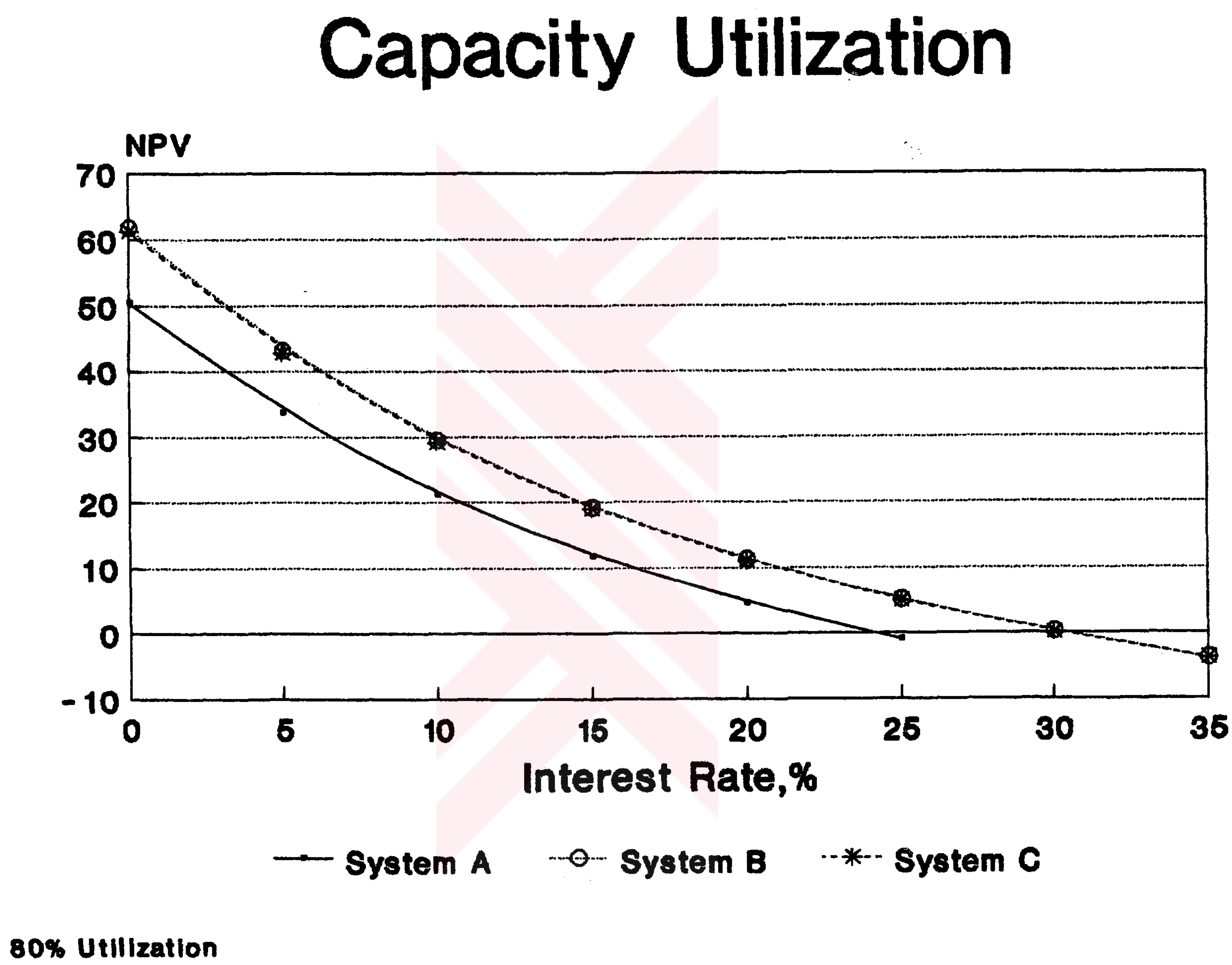


Figure A.II .11 Sensitivity Analysis at 80% Capacity Utilization

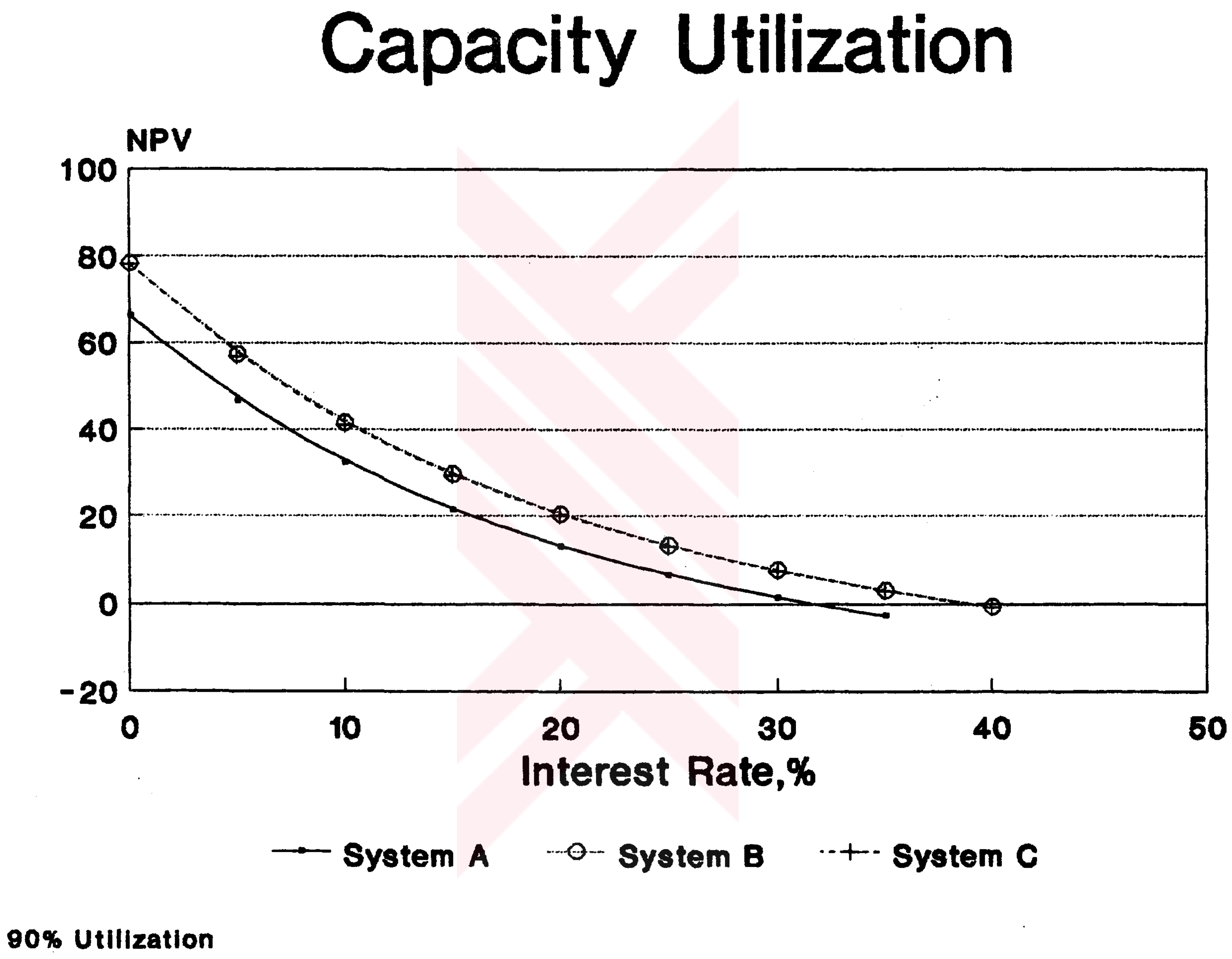
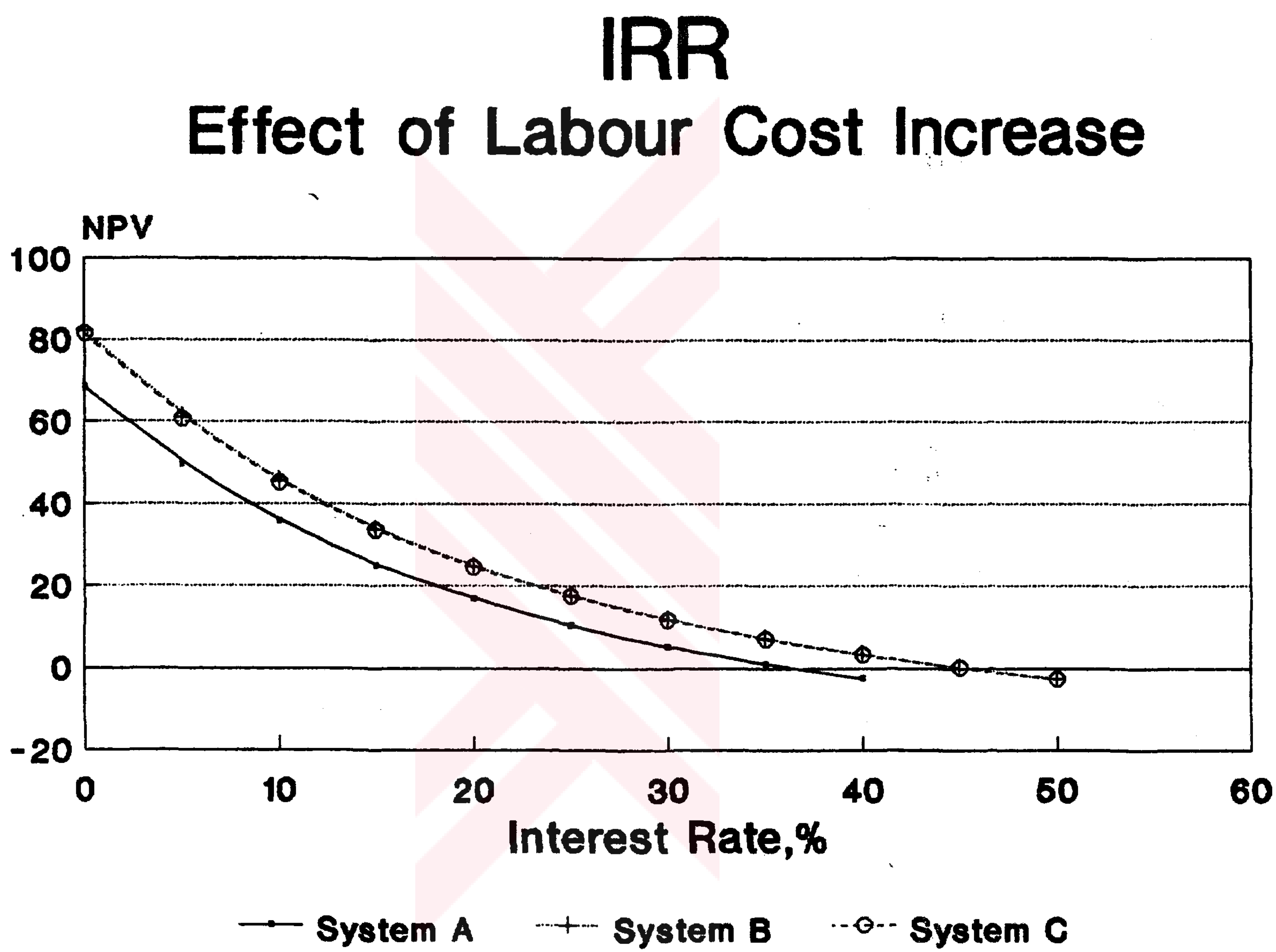
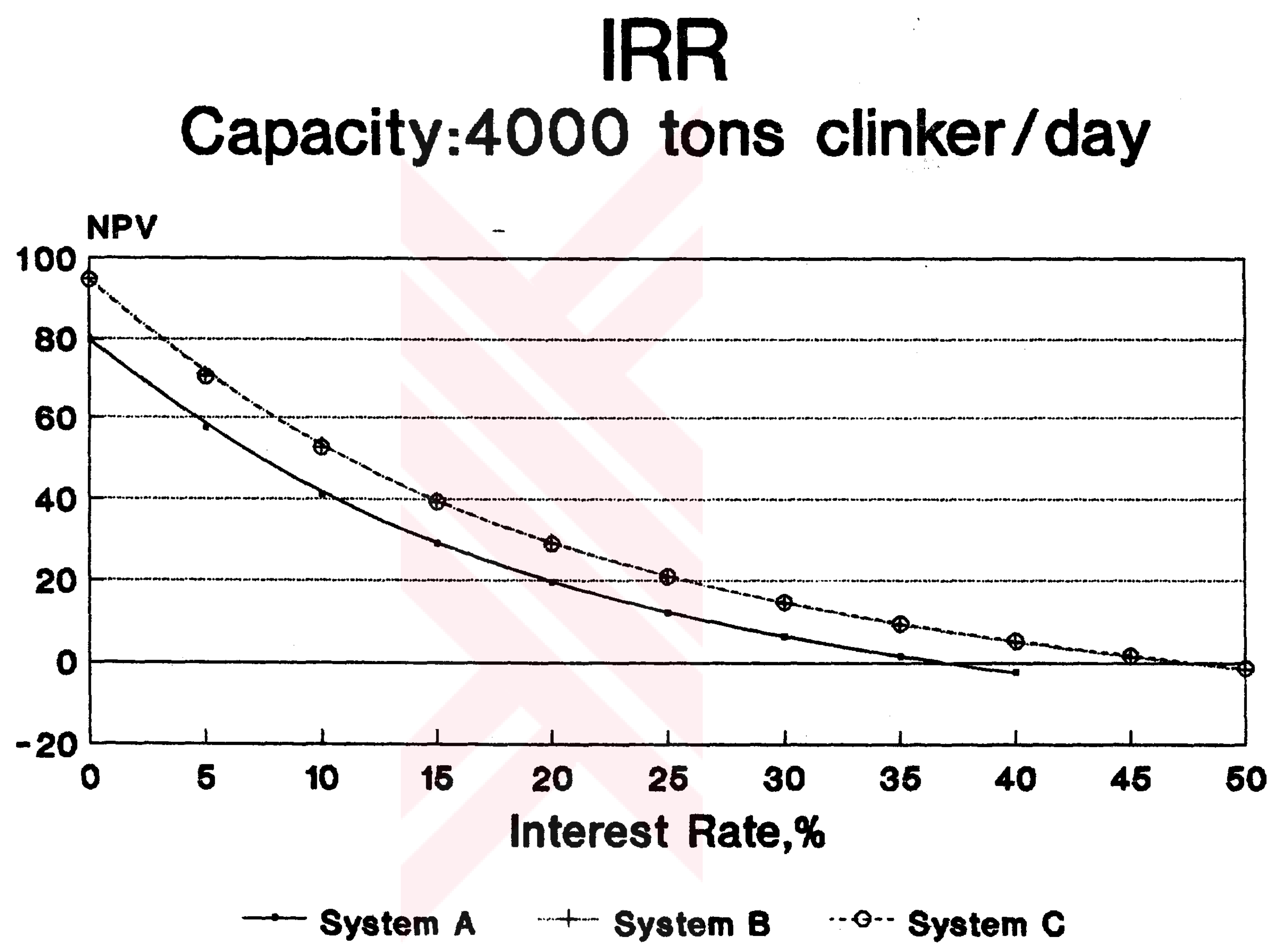


