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ASSISTANCE TO THE CEMENT INDUSTRY*

SI/ETH/78/802

ETHIOPIA

Technical report: General overhaul of kiln department, Ethiopian Cement Corporation, S.C.

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

Based on the work of Harald C. Boeck, cement consultant

United Nations Industrial Development Organization

Vienna

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Annexes

1.00 I N T R O D U C T I O N

There are three cement plants in Ethiopia, all owned by the Government of Ethiopia and managed by the Ethiopian Cement Corporation S.Co. The plants are situated in Massawa, Dire Dawa and Addis Ababa with a capacity of respectively 70,000, 40,000 and 70,000 metric tons per year.

The cement plant in Addis Ababa is the latest erected plant and supplied by INGRA, Zagreb in Yugoslavia. It went onstream in July 1964.

Since 1972 the plant has suffered from poor productivity mainly due to mechanical troubles. For that reason the plant has only been able to run with about 75% of nominal capacity for the last six years. Expressed in 1978 US$ the losses have reached about

US$4,200,000.-

assumming clinker has a value of say 40 US$/t.

The Government of Ethiopia has requested technical assistance from the United Nations Industrial Development Organization (UNIDO) and the writer arrived in Addis Ababa on 3 June for a two-month mission in order to make an assessment of the plant. As the Government decided to stop the plant for a fortnight the writer agreed upon an extension of the mission for one month in order to make an overhaul of the kiln department.

The kiln was stopped from 09-27 July for the general overhaul of preheater, kiln and cooler. Further improvements will have to be carefully planned. There are still many "bottlenecks", which will have to be eliminated.

2.00 SUMMARY OF FINDINGS AND RECOMMENDATIONS

The main problems at the plant are:

a. Raw materials coming from the quarries are not under sufficient control. Limestone and gypsum quarries situated 75 km from the plant and transported 9 km by ropeway and after by trucks. Clay quarry situated 17 km from the plant.

b. Overhead crane, only one, in the raw materials and clinker store creates tremendous maintenance problems.

c. Raw mill production very low in the rainy season, July - September.

d. Homogenizing silos not working efficiently. $CaCO_3$ variations exceeding $\pm$1.5%, which is nearly ten times more than acceptable figure $\pm$0.2%.

e. Four-stage cyclone preheater low efficiency.

f. Rotary valve before SCHENCK-Feeder worn out.

g. Back-spill at the kiln inlet

h. Frequently ring formation in the burning-and transition zone.

I. Kiln rollers and tires in bad condition.

j. Clinker cooler: Very short life of plates in the first chamber.

k. Cement Mill: low capacity and vibrations in the gearbox.

l. Packing plant extremely dusty.
Capacity low by one four-spout packing machine only.

R E C O M M E N D A T I O N S

It is recommended to build, as soon as possible, a new clinker production unit as close as possible to the raw materials, as clinker production is rawmaterial-oriented and clinker grinding market-oriented.

Thus, the existing kiln could be shut down after, say 5-6 years and the raw mill converted into a cement mill. Cement storage and packing plant could for instance be extended to a capacity of 200,000 MTPY of Portland cement or 240,000 MTPY of mixed cement, which will correspond to the total expected milling capacity of the existing two mills.

Preheater kilns of small size, like the kiln in the Addis Ababa cement plant, have never been easily available and most suppliers today will refuse to supply preheater kilns of a lower capacity than 500 metric tons per day.

Therefore, a minimum of investment should be done in the Kiln Department.

Following improvements are recommended:

A. Start preblending of the limestone at the quarry by building up a "long" pile.

B. Check the clay quarry for impurities (alkalies and Chloride)

It seems necessary to provide the kiln with a exit gas by-pass, which will cost about US$ 200,000.-. Otherwise the clogging of cyclone IV will continue. Maximum permissible chloride content in the raw mix to the kiln is .015% if more, a by-pass is indispensable.

C. Reduce pressure drop through the bag filter in the raw mill department and insulate, if the temperature cannot be kept above the dew-point 80-90°C.

D. Clean the main aeration pipe system at the bottom of the homogenizing silos and provide the Root blower room with an appropriate filter for cleaned air to the blowers. This is a <u>severe problem</u> and must be solved.

