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DP/ID/SER.A/100
21 June 1977
English

07897

CEMENT DEVELOPMENT AND RESEARCH CENTRE

DP/TUK/72/034

TURKEY

Technical report:
APPLYING NEW APPROPRIATE ENERGY-SAVING TECHNOLOGIES IN THE TURKISH CEMENT INDUSTRY

Prepared for the Government of Turkey by the
United Nations Industrial Development Organization,
executing agency for the
United Nations Development Programme

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id.77-6017

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Based on the work of Harald C. Boeck, mechanical engineer

United Nations Industrial Development Organization
Vienna, 1977

Explanatory notes

Reference to "tons" are to metric tons.

Reference to "dollars" ($) are to United States dollars.

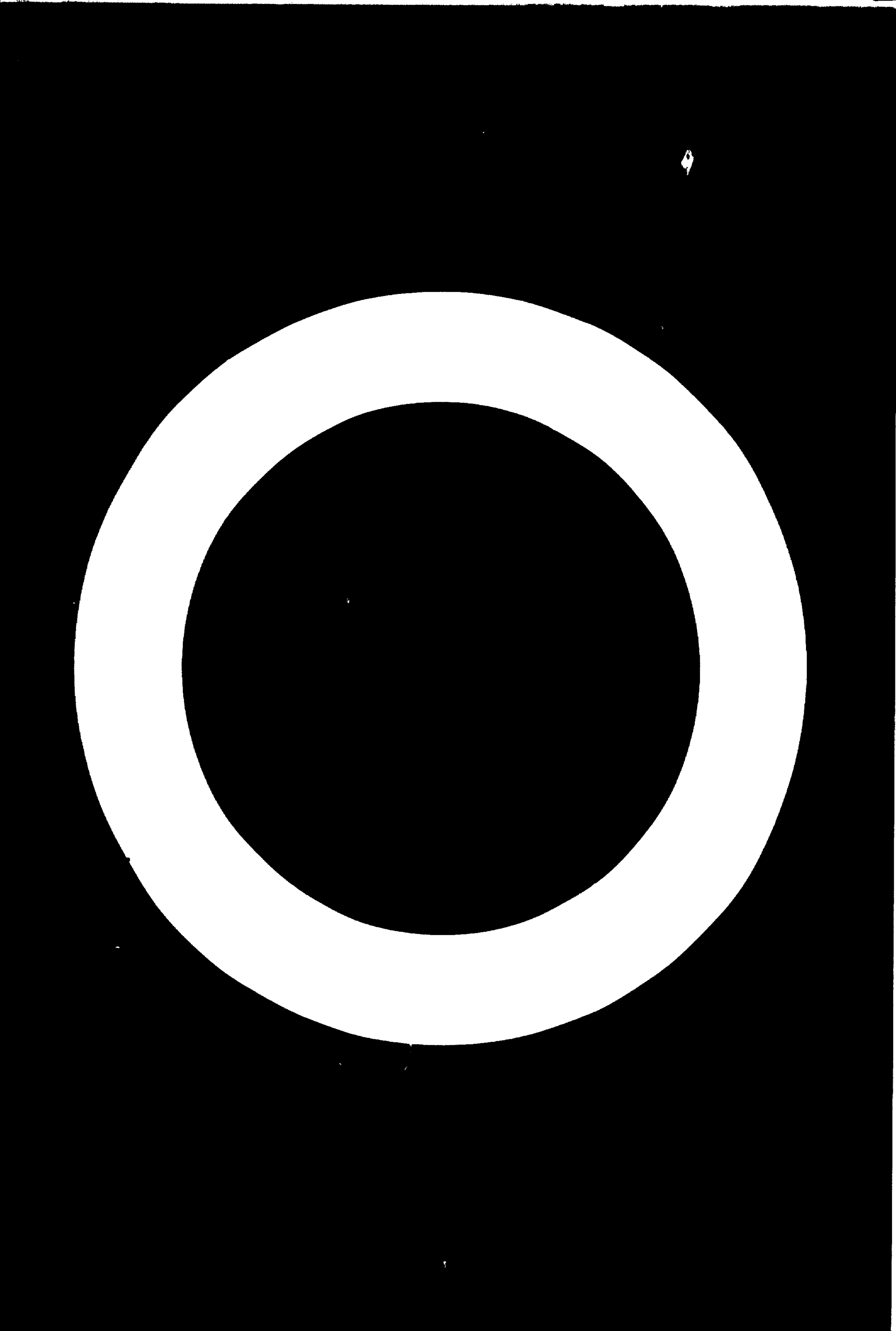
Besides the common abbreviations, symbols and terms, the following abbreviations have been used in this report:

TCS	Turkiye Cimento Sanayii (Turkish Cement Industry Corporation)
P-cK	push-car kiln
t/d	tons per day
t/a	tons per annum
cfm	cubic feet per minute
c.i.f.	cost, insurance, freight
psi	pounds per square inch

ABSTRACT

At the request of the Government of Turkey to the United Nations Development Programme (UNDP), an expert in cement was sent on a four-month mission to advise the Turkish cement industry on the latest technology, in particular, on trends in energy-saving equipment. The mission was part of the over-all project "Cement Development and Research Centre" (DP/TUR/72/034) that the United Nations Industrial Development Organization (UNIDO) is carrying out as executing agency for UNDP. The mission began on 25 November 1976 and ended on 24 March 1977.

As part of the mission, the expert visited the Readymix Cement Plant at Beckum, Federal Republic of Germany, to obtain the latest information on the push-car kiln, a promising new technology that may be applicable in Turkey. The expert also reviewed the feasibility studies that the Planning Department of the Turkish Cement Industry Corporation had made on the 18 new cement plants that are to be established. He gave a lecture course on cement technology in which he discussed new trends, giving special attention to energy-saving equipment.



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INTRODUCTION

The Turkish Cement Industry Corporation (Türkiye Cimento Sanayii- TCS) plays a leading role in the cement industry in Turkey and has various plants throughout the country. The rapid growth of cement production resulting from an ever-increasing demand experienced up to now and projected for the future has led to the introduction of large, modern plants designed and built abroad, most of which are being installed and started-up initially under the supervision of foreign specialists.

This expansion of capacity and technological increase have not always been based on the latest technology, and rising fuel prices now demand maximum saving of energy and most efficient utilization of equipment, manpower and national resources.

To improve this situation for future factories, the Government of Turkey requested assistance from the United Nations Development Programme (UNDP) under the ongoing project "Cement Development and Research Centre" (DP/TUR/72/034), a project that the United Nations Industrial Development Organization (UNIDO) is carrying out as executing agency for UNDP.

A cement expert was therefore sent on a four-month mission to advise the Turkish cement industry on the latest cement technology, in particular, on trends in energy-saving equipment, since TCS is planning to set up 18 new cement plants by 1985, each with a capacity of 550,000 tons of cement per year. The mission began on 25 November 1976 and ended on 24 March 1977. Annex I gives the expert's job description.

On his way to Turkey, the expert visited the Readymix Cement Plant at Beckum, Federal Republic of Germany, to obtain the latest information on the push-car kiln, a promising new technology that may be applicable in Turkey.

Another part of the expert's assignment was to review, together with a UNIDO expert in economics, the feasibility studies that the Planning Department of TCS had made on the 18 new cement plants planned. The expert also gave a lecture course on cement technology in which he discussed new trends, giving special attention to energy-saving equipment.