Figure A.II .12 Sensitivity Analysis at 90% Capacity Utilization



Annual Escalation Rate:1.1674

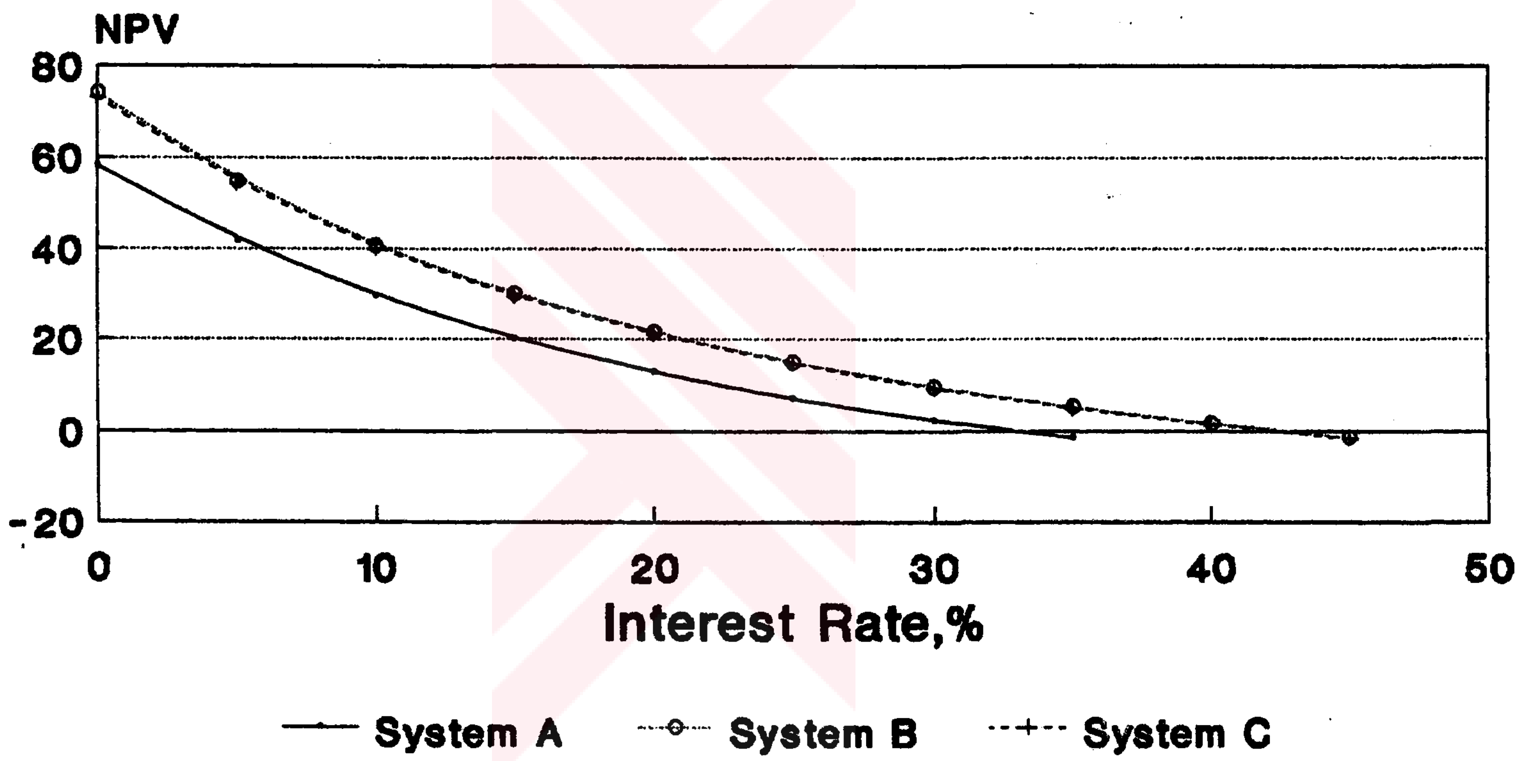
Figure A.II .13 Sensitivity Analysis for Labour cost Increase with an annual escalation rate of 1.1674