E. Bring the filter at the top of the homogenizing silos in a good condition.

F. Investigate the total cost for installation of another induced draft (ID) fan for the preheater with fixed-speed motor and an adjustable damper.

New data for the ID-fan should be:

= 1000 m^3/min

t = 350°C

p_t = 700 mm WG (existing 570 mm WG)

n = 950 RPM (existing 1450 RPM)

G. Try to keep the preheater better sealed (very difficult indeed).

H. Provide cyclone IV or all cyclones with permanent air jets to avoid clogging.

I. Complete the damaged oxygen gas analyser. Indispensable for assuring good clinker quality and fuel economy.

Ask for a quatation on a complete MAGNOS 5 Magnetic Oxygen (O_2) Analyser from the supplier of the existing analyser:

Hartmann & Braun AG
Mess-und Regeltechnik
P.O.Box 900 507
6 Frankfurt 90
Federal Republic of Germany

and use existing parts as spare parts.

J. Pyrometer for control of the burning zone temperature. Complete the existing WITTHOF system.

K. Keep plenty of spare parts for the UNITHERM oil burner in order to have a good atomizing of the fuel.

L. Keep oil and water away from the surface of tires and rollers. Use only graphite as lubricant.

M. Kiln motor too small. Should be increased from 36/18 to say 60/30 KW in order to overcome ring formation in the burning zone. As the kiln has too much slope (4%) it is very useful to keep a minor ring formation in order to retain the material for longer time in the calcining zone.

N. Primary air fan for the kiln should be exchanged with another one with smaller capacity and higher total pressure. Only 2 - 5% of primary air is required of the total amount of combustion air. Recommended size is:

V = 600 m^3/h (existing 1372)

p_t = 1200 mm WG (existing 560)

n = 2850 RPM

N = about 10 KW

The high total pressure is needed to assure high velocity of the primary air, exceeding 100 m/sec.

O. In order to make proper brick lining in the kiln a brick saw is essential. The same brick saw could be used for all three cement plants.

P. Bunker C fuel for the kiln costs about 120 US$/MT CIF Addis Ababa. Since Ethiopia has vast deposits of lignite it would be highly recommended to utilize this valuable energy source for burning of cement clinker.

Considerable savings in foreign currencies can be done.

By charring the lignite to lignite coke it would be an excellent fuel for the newly adapted vertical shaft kiln.

United Nations Industrial Development Organization (UNIDO) is making big effort to promote the development of economic cement plants for small-scale production of ordinary portland cement e.g. the total cost of a 90,000 MTPY plant will be about US$ 6 million.

Result of the UNIDO Mission

During a 19-day stoppage the kiln department has been improved mechanically.

The pyro process altered by using less primary air and more hot secondary air.

More constant feeding has been reached by repair of the rotary valve before the feeder.

Back-spill at the inlet of the kiln has disappeared after internal modifications.

Ring formations seems to be reduced after improved calcination before the burning zone. Preheater fan speeded up.

Concerning production improvement and reduced fuel consumption it is too early to make a proper statement. It remains to be proved after 2-3 months of operation. The lack of instrumentations makes it difficult to judge.

The stoppage has been extremely useful for teaching and explaining to the operators how things work and how to make improvements.

All modifications have been executed by the factory staff and were very well done indeed, inspite of a poorly equipped workshop. That brings satisfaction and self-esteem to the local people.

3.00 GENERAL OVERHAUL

It was decided by the Ethiopian Cement Corporation S.C. to make a general overhaul during the stay of the writer instead of recieving a comprehensive report on well-known problems and probably expensive suggestions on future improvements.

The plant was stopped from 09 through 27 July except the cement mill department and packing plant.

3.01 Raw Mill Department

In order to obtain an improvement of the kiln capacity, it was necessary to check the raw mill department.

During the rainy season, July - September, the raw mill capacity drops down to 11-13 t/h, but in the dry season it reaches 18-19 t/h. The closed circuit system consists of:

2	Rotary feeders	
1	Raw mill 2.6$^{\emptyset}$ x 5.7 m	530 kW
1	Elevator	10 kW
1	Separator 14' (4270 mm$^{\emptyset}$) ESCHER WYSS	72 kW
1	Bag filter, circular	
1	Filter fan	21 kW
1	Auxiliary furnace, 100 l/h	

The pressure drop through the mill and bag filter was found to be very high, 100 + 160 = 260 mm WG; this should never exceed 200 mm WG.