The expert learned that of the 18 plants 7 had already been contracted for. He concluded, therefore, that it would be difficult to make any alteration in layout and technology in these plants. For the remaining 11 plants, he believed there were good possibilities of applying modern, energy-saving equipment. He estimated the investment cost for each of these plants at TL 700-900 million ($40-50 million).

I. FINDINGS

Visit to Readymix Cement Plant at Beckum

The expert visited the Readymix Cement Plant at Beckum, Federal Republic of Germany, for the first time on 22 July 1976 to investigate new and appropriate technology for small-scale cement plants.

Since January 1975 the Readymix Cement Engineering (RCE) has carried out research and development on an oil-fired, small-scale kiln. The test kiln, a so-called push-car kiln (P-cK), has a capacity of approximately 60 t/d. Since the test kiln was not in operation owing to modifications to improve the process further, the writer was not able to observe a reliable demonstration of the new REBA process (called REBA after the group and the designer, Readymix and Bade). However, it was clear to the expert that the process was highly promising.

On 25-26 November 1976, en route to Turkey, the expert visited the plant for the second time. The kiln was in operation and burning lime. It should be mentioned here that the flexibility of the REBA process, which permits either cement clinker or lime to be burned, is an appreciable advantage, especially for the developing countries. The P-cK should also be of interest to TCS because of its simple construction.

A particular problem in Turkey is that consumption of cement is concentrated in only 5-6 months per year. By applying a P-cK to an existing plant, converting existing raw mill to cement mill and using a vertical mill as raw mill, if applicable, the peak production of clinker in the winter (for stockpiling) could be met and in the summer the P-cK could produce burned lime for which there may be a big demand.

Also for small-scale cement plants in eastern Turkey, where a 550,000 t/a plant probably would be too big, the P-cK could be of interest. UNIDO is making a great effort to solve the very serious problem of how to build up a low-cost small-scale cement plant for use in the developing countries, where cement demand is modest and infrastructure makes transport difficult and costly. Turkey would be an excellent country in which to set up a demonstration small-scale cement plant because of the experience gained there and its manufacture facilities.

The process in the kiln is more or less the same as in the Lepol kiln, which is still used successfully all over the world. The difference between the two processes is that the travelling grate has been replaced by two inclined fixed grates, one for calcining and one for sintering. As far as the material flow is concerned, nodules of a maximum of 10 mm are fed by airlock to the upper part of the kiln, which is a vertical shaft used only for drying the nodules. After drying, the nodules pass through the first inclined grate down to the upper push car situated in the second (calcining) chamber of the kiln.

The partition wall between the two chambers is one of the secrets of the process. The wall separates the chambers in such a way that the thickness of the layer of nodules will be permeable to flue gases passing through the second inclined grate in the sintering zone situated in the firing chamber.

The oil or gas burner is situated in the firing chamber at the front of the inclined grate.

After passing over the second inclined grate, the clinker proceeds by means of the lower push car, falling by gravity in a vertical cooler from where it is discharged by airlock to a clinker conveyor.

Secondary air for the burner passes through the cooler, and after combustion flue gases, excess air and added fresh air pass through the kiln in counterflow by means of Roots blowers and fans.

The following significant features may be noted:

Capital costs for installing the kiln are low;

The process has great flexibility since different materials - clinker, lime and similar materials - can be burned;

Since the kiln is flame-fired, fuel oil, gas or coal can be used;

As a static kiln, a high degree of insulation and a long life of the refractory bricks can be obtained;

Energy consumption for the kiln is low - 730-760 kcal/kg clinker and 14 kWh/ton of clinker;

Since heating-up time is only 3-4 hours (24-36 hours for conventional preheater kilns), there is no problem in stopping and starting;

The kiln can be shut down on weekends if desired, which is a great advantage in developing countries;

Since the total volume and height of kiln and cooler are low, the kiln is easy to maintain and civil engineering costs are low;

All air from the cooler goes through the kiln;

The kiln is easy to operate. There are no clogging, caking and ring formations; thus materials of inferior quality can also be used.

Several push-car kilns are expected to go on-stream in the near future. Seven projects are ongoing and more are under consideration. The first kilns in operation will be of relative small capacity until more experience has been gained.

Review of feasibility studies

Together with a UNIDO expert in economics, the expert reviewed the feasibility studies elaborated by the Planning Department of TCS.

The two experts have been very much concerned about transport costs, especially between the quarries and the plant sites. They agreed that the rubber-belt conveyor should be preferred wherever applicable in spite of the high initial investment costs.

The studies made by the Planning Department are quite impressive and will be completed plant by plant, taking into consideration new trends and technologies, which could change some figures.

Search for new and energy-saving technology for the new cement plants planned

Cement production is an energy-intensive process with a heavy, low-cost product. Because of the threatening shortage of energy, a search for all kinds of energy-saving equipment is essential. The search is especially important in Turkey, where it is planned to set up 18 new cement plants before 1985. Each of the new cement plants is to be of a standard size, with a capacity of 550,000 t/a. Seven of these plants had been contracted for prior to the UNIDO mission and therefore are partly out of the picture as far as modernizing is concerned. The 11 remaining projects are still under consideration and therefore suitable for updating.

New developments in cement production have in the last decade resulted in significant changes in plant layout and important savings in energy consumption. To make as much information as possible available to the Planning Department of TCS the expert asked several potential suppliers of equipment to provide TCS with information on these products. Their addresses are contained in annex II.

Suggestions for using newly developed energy-saving equipment are given below.

Quarry equipment

To produce 1 ton of cement, about 1.7 tons of raw materials must be quarried, taking moisture and losses into consideration. A homogenizing silo, which is expensive equipment and costly to operate, should not be used to prepare raw mix for the kiln.

The preparation of raw mix for the kiln should start at the quarry; therefore, a careful feasibility study on raw materials for a new cement plant should be made. Core drillings are indispensable; 100 m of core drilling is recommended for each 1 million tons of quarrying. The costs of such a feasibility study can easily reach 10-15% of the total investment costs of a new cement plant.

To open and run a quarry, highly skilled workers are required, especially where capacities exceed 0.5 million tons of rocks per year. A good quarry foreman saves energy and money.

The limestone quarry is the most important to develop, since the limestone needed amounts to 70-80% of all raw materials, depending on the composition. For quarrying of limestone, two main systems are employed - blasting and ripping. Today's high costs of equipment, fuel and maintenance call for a careful study on whether blasting, ripping or a combined system should be employed. If the limestone quarry appears as hard rocks, large-hole blasting would be the most favourable system. If marl or soft stones, ripping should be applied. Naturally, any supplier of ripping equipment will be interested in giving advice.

Annexes III, IV and V give some useful information provided by local suppliers agencies in Ankara.

In annex V a proposal for low-energy quarry equipment is presented. The total investment costs for this equipment are on the high side. Down-the-hole drills have been chosen. One is sufficient and one is stand-by. This system is probably new to the Turkish cement industry, but savings in energy and maintenance costs are considerable.