Rotary Kiln exponent:0.60

Figure A.II .14 Sensitivity Analysis for scale-up exponent of Kiln=0.60

IRR
Effect of Electricity and Coal Escalation



Escalation Rates;Coal-1.05
Electricity-1.08

Figure A.II .15 Sensitivity Analysis for Fuel and Electricity escalation rates

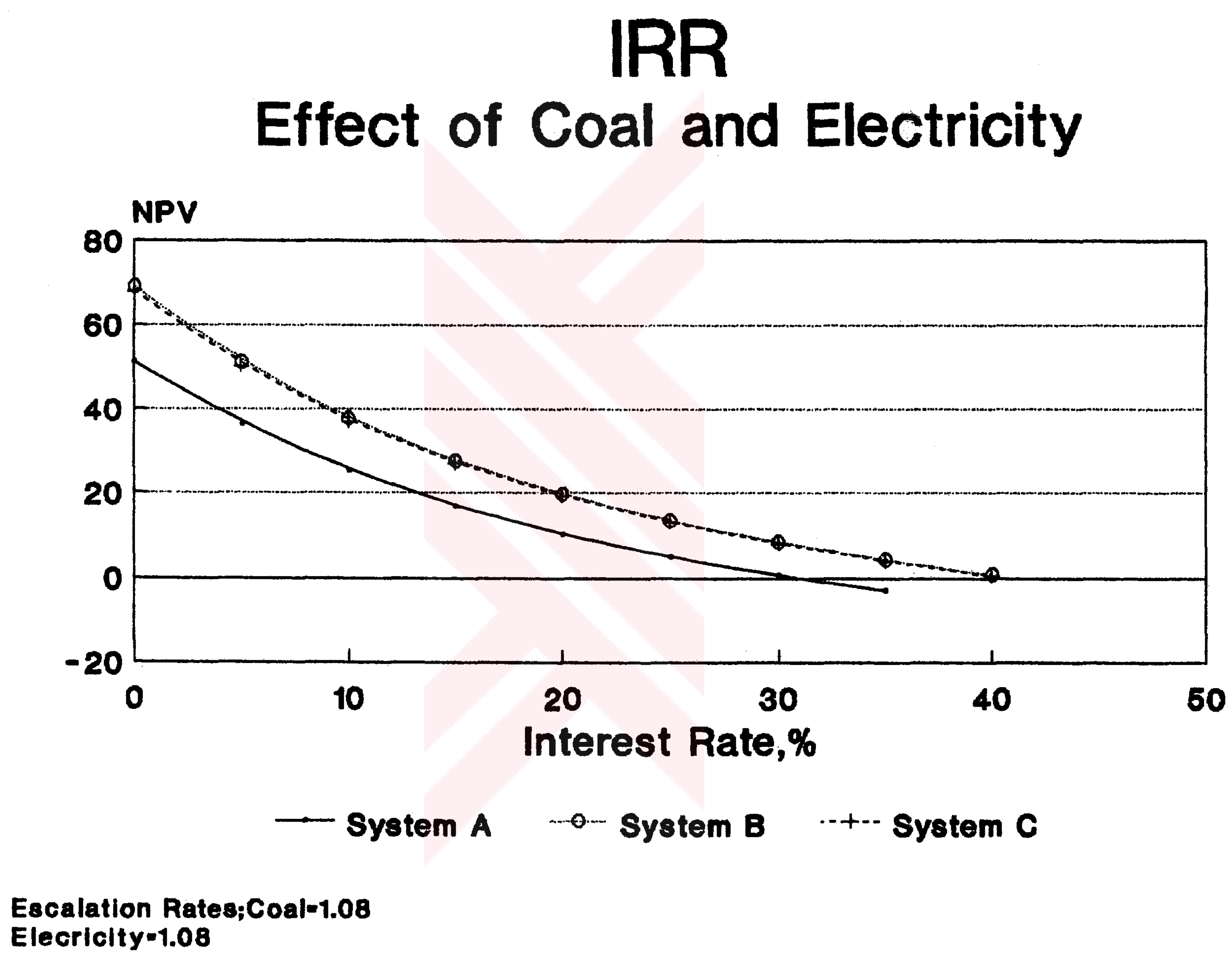


Figure A.II .16 Sensitivity Analysis for Fuel and Electricity escalation rates