A minor modification in the mill inlet has reduced the pressure drop a little. Filter bags are closed by mud, due to high moisture and low temperature.

The filter should be insulated if it is impossible to keep a temperature above the dew-point 80-90°C.

By means of the installed power this mill should be able to produce about 30-35 t/h in the dry season. Thus, the raw mill can be improved considerable if desired.

3.02 Homogenizing Silos

Unfortunately there was not enough time and manpower to open and clean the entire aeration system. All pipes are filled up with dust due to insufficient filters for the Root blowers.

It is very important to bring the homogenizing silos in a good working condition and it must be done during the next kiln stoppage, when outlet sectors will have to be changed.

Actually the Calcium Carbonate ($CaCO_3$) variation before the kiln feed reached about ±1.5%. It should not exceed ±0.2%.

The bag filter on the top of the homogenizing silos should be extended by one compartment more. Since the erection of the plant one bag has been removed in order to have enough under-pressure in the silos during aeration. That means, the filter is too small.

3.03 Four-stage Cyclone Preheater

The SCHENCK-feeder for the preheater was in a fairly good condition, but the POLYSIUS Rotary Valve before the feeder was in a poor condition, which created "vomits" to the feeder.

After the repair of the rotary valve the feeding to the preheater started to be constant.

All double flap boxes for cyclone stage I, II and III, and the single flap box before the kiln have been checked and brought in a better condition. Those flaps are not working satisfactorily due to the lack of lubricable bearings. It is recommendable to modify the flap boxes by providing them with bearings.

The immersion tubes (also called dip pipes or center pipes), where the exit gases come out of the cyclone, were all in an acceptable condition. However, the immersion tube in cyclone II was fairly deformed.

The ID-fan (Induced Draft fan) for the preheater was in a reasonable good condition and has following data:

V = 1000 m^3/min by 350°C

p_t = 570 mm WG by 1450 RPM

H = 172 HP = 128 KW

The ID-fan is supplied by HUMBOLDT WEDAG in the Federal Republice of Germany.

The corresponding variable speed motor is supplied by SIEMENS in the Federal Republic of Germany and has the the following data:

Rotor-FEA, 3 PHASE MOTOR
Type RAH 316/16-6
130 kW
425-1425

It should be mentioned here, that the preheater and kiln have been designed by HUMBOLDT WEDAG in 1961. At that time the experience in preheater kilns was poor.

When the writer arrived at plant the raw meal temperature at the inlet of the kiln hardly reached 650°C and the ID fan was running at about 750 RPM only without keeping under-pressure at the kiln inlet.

By receiving partly decarbonated material at the burning zone, ring formations have been a problem. This is probably due to the presence of Spurrite, $2CaO\ SiO_2\ CaCO_3$ (Calcium silicate carbonate).

In order to keep the preheater working more efficiently the ID-fan has been speeded up.

Taking into account that the plant is situated in the altitude of 2,500 m above sea level a roughly determination of the exit gas volumen can be done by following assumptions:

a. Rated capacity 70,000 MTPY equal to about 9.1 tons of clinker per hour.
b, Exit gas volume about 1.5 Nm^3/kg clinker.
c. The weight of 1 m^3 air by 25°C at 2,500 m is about 0.865 kg.
d. Estimated leakage 20% in the 14 year old preheater.

Exit gas volume $= \frac{9100 \times 1.5}{60} = 227.5$ or say 230 Nm^3/min

By 350°C the volume will be:

$230 \times \frac{350 + 273}{273} = 525\ m^3/min$

$1.293 \times 0.23 = .297\ kg\ O_2/Nm^3$ air

$0.885 \times 0.23 = .204\ kg\ O_2/m^3$ air at 2,5000 m, 25°C.

Thus 46% more air is needed at the altitude of 2,500 m.

The capacity of the ID-fan should be, with an allowance of 20% for leakages in the preheater:

$525 \times 1.46 \times 1.2 = 920\ m^3$ by 350°C

That means the ID-fan should run at about 1350 RPM with the rated capacity of the kiln, provided the before-mentioned assumptions are correct.