The following figures have been used for the sizing of quarry equipment:

Effective working hours per year	1,600
Effective working days per year	250
Effective working hours per day	6.4
Explosive consumption, ammonium nitrate fuel oil (ANFO)	250-300 g/t blasted rock
Bore metre per shift and machine	
Conventional drill	50-60
Down-the-hole drill	75-90
Maximum number of boulders	1/100 t of blasted rock

The blasting system will have to be developed quarry by quarry. Annex VI gives suggested spacing of bore holes. The aim of the spacing is to minimize the number of boulders, i.e. stones too big to pass the mouth of the crusher. As explosive, ammonium nitrate fuel oil (ANFO) is considered. The use of milli-second delay is important.[1/]

Annex VII gives the cost of civil engineering in 1976.

1/ See Joseph M. Pugliese, "Designing blast patterns using empirical formulas", Pit and Quarry, August 1973, pp. 85-88.

Transport from the quarry to plant site

In choosing the plant site, it should be borne in mind that transport costs are rocketing; thus, the distance between the quarry and plant site should be kept as short as possible. However, a distance of 1.5 - 2.0 km seems to be the most suitable, since large-hole blasting can create disturbances at the factory.

Annex VIII gives cost estimates for a long-distance rubber-belt conveyor. Comparison with other means of transport should be made plant by plant.

The rubber-belt conveyor is a capital-intensive installation, but maintenance and energy costs are extremely low. Thus it is increasingly being used throughout the world.

To use the energy-saving rubber-belt conveyor, the limestone must be crushed at the quarry. This practice is increasingly being followed, and in the last decade mobile crushers have been manufactured and used in many quarries. Today both mobile crushers and long-distance rubber-belt conveyors are commonly used and should be of great interest to the Turkish cement industry. As the first step, a stationary crushing department at the quarry may be the best solution, since the mobile crusher requires more maintenance. The quarry layout will also have to be suitable for either a mobile or stationary crusher.

Other means of transportation are the aerial ropeway and the pipeline. The first is out of the question owing to low capacity and tremendous maintenance costs after a few years of operation. Broken wire rope is uncommonly difficult to replace. For these reasons, an aerial ropeway should only be chosen in an exceptional case.

The pipeline is not suitable for dry process cement plants. However, it could be of interest for cheap transportation of lignite coal, since the coal already has a high moisture content at the deposit, i.e. about 54% water.

Prehomogenizing of raw materials

Homogenizing of the raw mix for the kiln starts at the quarry by selective quarrying according to continuous analysis of the dust from the drill(s) used for blast holes; thus team-work between the workers at the quarry and laboratory is extremely important.

Today intensive effort is made to facilitate sampling, by transporting samples rapidly and using quick-service analysis equipment, e.g. continuous radiometric analysis of flowing materials. The use of computers has given excellent results in connexion with X-ray and isotope analysers; accordingly, the layout of a cement plant has changed considerably in the last decade.

The selected, blasted and crushed limestone is transported by means of a rubber belt to a preblending plant normally situated at the plant site. The preblending plant is equipped with a stacker to build up a preblended stockpile and a reclaimer to reclaim and feed it to a rubber belt that will transport it to the raw mill department.

Preblending plants of varied design are available, and the choice of the most suitable design must be made carefully. Depending on the raw materials, preblending plants (also called prehomogenizing plants) can be designed for combined preblending, whereby ready-mixed raw material can be fed to the raw mill with only small quantities of corrective materials, e.g. high-grade limestone, sand and iron ore added.

However, combined preblending is seldom possible. Thus separate preblending of each component of raw materials is the system most used today, and it [illegible] of different types of cement at the same plant.

Preblending can reduce the total investment costs for a complete cement plant through savings on silo capacities and reduce the prime costs through improved availability of the kiln. It is cheaper to store materials on the ground than in a silo.

The aim of preblending is to supply the kiln with raw meal (powdered raw mix) with a maximum deviation from the $CaCO_3$ (calcium carbonate) content of ± 0.20 % and of an appropriate combustibility.

Before crushing the limestone can have a deviation from the $CaCO_3$ content of, say, ± [illegible] %, or even more. To reach a variation of possibly less than ± 0.20% for the raw mix fed to the preheater, the total reduction factor should be 30. The following reduction factors can be obtained in various stages of the raw materials preparation:[2]

2/ Zement-Kalk-Gips, No. 12 (1975) p. 509.

Quarry with selective quarrying	1 - 1.5
Intermediate storage	1 - 1.5
Crushing	1 - 1.5
Blending beds	4 - 10
Intermediate storage	1 - 1.5
Raw grinding	1 - 2
Continuous homogenization	3 - 6
Batchwise homogenization	5 - 30

Low-energy raw mill department

Most of the existing raw mill departments in the Turkish cement industry are working according to the air-swept principle in conjunction with a ball mill. Today the ball mills are being replaced by the so-called roller mill, also called vertical mill. The reasons for this trend are as follows:

(a) The roller mill has the capability to grind raw materials with a moisture content of up to 22% and to dry it to below 1%;

(b) Large-size mill feed can be obtained, i.e. maximum size equal to 5% of roller wheel diameter which saves in crushing. However, owing to the use of a preblending plant, the mill feed size should not exceed 60 mm in order to avoid too much segregation;

(c) Specific power consumption is approximately 15-20 % lower than by ball mill;

(d) Investment and operation costs are approximately 20% lower than those for a ball mill, including civil and electrical engineering;

(e) Noise emission is about 15 % lower than for a ball mill, 90-95 and 105-110 dB(A), respectively;

(f) Mill loading is extremely low - thus the composition of the raw materials can be changed instantly; the raw materials stay in the mill approximately 2-3 minutes;

(g) On-line analysis and computers can be applied.

If the limestone has a high quartz content the roller mill would not be suitable because of excess wear. In that case a conventional ball mill would be preferable.

The raw mill department consists of silos for corrective materials, feeders, ball or roller mill, auxiliary furnace and an electrostatic precipitator.

If the moisture content of the raw materials does not exceed 6-7 % the hot exit gases from the preheater are sufficient for drying; above 7 % a predrier is necessary if a ball mill is used. The need for a predrier installation can be eliminated by using a roller mill.

An auxiliary furnace is always to be recommended for running the raw mill during kiln stoppage.

The introduction of the roller mill in the Turkish cement industry could save considerable energy, say, 4 kWh/t of raw materials. Assuming a price of, say, 0.43 LT/kWh, the annual savings for the 11 new cement plants would amount to 11 x 550,000 x 1.6 x 4 x 0.43 = LT 16,649,600, equal to $951,400 or say $1,000,000. In addition, the same amount could further be saved by using the satellite cooler for the kilns instead of the grate cooler.

For the time being, as far as the expert is aware, only one private cement plant is equipped with roller mills (Darica), but more roller mill installations are under consideration, which is very important.

Homogenizing silos for raw meal

After the raw mill, the produced raw meal must be finally homogenized in one or more homogenizing silos. Two main systems of homogenizing silos are employed in the cement industry: batchwise and continuous.

The batchwise (intermittent) homogenizing system has a high homogenizing effect, reduction factor up to 30, depending on the air supply rate and length of time the material is in the silo.

The silo where the homogenization takes place is situated on the top of the store silo, both of the same diameter. Owing to the limited size of each silo, i.e. 3,000 tons storage capacity, and extensive height, the civil engineering costs are high.

The continuous homogenizing system is further subdivided in two systems: cascade arrangement and homogenizing compartment.

Continuous homogenizing with the cascade arrangement consists of two or more silos where the raw meal is fed to one of them and thereafter by overflow goes to the next and so forth. Also here the capacity of each silo is limited to 3,000 tons; thus the civil engineering cost is high.