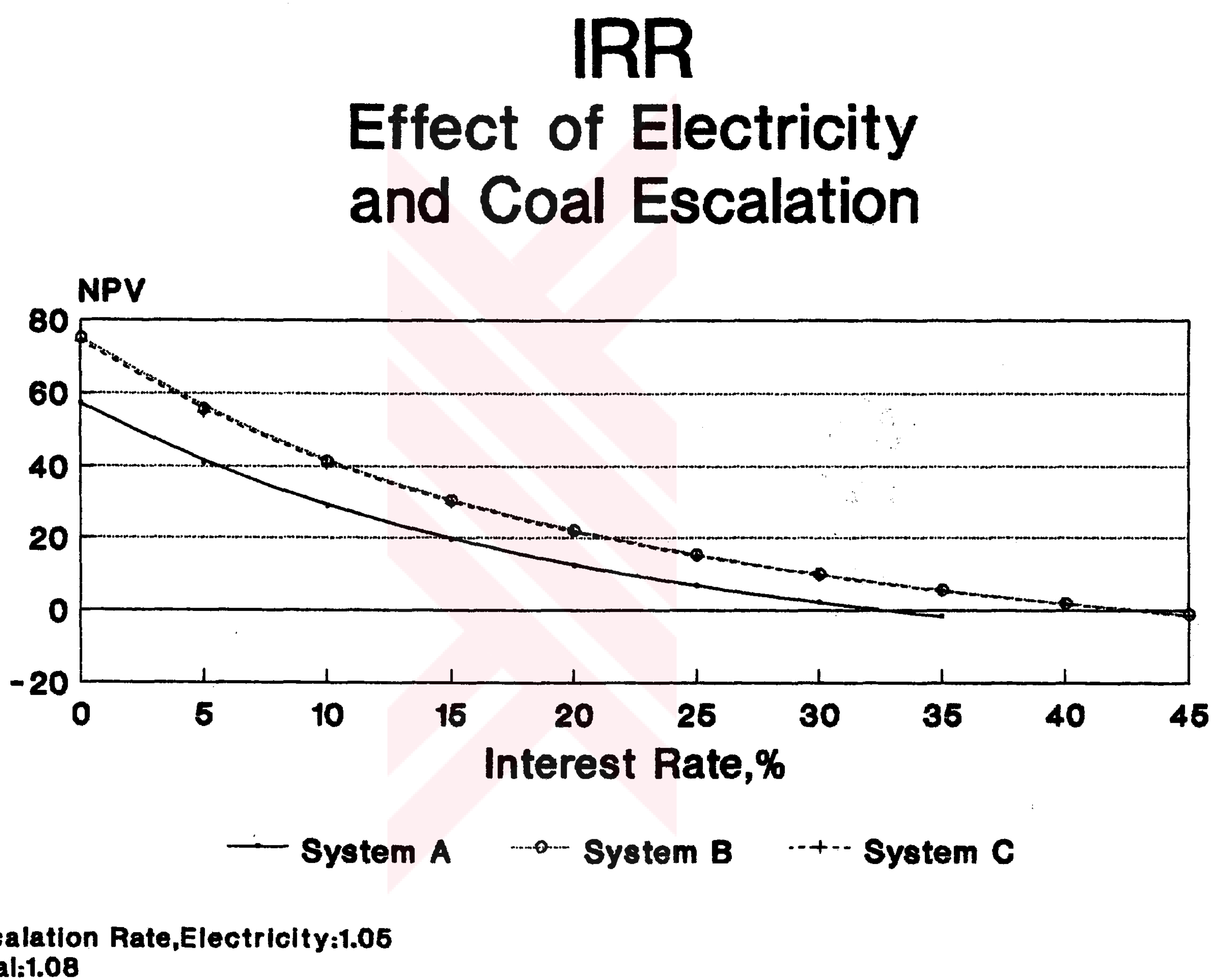


Figure A.II .17 Sensitivity Analysis for Fuel and Electricity escalation rates

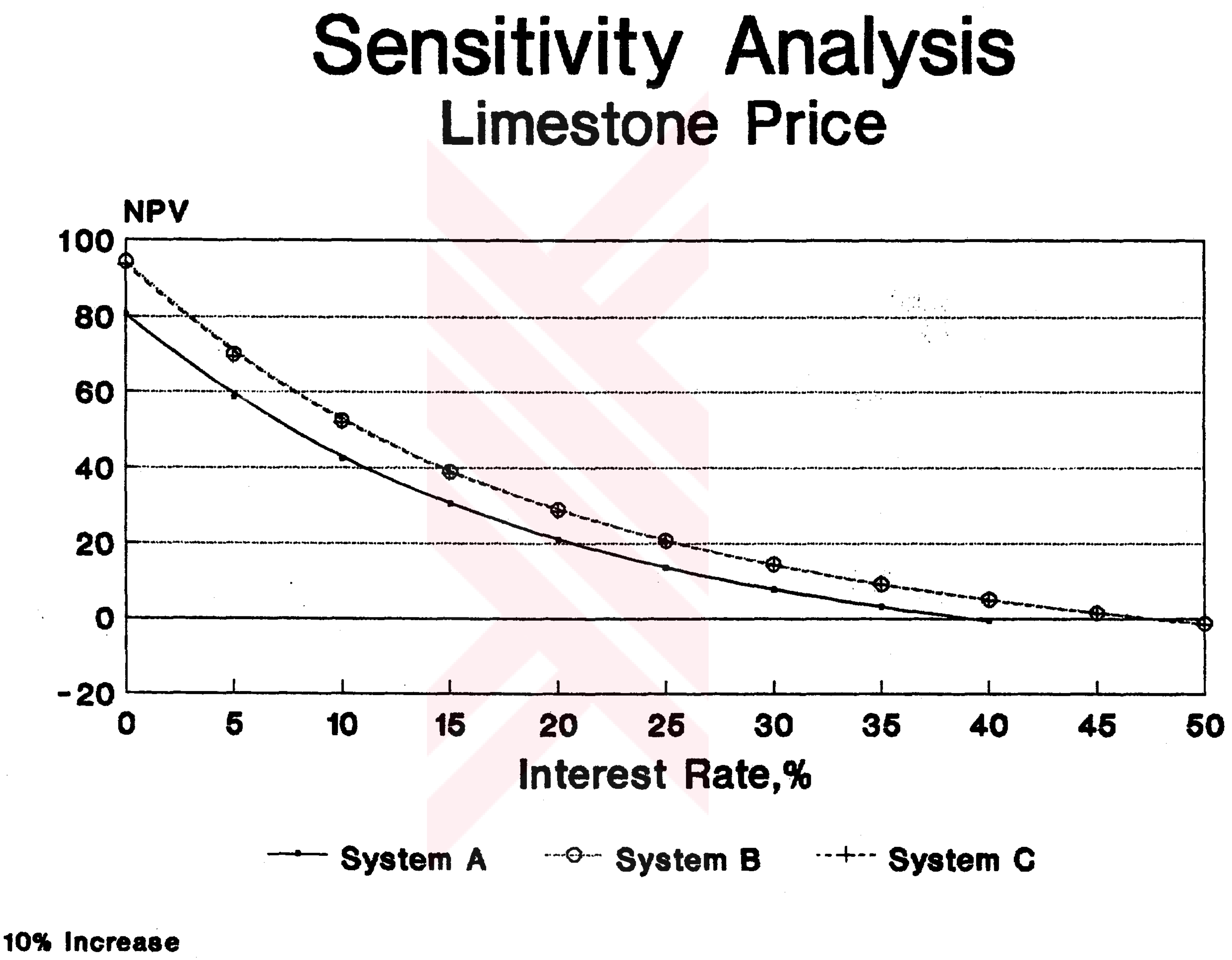


Figure A.II .18 Sensitivity Analysis for Limestone Price,10% increase

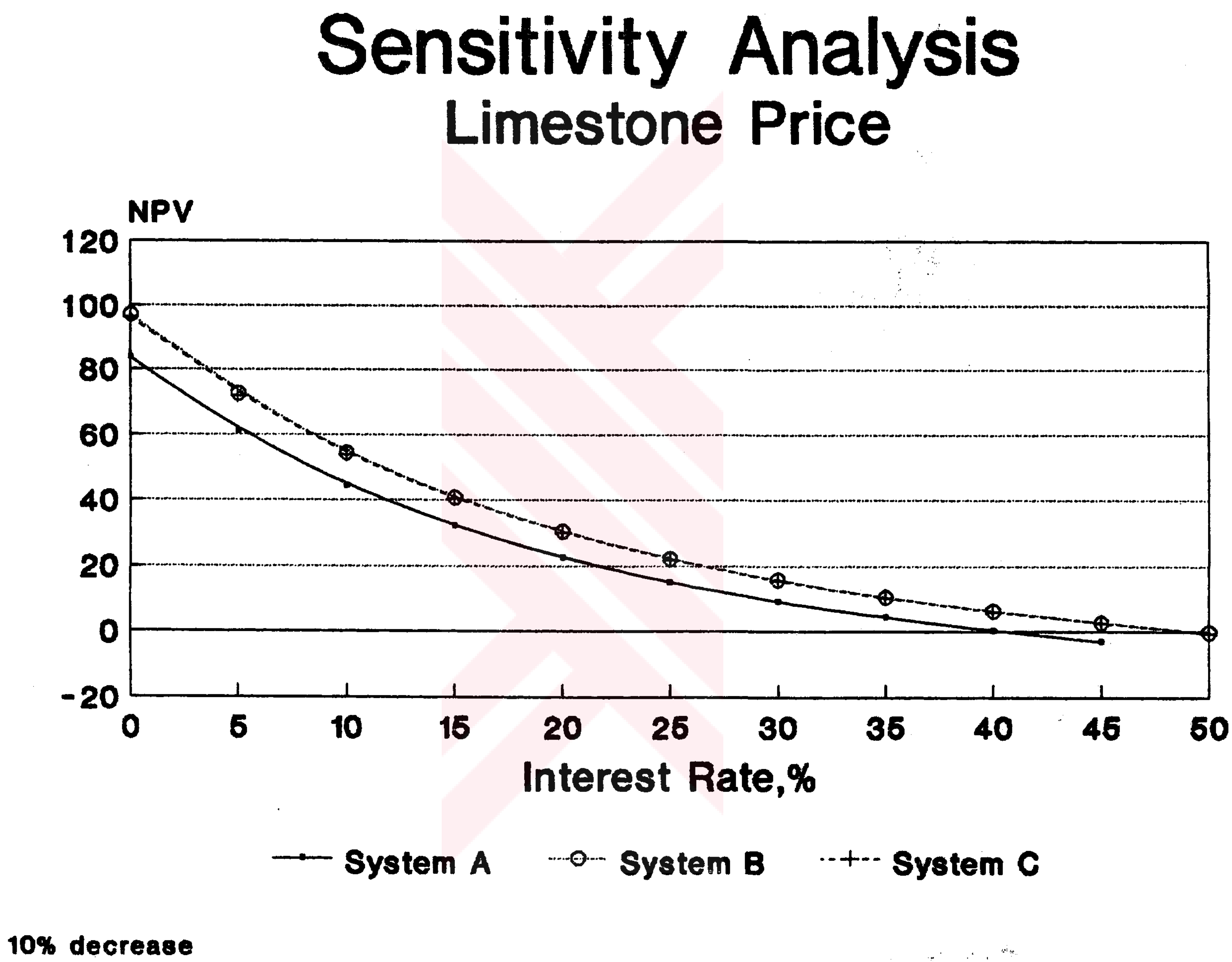
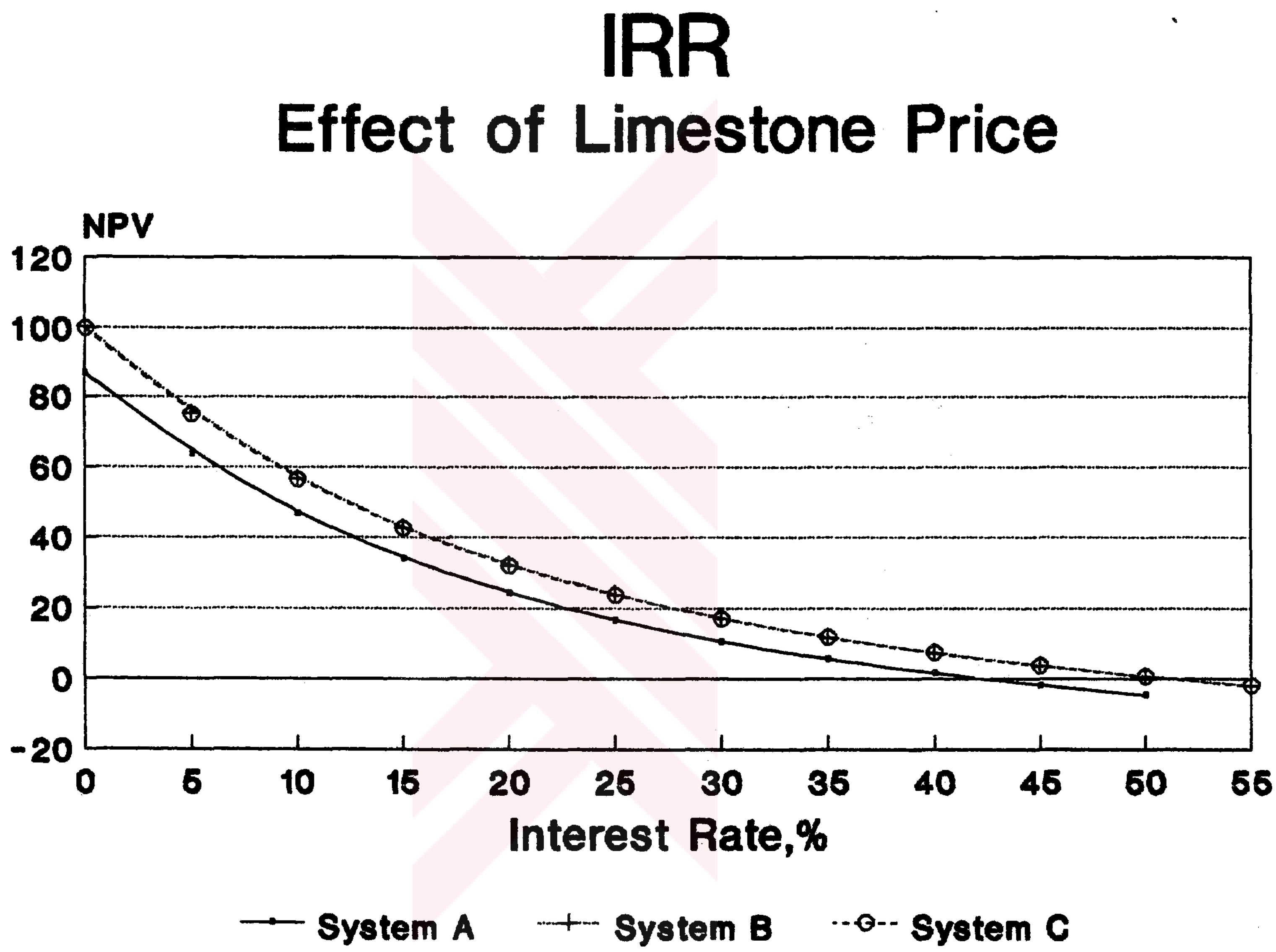
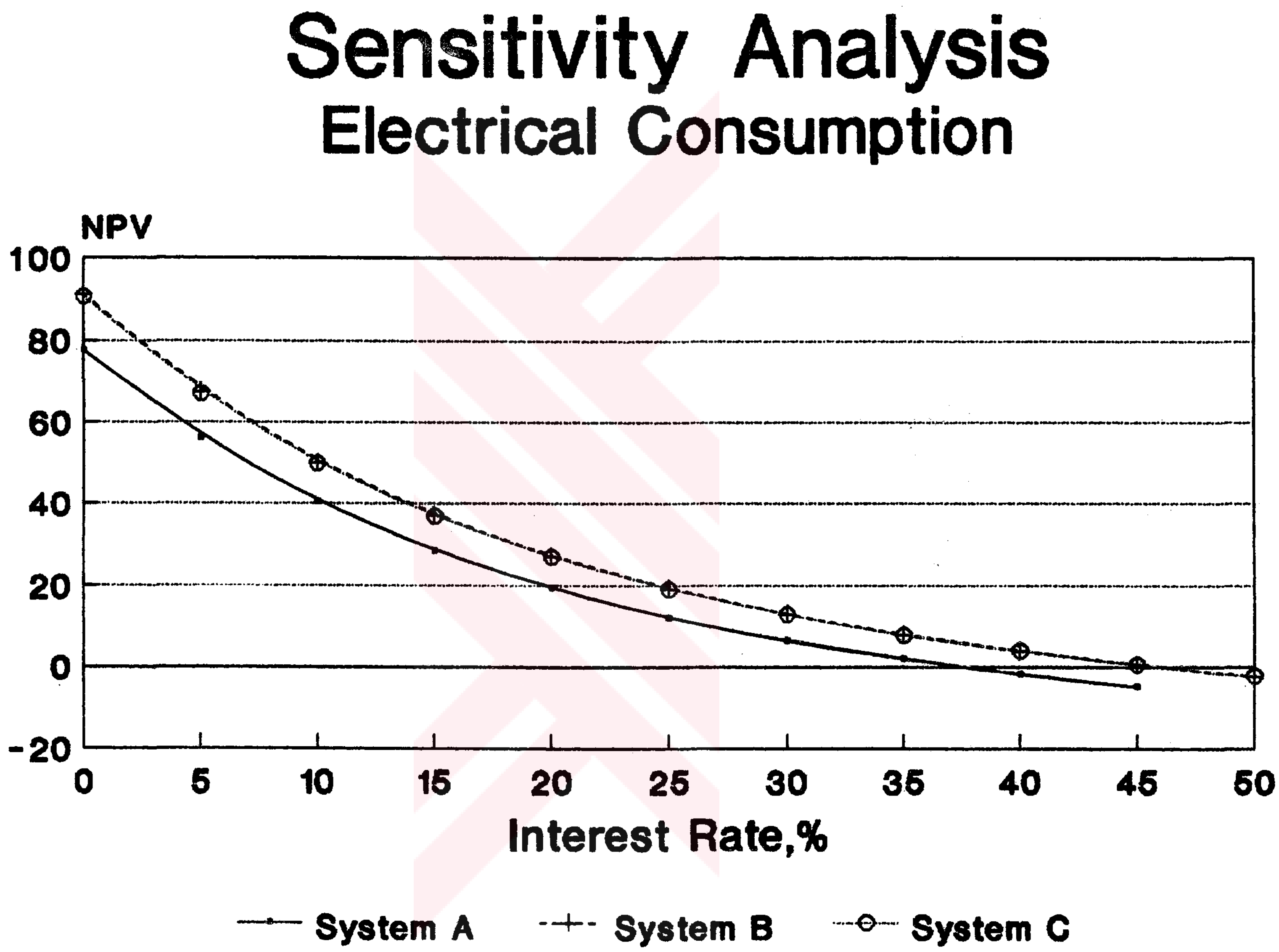