Continuous homogenizing with the homogenizing compartment is the most interesting and widely used system today. The silo can be built up to a very large size with a height/diameter ratio of about 1.5; to construct silos with a capacity of 12,000 tons is no problem. The homogenizing effect depends on the charge of the silo, i.e. the level of raw meal. With a completely full silo the reduction degree can reach more than 6, but on an average, 4-6 should be feasible.

Consumption of air is low, since the system works by means of a specially designed outlet with a big cone situated in the bottom of the silo. The relatively low height and low consumption of air make the system a low-cost and low-energy one.

For the 11 new cement plants, continuous homogenizing with homogenizing compartment should be considered. One silo is sufficient with a capacity equal to, say, 2-3 days of production. Two silos would be excellent each with a capacity of 3,000 tons for better maintenance. If the two silos are working in parallel, the reduction factor could reach more than 6.

Characteristic data for batchwise and continuous homogenizing are given below.

Item	Batchwise	Continuous	
		Cascade	Homogenizing compartment
Investment costs/ton (%)	100	120	65
Installed kW (%)	100	85	35
kWh/t	1.65	2.80	1.30
Reduction factor	10-30	5-15	3-8

Source: Zement-Kalk-Gips, No. 12 (1975) p. 518

It should be stressed that silo storage capacity is expensive. Thus, extended storage capacity at the preblending plant should be considered. This is advantageous, especially if a roller mill, where raw meal composition can be corrected instantly, is used.

Preheater and calciner

Estimating a reliable availability of the kiln department of 85% equal to 310 working days per year, the daily clinker production should be about 1,700 tons, when 5% addition of gypsum to the cement mill is calculated. It should be mentioned here that the actual availability for all cement plants in Turkey is in the range of 80-82%. The above-estimated availability could easily be reached if the raw materials were prepared more carefully.

As shown in annexes IX and X, two preheater systems can be employed, but in view of the high interest in using low-calorific lignite as fuel, a preheater with separate precalciner should be considered.

The two preheater systems in question are a conventional four-stage cyclone preheater and a so-called integral precalciner, where the precalcining takes place at the kiln inlet and amounts to approximately 60 %. In both systems the cyclones and kiln diameters are the same, but in the latter the kiln is shortened by 40-45%, which reduces the space requirements and initial costs.

The integral calcining system has been recently developed by a Danish company, and further improvements are being made. One could ask how it is possible to shorten the kiln so much and still keep the same production. It is possible by feeding the approximately 700°C hot raw meal from the third cyclone stage (second lower) direct to the kiln inlet, where a special device distributes the raw meal like a curtain right at the kiln inlet section before the riser pipe. There the raw meal meets the approximately 1,600°C hot exit gases from the kiln, and almost instantly the raw meal reaches a calcining temperature of approximately 840°C. After passing the fourth cyclone stage it passes to the kiln inlet again through a specially designed feed pipe.

Owing to the high temperature at the kiln inlet, a kiln by-pass is not recommended, since thermal losses will be too high. Thus the integral calcining system is not applicable where content of chlorine is high, i.e. exceeding 0.015%.

The advantages of the integral calcining system are that initial costs, radiation losses, and power consumption are lower and all kinds of coolers can be employed.

Normally, separate precalciners are not employed in production units with a capacity of less than 2,500 t/d. This secures an acceptable lifetime of the burning zone brick lining for conventional kilns up to 5.2 m diameter. Nevertheless, the expert was informed that a private cement plant near Izmir is using low-calorific lignite as fuel in a conventional kiln without mixing fuel oil. This case should be examined carefully.

For all kinds of preheaters and calciners the total pressure drop, which differs considerably from system to system, should be kept as low as possible. To operate a preheater trouble free, feed should be kept constant, with a maximum variation in $CaCO_3$ content of $\pm 0.20\%$, and the combustibility of the raw meal should be carefully controlled.

Kiln and cooler

For a kiln capacity of 1,700 t/d, a rotary kiln of approximately 4.6 x 75 m (diameter x length) should be appropriate. All parts of the kiln can be manufactured in Turkey except for a few items such as motors and gear boxes.

Most kilns in Turkey are equipped with a grate cooler. Four main types of clinker cooler are employed.

Type of cooler	Approximate power consumption (kWh/t of clinker)
Grate	6.0 - 8.0
Vertical	5.8 - 6.6
Satellite	0.5 - 1.3
Rotary	2.5 - 3.5

The production department prefers mainly the grate cooler because of its independence and capability of cooling in any kiln condition and especially in the case of high MgO content where air-quenching can be applied. Using excess air for cooling naturally consumes more energy, and the excess air has to be removed through a filter. However, the grate cooler becomes important when it supplies hot air to the precalciner.

The vertical cooler normally operates with only as much cooling air as needed for secondary air to the kiln, thus more economically than the grate cooler. If a precalciner is added later hot air can be supplied from the cooler. Good results have been obtained by using this cooler. Total installation costs are 25-30% lower than for a grate cooler, since no filter is necessary for dedusting excess air.

The satellite cooler has been very popular in the last decade owing to its low power consumption and simplicity. Even though a satellite cooler costs 15% more than a grate cooler, the satellite cooler is cheaper in the end owing to the savings in civil engineering and installation of a big filter for dust collection. The savings are considerable.

The satellite cooler is a real low-energy cooler. Compared with a grate cooler with dust collector, about 6.0 kWh/t of clinker can be saved. With a price of LT 0.43/kWh the annual saving amounts to 11 x 1,700 x 310 x 6.0 x 0.43 = LT 14,956,260 for the 11 new plants, or $854,640.

If a separate hot-air pipe from cooler to precalciner is foreseen, the satellite cooler cannot be used. It is impossible to take hot air from this cooler.

A kiln equipped with a satellite cooler can rarely be pushed to a higher capacity, and sealing of all cyclones calls for efficient maintenance, since the secondary air to the kiln is limited to 1 kg/kg clinker.

A satellite cooler for a 1,700 t/d kiln is considered mechanically reliable.

The rotary cooler is one of the oldest types of coolers, and to prevent environmental pollution some factories have returned to using this type. Power consumption is relatively high and thermal efficiency approximately 70%. The three other coolers can reach 80% or more.

Clinker transport and storage

The transport of clinker from the kiln to the storage point is always critical at a cement plant. The means of transport should be equipped with stand-by machinery at least from the kiln to somewhere in the open and accessible to a front-wheel loader and/or a truck. This precaution is extremely important, expecially if a rotary or satellite cooler is employed, since no accumulation of hot clinker can be accepted by this type of cooler.

The drag chain or bucket-cell conveyor is the most common clinker conveyor. The latter can be constructed up to 70 m in height and therefore used especially where a silo is used for storage. Clinker conveyors are expensive; thus there is reluctance to install a complete stand-by conveyor.

Clinker conveyor capacity should always be kept high, say, 1.5 - 2.0 according to kiln capacity to meet "vomits" from the kiln when a coating falls down.

A rubber-belt conveyor should not be employed for clinker transport unless efficient additional cooling is available, e.g. by means of water. Clinker temperature in normal kiln and cooler conditions should not exceed 120°C. With uncertain conditions the clinker temperature can reach 350-400°C and more.

Clinker storage in Turkey presents a serious problem. Most cement plants in Turkey lack capacity to store clinker because of the concentrated demand for cement in the summer. Open-stock storage is naturally an easy solution, but it can result in losses and high consumption of energy in the grinding process.

Cement mill department

For grinding cement clinker to the end-product of cement three main systems are employed: open-circuit grinding, continuous open-circuit grinding and closed-circuit grinding. The choice of the open- or closed-circuit grinding system depends on the desired fineness and strength of the cement produced.

The open-circuit grinding system, consisting of feeders, mill and dust collector for the dedusting of the mill, is the most simple. The total investment costs are 25% lower than those for the closed-circuit system. As far as energy consumption is concerned, cement up to a Blaine of 3,300 cm^2/g can be produced equal to the closed-circuit system.3/ Important for the open-circuit system is proper ball charge and water injection with grinding aids to avoid agglomeration and cushioning, i.e. coating of the grinding media.

If further fineness is required, the two other systems must be employed. For the continuous open-circuit system, another mill must be added working in series as the secondary mill. For the closed-circuit system, a classifier (air separator) with connecting transport equipment must be added.

For the 11 new cement plants the choice of grinding system must be considered carefully. Some of the plants will probably need to produce cement with a Blaine exceeding 3,300 cm^2/g; here the closed-circuit system will have to be used.

3/ Zement-Kalk-Gips, No. 2 (1972) p.63.

Since two mills, each of 50 t/h capacity, are desired for each cement plant, one of them could be an open-circuit and the other a closed-circuit mill and so forth. Saving in capital costs is important, since they are fixed costs.

Nevertheless, a closed-circuit system makes it easier to produce cement of any quality regardless of the condition of the ball charge in the mill. An incorrect condition will create high circulation, which can reach 500%, and thus a powerful conveyor that can handle at least 300% circulation will have to be employed.

Needless to say, maintenance costs for the closed-circuit system are considerably higher than those for the open-circuit system.

Packing plant

Putting cement in paper bags seems simply to be a bad habit. Wood and fuel oil, of which there is a world shortage, are needed in large quantities for the production of paper bags.

Distribution of bulk cement has developed rapidly, and a study should be carried out on how to distribute bulk cement in small quantities. The prime cost of cement could be reduced by about 5-10%.

II. RECOMMENDATIONS

1. TSC should follow the development of the P-cK closely. The clinker production of existing plants could be increased by replacing the present raw mills by vertical roller mills of the appropriate capacity. The former raw mills could be converted into cement mills. Thus, capacity could be improved and flexibility increased at low cost.

2. As a means of transport, the rubber-belt conveyor should be preferred wherever possible in spite of the high initial investment costs.

3. Preblending plant should be applied at existing cement plants to increase production capacity and improve clinker quality. It should be included in all new cement plants.

4. To utilize Turkey's huge deposits of lignite, the use of separate precalciners where lignite can easily be used as fuel should be considered.

5. A study should be carried out on how to store large amounts of clinker at lowest possible costs.

6. Delivery of cement in paper bags should be reduced in favour of bulk transport since the cost of paper bags is considerable.

7. For the 11 cement plants that have been planned but not yet contracted for, the supplier should be free to design a low-energy plant. Alternatively, an independent consulting company could be asked to undertake the plant layout and to select the equipment, giving special regard to equipment that could be manufactured locally.

8. For the 11 new cement plants, continous homogenizing with the homogenizing compartment should be considered.

9. The best existing plants should be modernized, which could be done in a short span of time and with low annual investment costs per ton.

Annex I

JOB DESCRIPTION

Post title:	Expert on feasibility studies in cement industry
Duration:	Two months (with possible extension)
Date required:	As soon as possible
Duty station:	Ankara

Duties: The expert will be expected to assist and guide in preparing complete feasibility studies for cement plants to be set up in the near future, including:

1. Making projections for cement consumption.
2. Measuring efficiency in interregional movements.
3. Making studies for the plants to be set up.
4. Selecting plant site.
5. Estimating investment and operating expenses and their yearly distribution.

Qualifications: Experience in preparing complete feasibility studies, particularly for the cement industry

Language: English

Background information: The first cement plant in Turkey was set up at Darica, Istanbul, in 1911, with an annual capacity of 20,000 tons. Other factories and expansions followed; and by the end of 1976, the installed capacity exceeded 15 million tons. The accelerated development of the cement industry is illustrated by the rapid doubling of both production and consumption as follows: 2 million tons in 1960, 4 million tons in 1966 and 8 million tons in 1972. Participating in the development and playing a role of growing importance since its establishment in 1953, the Turkish Cement Industry Corporation has now a dominating position in the cement industry.

Consumption is forecast as follows (1,000 tons):

1980	16,401
1985	24,835
1990	37,838
1995	57,334

To meet this rapid increase in demand from domestic production, it is planned to set up 18 new cement plants by the end of 1984, each having a cement production capacity of 550,000 t/a.

UNIDO assistance is requested for these projects.

Annex II

ADDRESSES OF SUPPLIERS

Mobile crusher with capacity of 500 t/h

Bühler-Miag GmbH, Postfach 3369, D-3300 Braunschweig, Federal Republic of Germany

Burners for burning of lignite (approx. 3,000 - 5,000 kcal/kg), lignite and fuel and natural gas in cement kilns

Pillard Freres & Cie, Marseille (9), 13 rue Raymond Teissere, France

Equipment for cement plants with special regard to raw materials preparation and cooling of clinker

Claudius Peters, Steine und Erden, Industrieanlagen GmbH, Kapstadtring 1, D-2000 Hamburg 60, Federal Republic of Germany

Electrostatic precipitators for cement plants

Lurgi Apparate-Technik GmbH, Gervinusstrasse 17/19, D-6 Frankfurt (Main), Federal Republic of Germany

General information on equipment for cement plants

Fuller Company, A Gatx Company, P.O. Box 29, Catasauqua, Pennsylvania 18032, United States of America

General information on equipment for bagging, transporting and loading of cement

Haver & Boecker, Postfach 2210, D-4740 Oelde 1, Federal Republic of Germany

General information on equipment for dust collection

Maschinenfabrik Beth GmbH, Postfach 1808, D-2400 Lübeck 1, Federal Republic of Germany

General information on GFE-cyclone-gravelbed filters

Gesellschaft für Entstaubungsanlagen m.b.H., D-8113 Kochel am See, Federal Republic of Germany

General information on roller mills for limestone and coal

Loesche Hartzerkleinerungs- und Zementmaschinen KG, D-4 Düsseldorf 1, P.O. Box 5226, Federal Republic of Germany

Gebr. Pfeiffer AG, Postfach 3080, D-6750 Kaiserslautern, Federal Republic of Germany

Equipment for cement plants with special regard to air separators

Christian Pfeiffer, Maschinenfabrik, D-4720 Beckum, Federal Republic of Germany

General information on equipment for cement plants with special regard to raw-meal homogenizing plants

Möllers Maschinenfabrik, Sudhoferweg 93, Postfach 1409, D-4720 Beckum, Federal Republic of Germany

500 t/h long-distance rubber-belt conveyor for limestone varying from 1.5 to 5 km in length

Fredenhagen KG, Maschinenfabrik, Postfach 15, D-605 Offenbach/Main, Federal Republic of Germany

Beumer - Maschinenfabrik KG, Oelder Strasse 40, Postfach 1867, D-4720 Beckum/Westfalen, Federal Republic of Germany

Robins Engineers & Constructors, 711 Union Blvd, Totowa, N.J. 07511, United States of America

Large-hole drilling machines for limestone quarries with an annual capacity of 750,000 tons

Maschinenfabrik Rudolf Hausherr und Söhne KG, Postfach 1240, D-4322 Sprockhövel, Federal Republic of Germany

General information on equipment for cement plants, e.g. FLS-newsfront with special regard to coal-firing systems for low-calorific-value lignite

Messrs. F.L. Smidth & Co. A/S, 77 Vigerslev Alle, DK-2500 Copenhagen, Valby, Denmark

General information on equipment for cement plants, e.g. "Polysius teilt mit" and "Polysius colleg".