Figure A.II .19 Sensitivity Analysis for Limestone Price,10% decrease



Price:$1.11/ton limestone

Figure A.II .20 Sensitivity Analysis for Limestone Price; $1.11/ton limestone



10% Increase

Figure A.II .21 Sensitivity Analysis for Electrical Consumption,10% increase

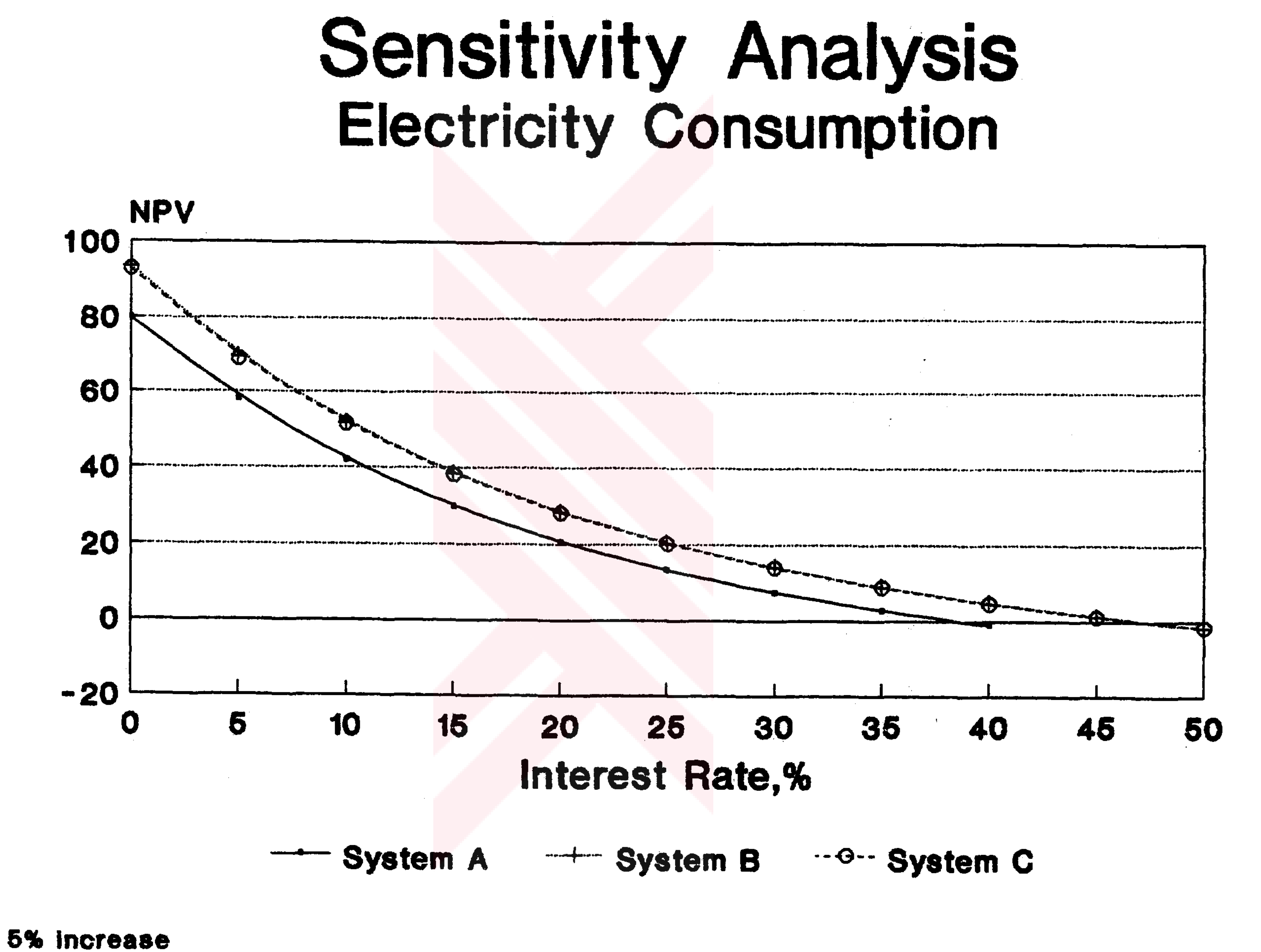
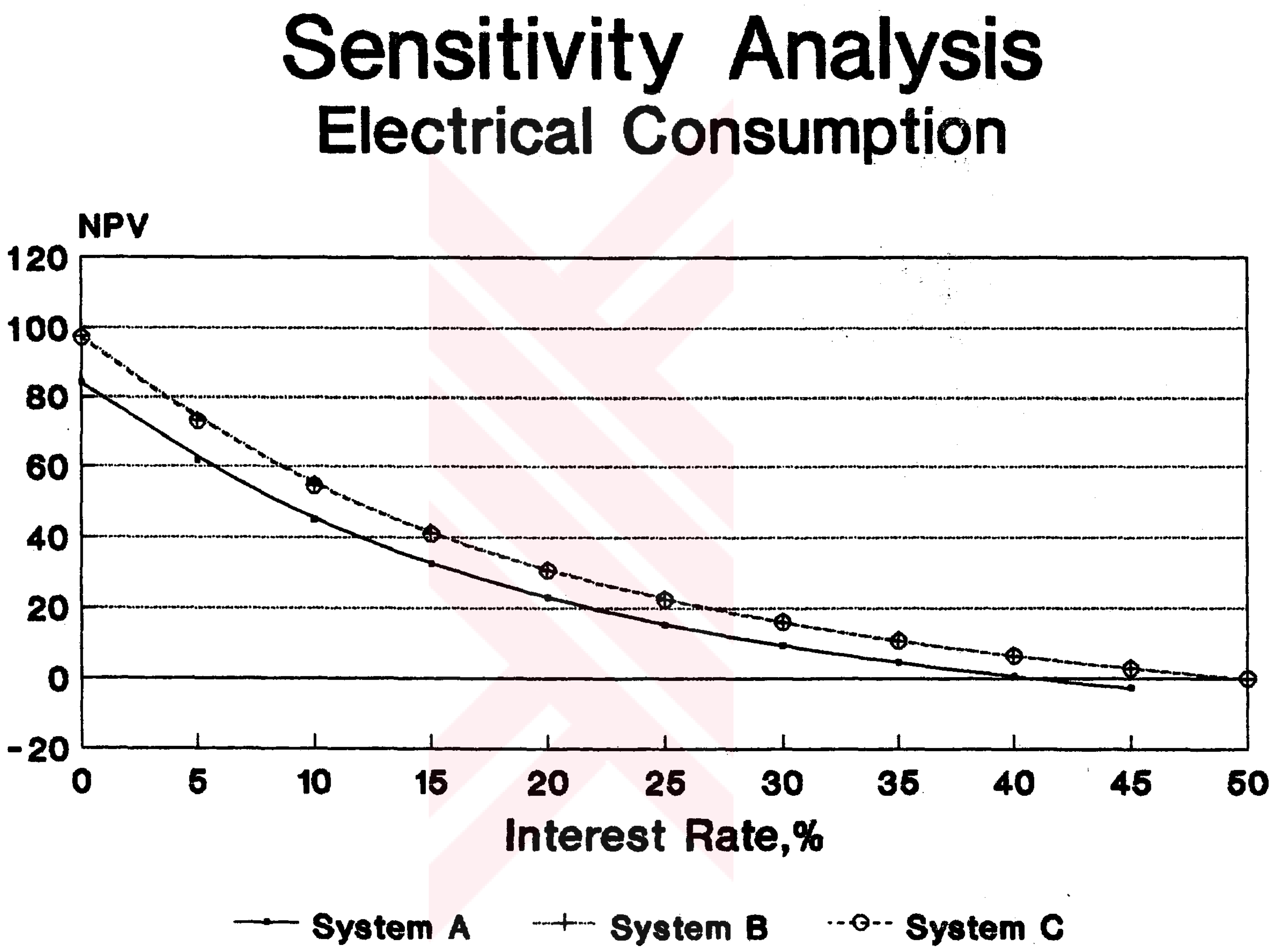