Polysius AG, Graf-Galen-Str. 17, D-4723 Neubeckum, Federal Republic of Germany

General information on equipment for cement plants

KHD Industrieanlagen AG, Humboldt Wedag, Wiersbergstrasse, Postfach 91 04 04, D-5 Cologne, Federal Republic of Germany

General information on equipment for cement plants, with special regard to precalcining and burning of low-calorific-value lignite

Ishikawajima-Harima Heavy Industries Co., Ltd., Machinery Export Division, Shin Ohtemachi Bldg., 2-chome, 2-1 Ohtemachi, Chiyoda-ku, Tokyo 100, Japan

General information on equipment for cement plants with special regard to mobile crushing, screening and preblending plants

Messrs. Fives-Cail Babcock, 7 rue Montalivet, F-75383 Paris, France

Annex III

ATLAS COPCO QUARRY EQUIPMENT IN TURKEY, January 1977

Type of equipment	Bore-hole diameter (mm) (production drilling)	Weight (kg)	Air requirements (cfm at a working pressure of 6 bar (87 psi) impact	C.i.f.-price ($)	Kilo price ($/kg)
Complete wagon drill BVB 25	64 - 89	1,255	582	17,300 (estimate)	13.70
Drill wagon BVB 25-00 self-propelled		805			
Chain feed BMH 35K 257		330			
Rock drill BBE 57	64 - 89	120	582		
Dust collector DCT 95		260	136	3,500 (estimate)	13.46
		Total	718		
Portable rotary screw compressor PR 700 Dd, capacity, 700 cfm		3,240		30,900 (estimate)	9.53
Total price per one unit				51,700 (estimate)	

Type of equipment	Bore-hole diameter (mm)(production drilling).	Weight (kg)	Air requirements (cfm at a working pressure of 6 bar (87 psi)	c.i.f.-price ($)	Kilo price $/kg
Complete wagon drill BVB 25	105-114	1,254	437	17,200 (estimate)	13.72
Drill wagon BVB 25-00, self-propelled		805			
Chain feed BBM 35K 859		330			
Down-the-hole drill COP 4	105-114	36	367		
Rotation motor BBR 4		83	70		
Dust collector DCT 95		260	136	3,500 (estimate)	13.46
			Total 573		
Portable rotary screw compressor PR 700 Dd, capacity, 700 cfm		3,240		30,900 (estimate)	9.53
Total price per one unit				51,600	

Type of equipment	Bore-hole diameter (mm) (production drilling)	Weight (kg)	Air requirement (cfm at a working pressure of 6 bar (57 psi)	c.i.f. price ($)	kilo price ($/kg)
Complete crawler drill ROC 301	105 - 114	3,559	573	28,300	7.95
Crawler drill ROC 301	105 - 114	2,860			
Chain feed BBM 35K 859		330			
Down-the-hole drill COP 4	105 - 114	36	367		
Rotation motor BHR 4		83	70		
Dust collector DCT 91		250	136		
Portable rotary screw compressor PR 700 Dd, capacity, 700 cfm		3,240		30,900 (estimate)	9.53
Total price per unit				59,200 (estimate)	

Source: Atlas Copco, Ankara, Istambul.
Note: prices indicative only and subject to alteration.

Annex IV

CATERPILLAR EQUIPMENT IN TURKEY, January 1977

Type of equipment	Capacity	Weight (kg)	Power (kW)	C.i.f. price ($)	Kilo price ($/kg)
Track-type tractor	mm x mm				
D3, backhoe				30,183	
D3	2,410 x 740	6,200	45	24,930	4.02
D4D	3,140 x 840	8,600	56	36,619	4.26
D5	3,250 x 860	11,700	78	56,646	4.84
D6C	3,710 x 1,040	14,400	104	72,267	5.02
D7G	4,250 x 960	20,300	149	100,226	4.94
D8K	4,240 x 1,520	31,700	224	143,423	4.52
D9H	4,390 x 1,820	42,400	306	233,315	5.50
Off-highway rear dump truck	tons				
769B	32	27,500	309	139,879	5.09
773	45.4	37,200	447	198,704	5.34

Type of equipment	Capacity (m^3)	Weight (kg)	Power (kW)	C.i.f. price ($)	Kilo price ($/kg)
Wheel loader					
910	1.00	6,400	48	24,630	3.85
920	1.34	8,190	60	35,522	4.34
930	1.70	9,276	75	41,413	4.46
950	2.68	12,200	97	56,613	4.64
966C	3.45	16,000	127	73,287	4.58
980B	4.20	24,440	194	98,839	4.04
988B, beadless	5.40	42,640	280	172,491	4.05
988B	5.40	39,330	280	165,345	4.20
992B	7.65	62,140	410		
Track loader					
931, backhoe	0.80			31,117	
931	0.80	7,030	46	24,392	3.47
941B	1.15	11,090	60	35,330	3.19
951C	1.34	12,200	71	41,721	3.42
977L	2.50	21,320	142	82,669	3.88
983	4.21	34.470	205	127,581	3.70

Type of equipment	Capacity (litres)	Weight (kg)	Power (kW)	C.i.f. price ($)	Kilo price ($/kg)
Motor grader					
120G		10,700	93	56,827	5.31
130G		11,600	101	63,910	5.51
140G		13,010	112	69,985	5.38
12G		12,700	101	65,905	5.19
14G		17,460	134	89,950	5.15
16G		23,590	186	129,384	5.48
Excavator					
215				62,863	
225	1,110	20,900	93	82,956	3.97
245	2,610	56,700	242	221,784	3.91

Source: Caterpillar, Ankara.
Note: Prices indicative only and subject to alteration.