Figure A.II .22 Sensitivity Analysis for Electrical Consumption, 5% increase



5% Decrease

Figure A.II .23 Sensitivity Analysis for Electrical Consumption, 5% decrease

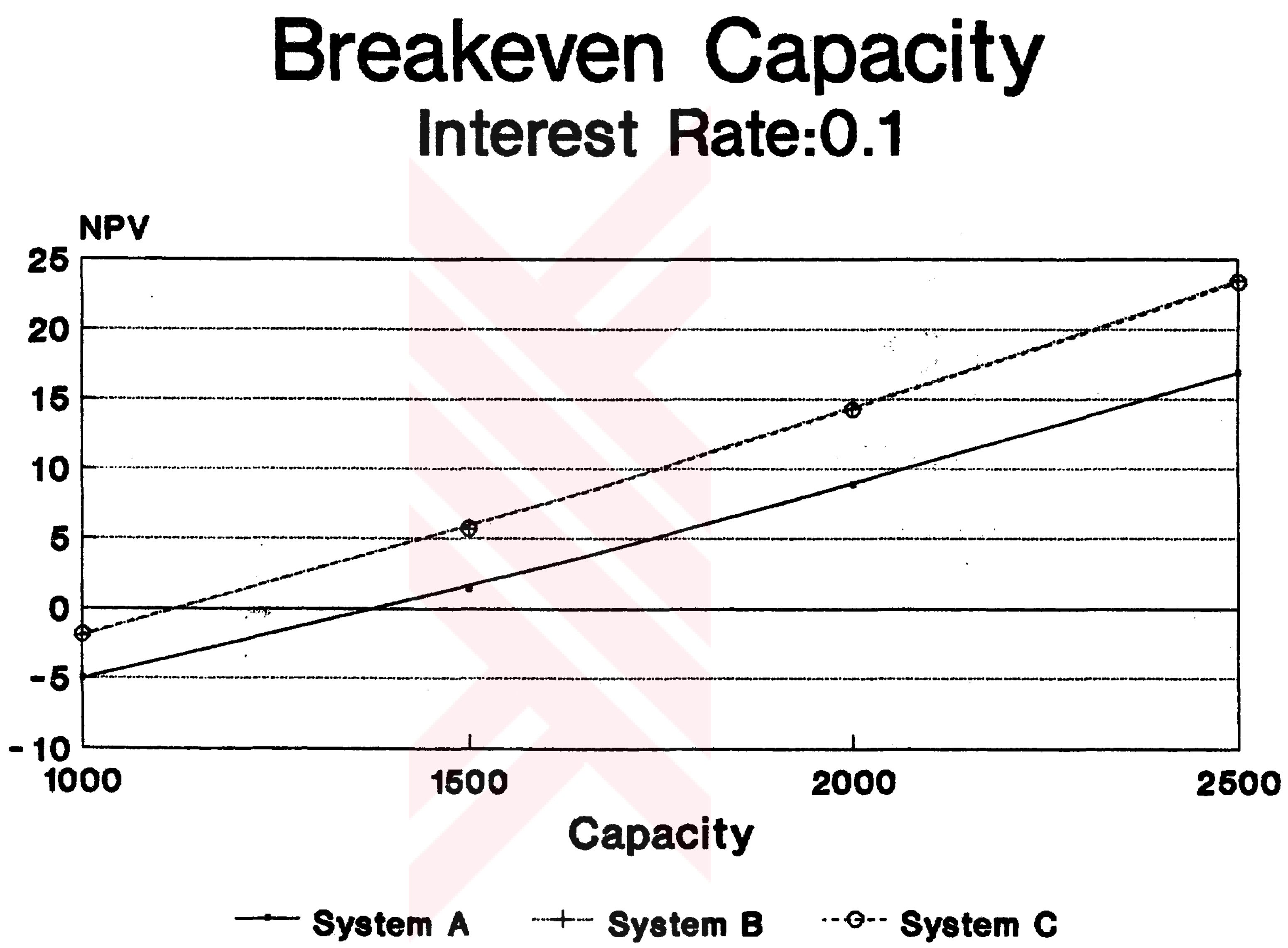


Figure A.II .24 Breakeven Capacity versus NPV,interest rate=0.10

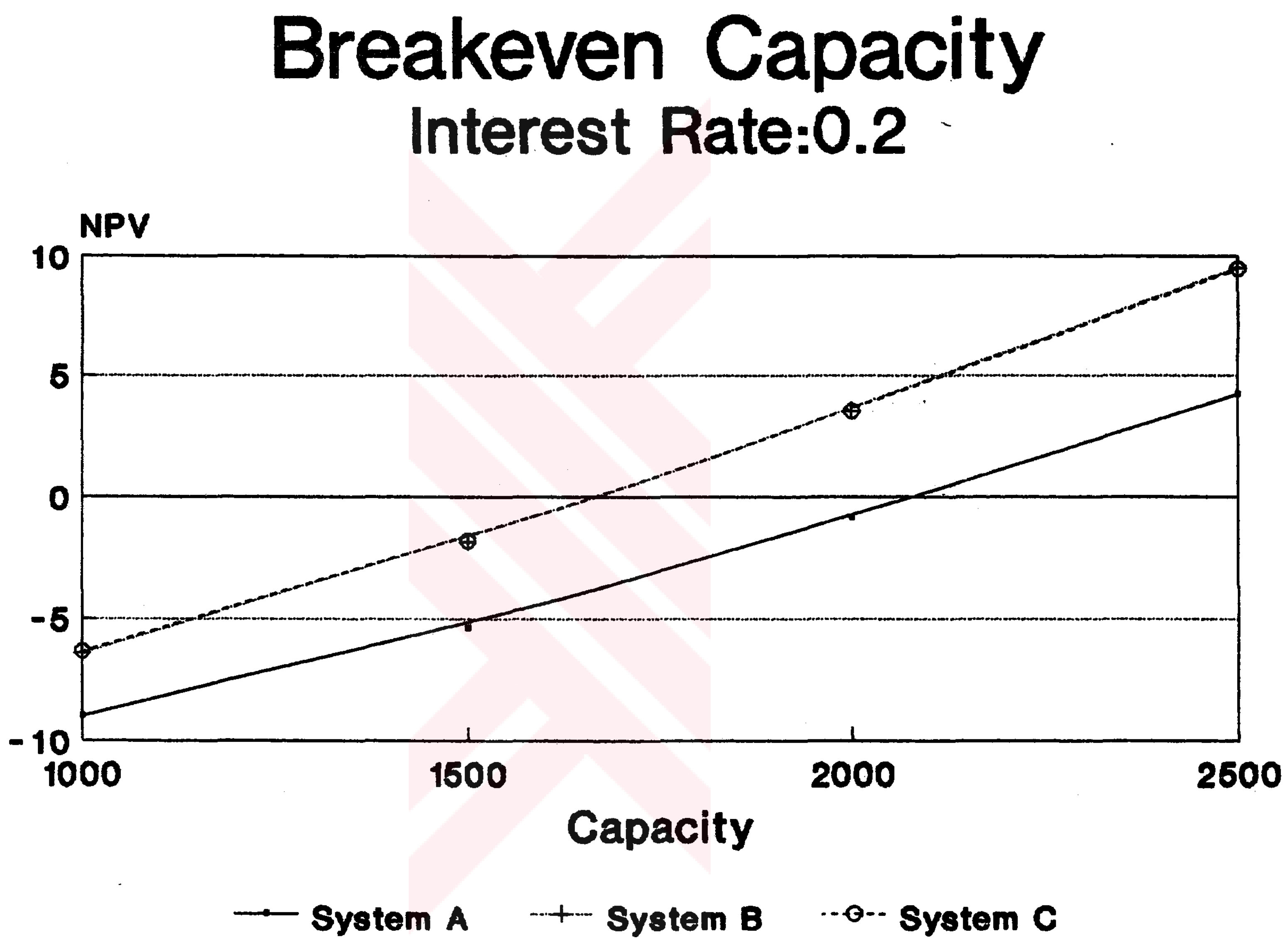


Figure A.II .25 Breakeven Capacity versus NPV,interest rate=0.20

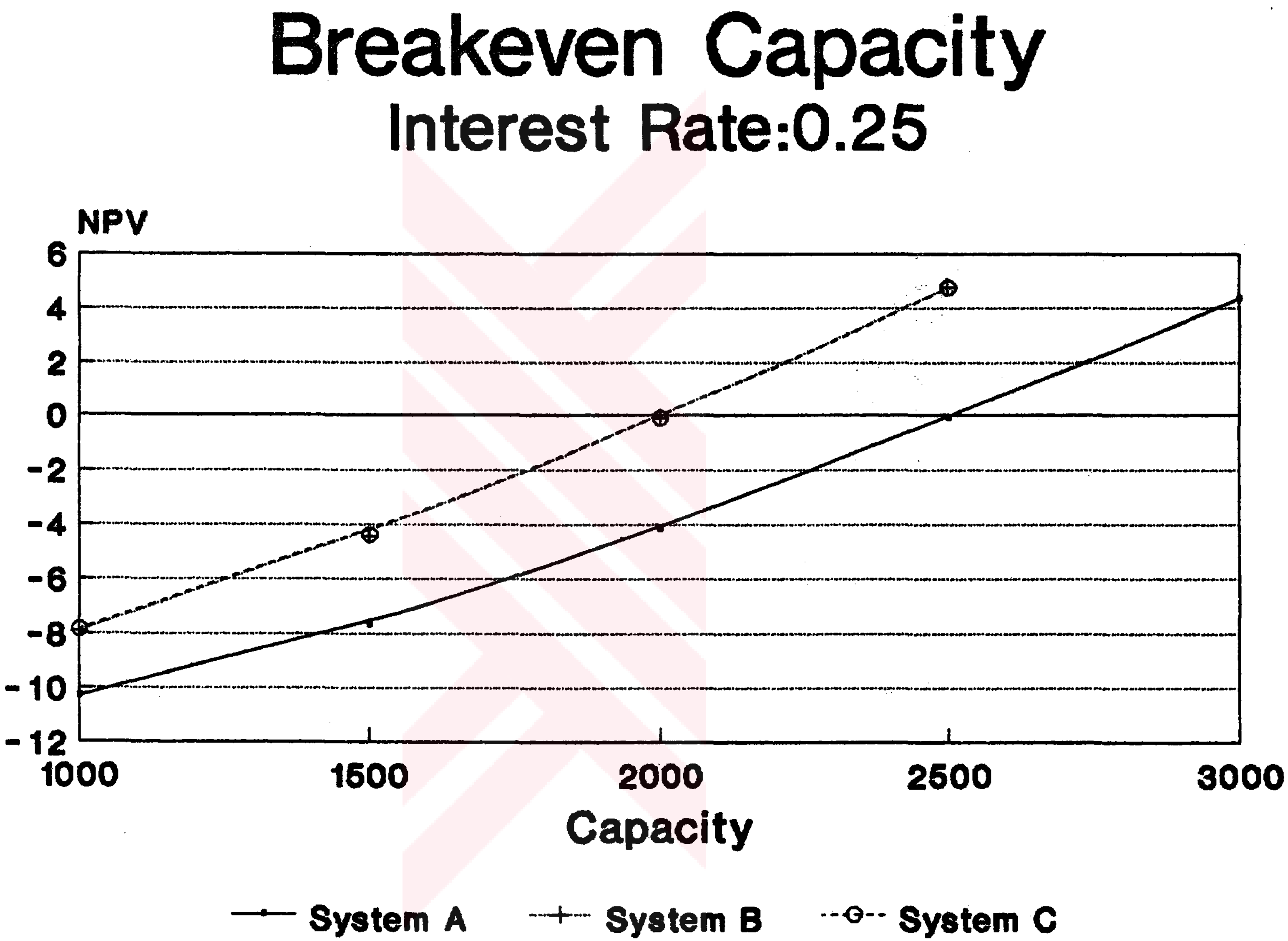


Figure A.II .26 Breakeven Capacity versus NPV, interest rate=0.25

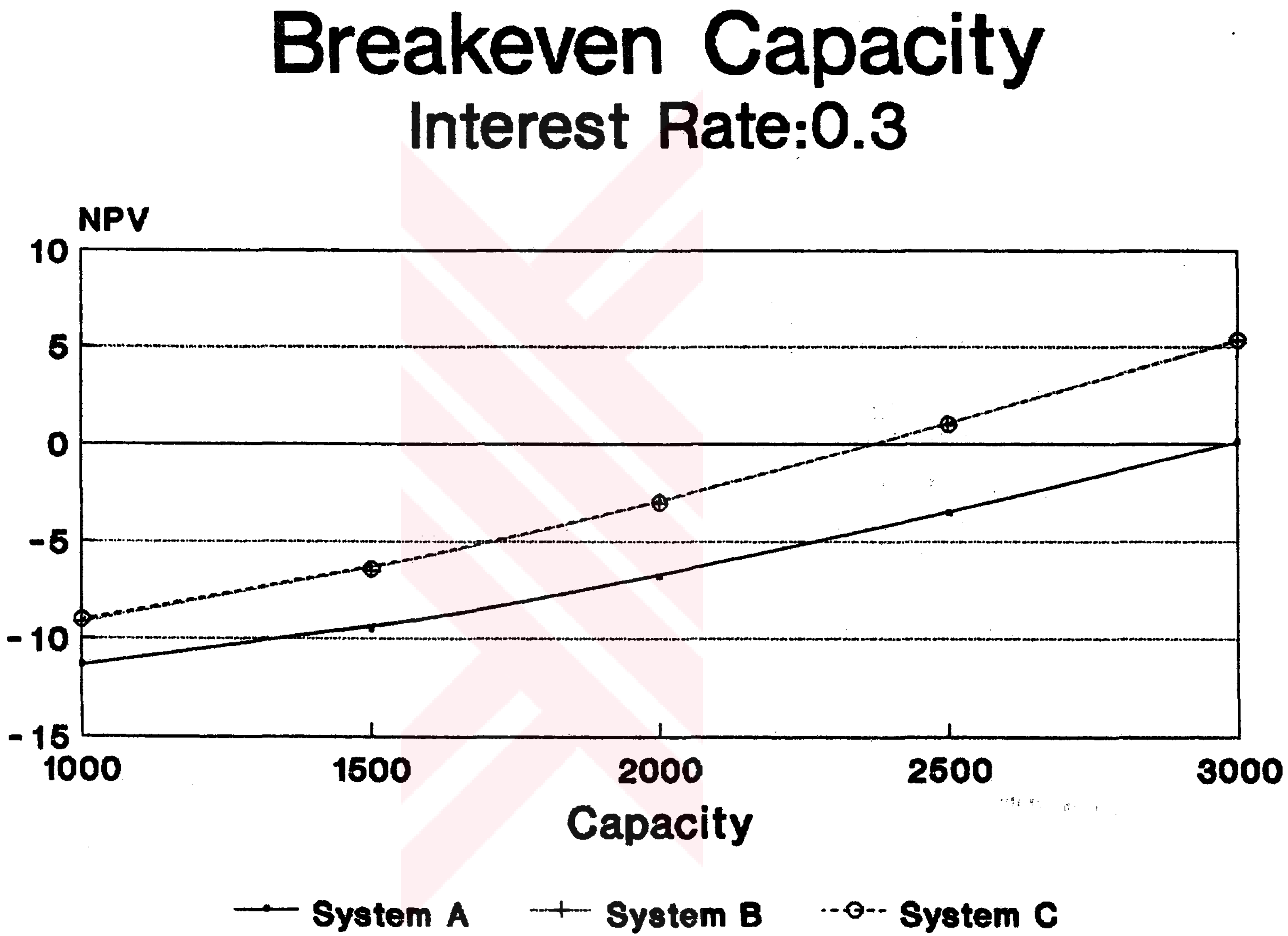