Annex V

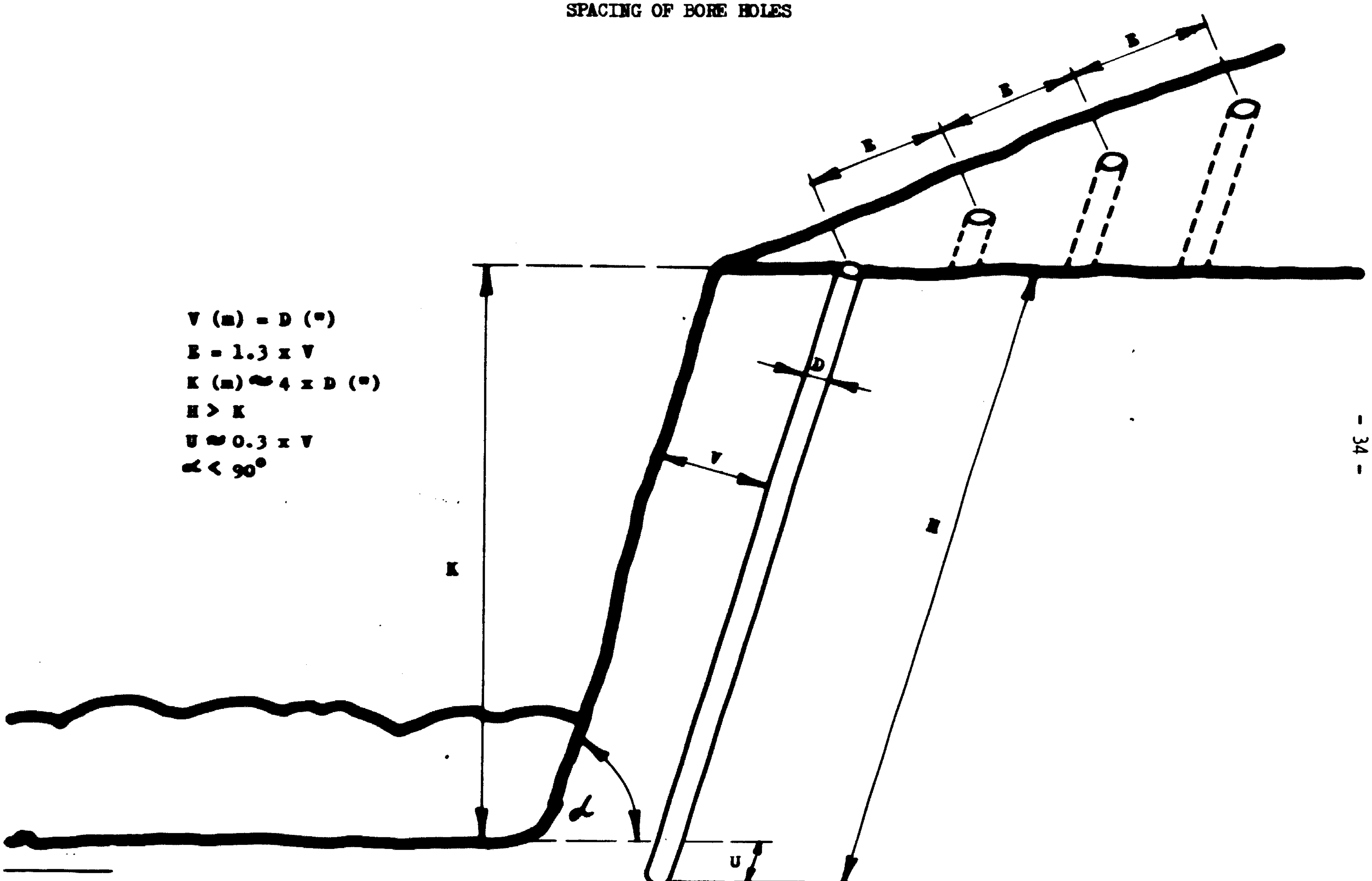
ESTIMATED COSTS OF QUARRY EQUIPMENT FOR A CEMENT PLANT WITH A CAPACITY OF 550,000 TONS PER ANNUM
(Dollars)

2	Crawler drill ROC 301, Atlas Copco (one stand-by) down-the-hole, 105 mm, including dust collector DCT 91	56,600
2	Portable rotary screw compressor (one stand-by) 700 cfm (19.8 m^3/min), Atlas Copco	61,800
6	Jackhammer (11.1 kg) as Atlas Copco BBD 12LH	1,000
1	Portable rotary screw compressor 425 cfm (12 m^3/min), Atlas Copco	24,500
1	Set of rubber hoses, 450 m x 0.75 in., 400 m x 2 in.	13,000
2	Ignition apparatus	500
1	Ohm meter	300
1	Utility car	4,000
1	Mobile workshop for light repair works, including generator 5 kVA	25,000
1	Servicing lorry, including welding unit; for lubrication work following services: 3 kinds of engine oil 2 kinds of gear oil supply High-pressure greasing Compressed air generating Cooling water supply Washing and cleaning Waste oil collection	50,000
1	Track-type tractor, Caterpillar D9H	233,315
1	Wheel loader, Caterpillar 988B, beadless for limestone	172,491
1	Excavator 225, 1,110 litres, Caterpillar for clay	82,956
3 a/	Off-highway rear dump truck, Caterpillar 769B	419,637
1	Motor grader, Caterpillar 14G	89,950
Estimated total investment costs for quarry equipment:		1,235,049

a/ Depends on the distance from quarry face to crusher. If mobile crusher is used, one more wheel loader 988B can be saved.

Annex VI

SPACING OF BORE HOLES



Source: Atlas Copco, Ankara/Istanbul.

Annex VII

COST OF CIVIL ENGINEERING IN TURKEY, 1976

	Unit	LT/unit	$/unit
Machine grading (earth)	m^3	12.36	0.75
Foundation excavation (earth)	m^3	52.25	3.17
Concrete - mass	m^3	292.56	17.73
Concrete - columns	m^3	421.69	25.56
Formwork at ground	m^2	51.19	3.10
Formwork above ground	m^2	124.13	7.52
Reinforcing steel	kg	8.44	0.51
Reinforced concrete at ground	m^3	358.29	21.71
Concrete block walls, 20 cm width	m^2	297.23	18.01

Source: Cimsa, Ankara.

Annex VIII

COST ESTIMATES FOR A LONG-DISTANCE RUBBER-BELT CONVEYOR (Thousand LT)

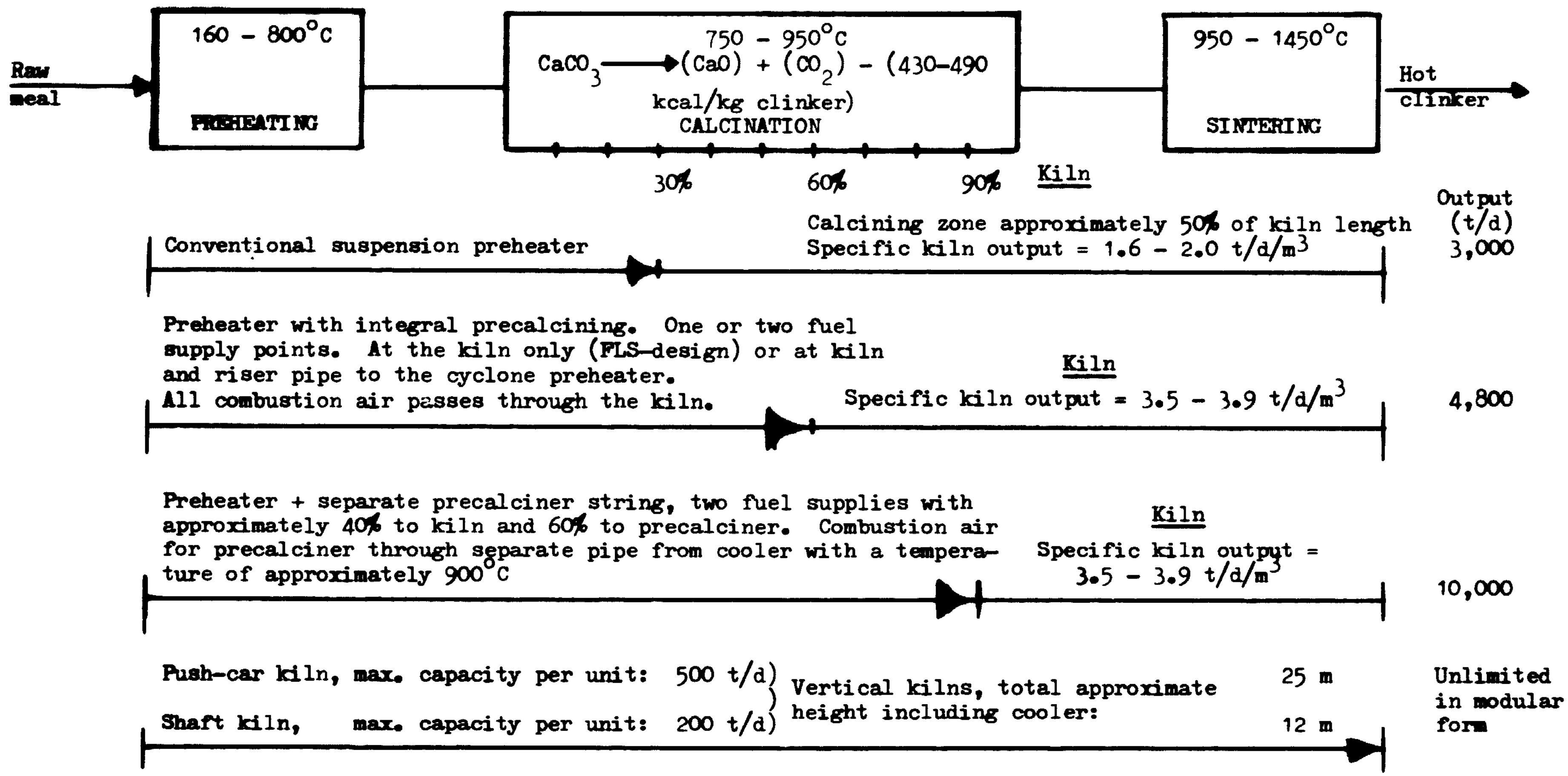
Investment costs		
(a)	Rubber-belt conveyor, width, 800 mm; length, 2,200 m; capacity, 500 t/h, on-the-ground version Mechanical and electrical parts, total weight approximately 500,000 kg, manufactured in Turkey at, 25 LT/kg	12,500
(b)	Civil engineering, if any	500
(c)	Erection and start-up, 20% of (a)	2,500
(d)	Contingencies, 15% of (a)	1,875
	Total investment costs (TIC)	17,375
Operation costs for 25 years (lifetime of the conveyor)		
(e)	Maintenance and repair, 4%/a of (a) for 25 years	12,500
(f)	Wages for two workers for 25 years 5,000 x 12 x 2 x 25 =	3,000
(g)	Electric energy, LT 0.43/kWh, consumption estimated at 0.4 kWh/t-km Limestone production = 550,000 x 1.7 x 0.8 x 25 = 18,700,000 tons Cost of electric energy in 25 years = 18,700,000 x 2.2 x 0.4 x 0.43 = 7,076,080	7,100
(h)	Capital cost = 16%/a in average of 60% of TIC = 17,375,000 x 0.6 x 0.16 x 25 =	41,700
Total costs for 25 years' operations		81,675

Average ton-km price in 25 years = $\frac{81,675,000}{2.2 \times 18,700,000}$ = 1.985 or

LT 2.00/t-km (0.11 $/t-km)

Annex IX

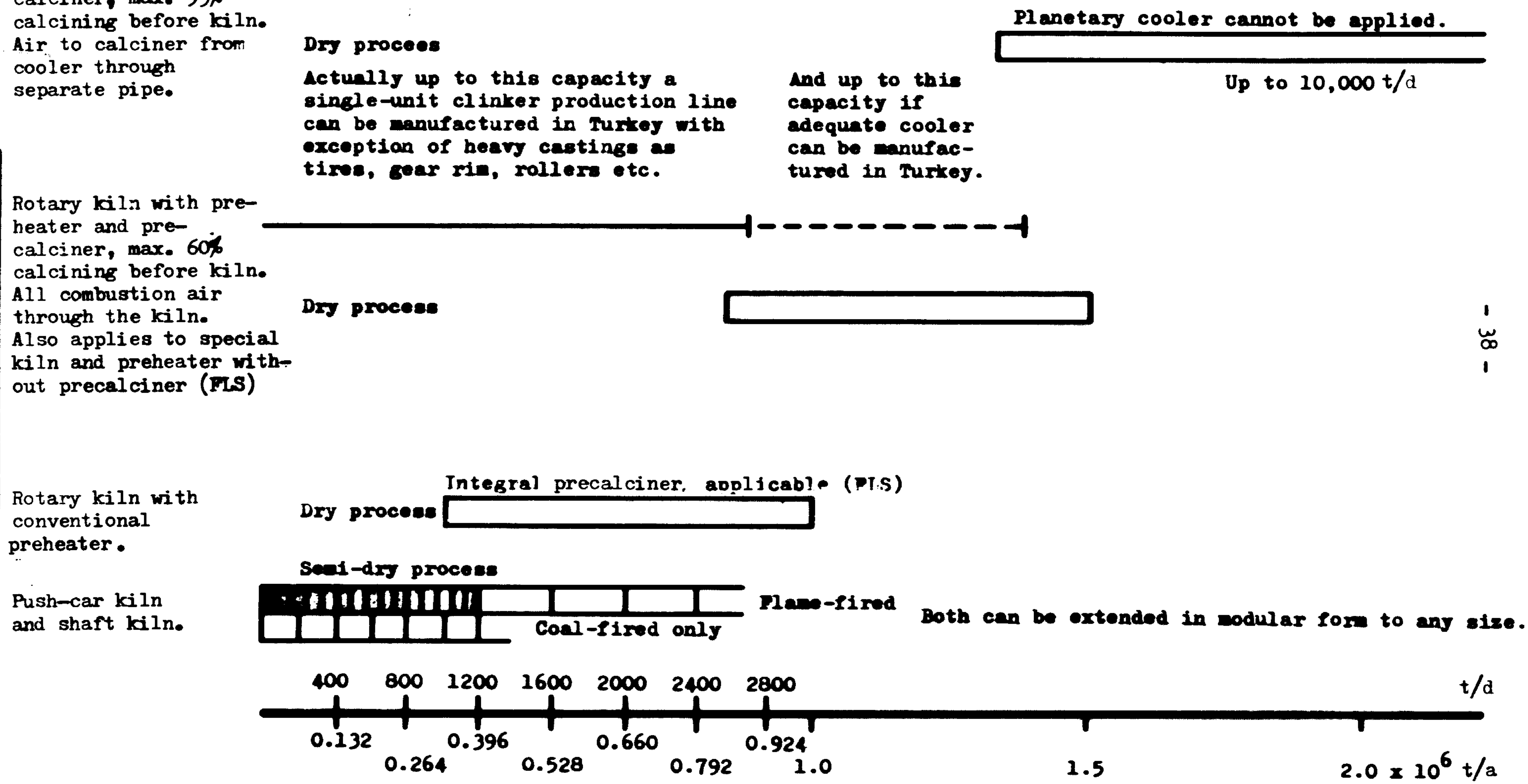
CEMENT CLINKER BURNING PROCESS



Source: Based on Zement-Kalk-Gips, No. 8 (1976) p. 356.

Annex X

APPROPRIATE TECHNOLOGIES FOR CLINKER PRODUCTION AT DIFFERENT CAPACITIES



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