Figure A.II .27 Breakeven Capacity versus NPV,interest rate=0.30

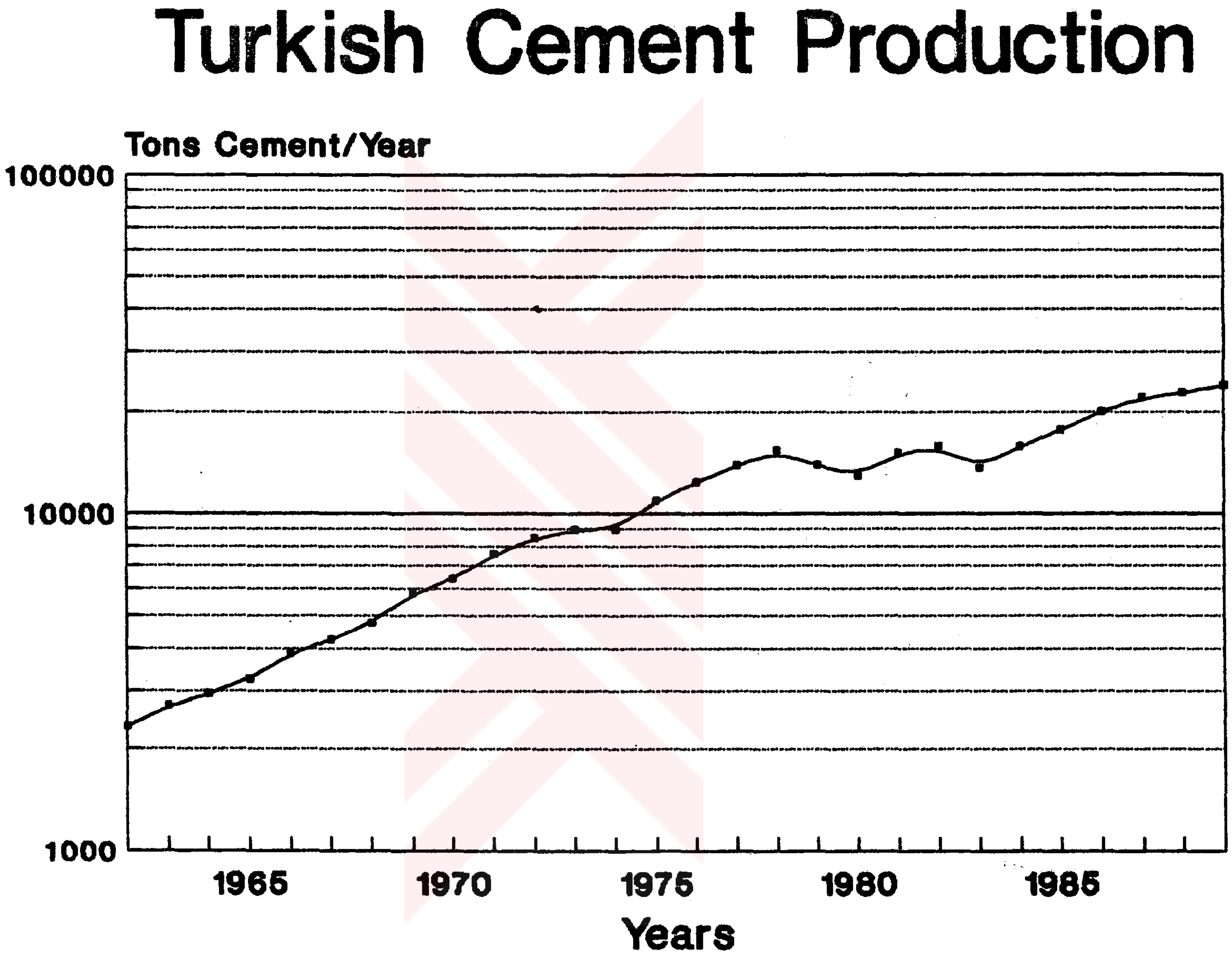
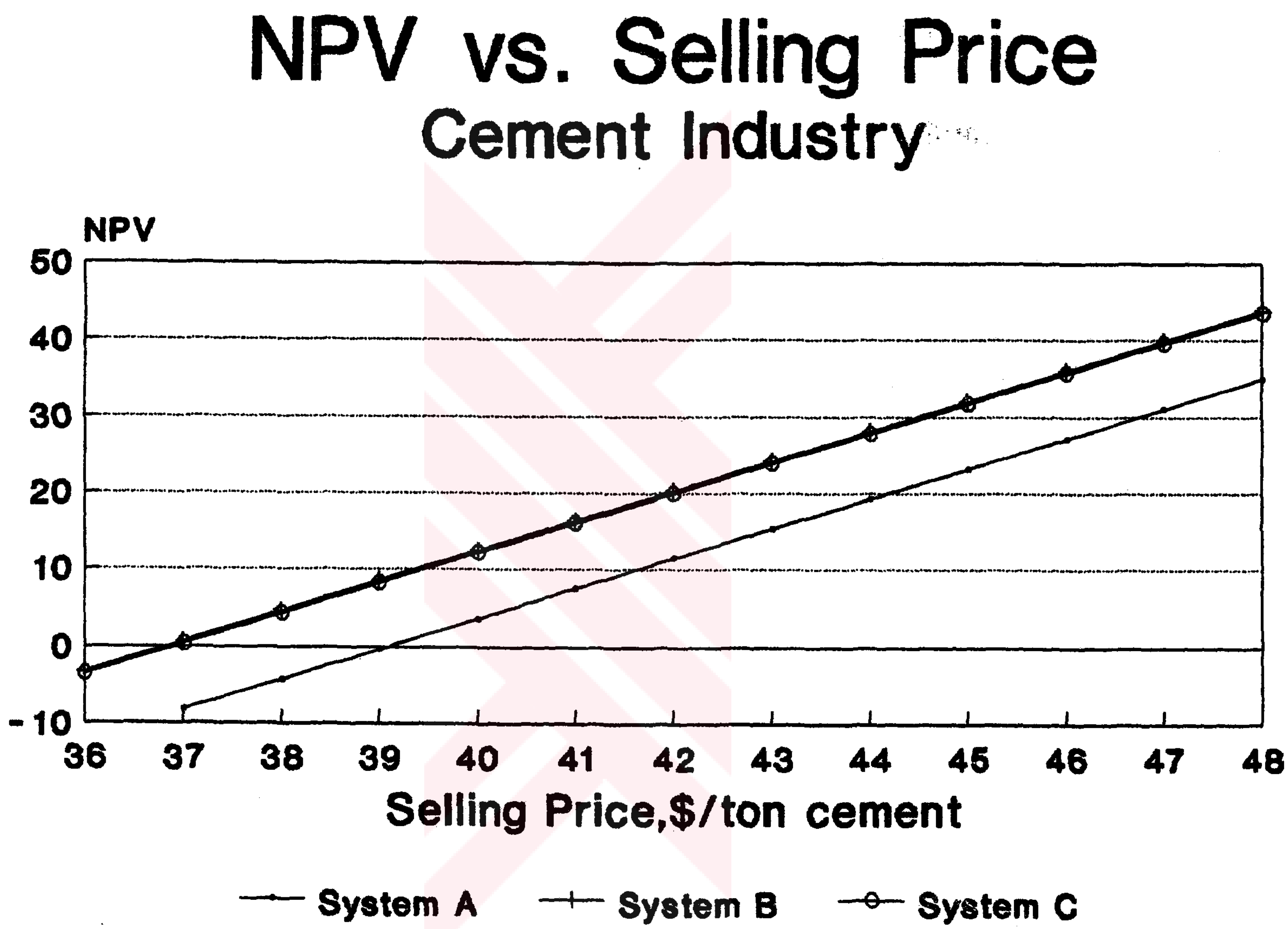


Figure A.II .28 Turkish Cement Production



Price;ex works
4000 tons clinker/day

Figure A.II .29 NPV versus Selling Price