However, the correct speed of the ID-fan will in practice be determined by the Oxygen content at the inlet of the kiln and should be kept in the range of 0.7 - 3.5%.

Unfortunately the Oxygen analyser (MAGNOS 5) is not working.

After 13 days of operation it was necessary to replace the ID-fan motor with a fixed speed motor and bring the original motor down for repair. Consumption of carbon brushes

very high and a short circuit in the stator took place during a start-up after changing carbon brushes.

In order not to start up the motor under full load a damper has been installed before the ID-fan.

The connection between the ID-fan and the conditioning tower is highly undesirable. Dust can be accumulated in the bend before the ID-fan, which is very dangerous during start-up.

Furthermore the conditioning tower is not working at all as a conditioning tower. Water injection at the top of the tower can create slurry at the ID-fan, which had happened some years ago. Therefore the water is sprayed in at the riser pipe between I and II cyclone stage, where also the raw meal is fed to the preheater. That means, where heat is needed the gas is cooled down by water.

A modification of the conditioning tower will have to be done.

Following temperatures of the exit gases should be kept in the preheater:

	°C
Behind cyclone stage I	300 - 360
Behind cyclone stage II	430 - 550
Behind cyclone stage III	650 - 700
Behind cyclone stage IV	800 - 850

Dimensions of cyclones are:

I stage, twin-cyclone	2 x 2060 mmØ
II + III + IV stage	3 x 3400 mmØ

The negative pressure in the riser pipe from kiln to cyclone IV should be kept in the range of 30 - 50 mm WG in order to have an appropriate negative pressure at the kilnhood

The ID-fan has been started up again on 21 August at noon, provided with a damper and a fixed speed motor with following data:

W S W Wiener Starkstromwerke
Type R 152 S-C
Nr. 590395/1966
V/Y 220/380 V, 312/180 A
95 kW
970 RPM
50 Hz
Cos phi = 0.9
Is. kl. B
P = 24
Rotor Y 257 V, 232 A

The above-mentioned motor has previously been used for cement transport from the cement plant to the asbestos plant, but only for a short period and not successfully.

It seems to be an excellent stand-by motor for the ID-fan.

3.04 Rotary Kiln

The 2.6Ø x 3[illegible].0 m rotary kiln is designed by HUMBOLDT WEDAG and has an inclination of 4%. The latter is a serious problem as the kiln speed will have to be kept low, which results in higher thermical load on the refractory bricks, slowl heat transfer and promotes ring formations.

It would be extremely useful to change the inclination from 4% to say 3% by lifting up the kiln about 250 mm at the lower rollers. Supposed the kiln will have to run 5-6 years more, it should be considered.

During the stoppage following improvements have been achieved:

a. One complete set of rollers exchanged at the lower kiln support.

b. The two rollers at the upper kiln support have been turned.

c. The seal between preheater and kiln repaired.

d. Kiln feed refractory modified in order to avoid back-spill.

e. Brick lining at the burning zone (few metres) and kiln outlet. The latter is in a very poor condition.

f. Repair of seal at kiln outlet.

g. Burner pipe modified for use of 3% primary air.

h. Meter for primary air exchanged by a new one.

i. Preheater for Bunker "C" fuel cleaned and thermostate adjusted in the range of [illegible] - 120°C.
It would be better if the range could be kept [illegible] - 120°C.

[illegible]ing adjustment of kiln rollers for keeping the kiln moving up and down ± 25 mm it was learned that the inlet seal could not permit such movement due to wrong inclination of the static part of the seal (less inclination).

Therefore the kiln has to remain in the lower position.
This defect is difficult to eliminate.

Concerning good fuel economy it is essential to:

a. Keep the temperature of Bunker "C" fuel at 120°C

b. Keep the pressure at 25 - 35 kp/cm^2 by changing to appropriate nozzle.

c. Keep secondary air as hot as possible.
The outlet sectors of the kiln make the limit of about 800 - 900 ^{o}C at the kiln hood.

d. Keep a wide and short flame, that makes the calcining zone longer as the kiln is relatively short.

e. Keep kiln feed and speed as constant as possible and syncronized.

f. Keep the preheater hot by means of the ID-fan.
The temperature of raw meal fed to the kiln must be 300-350 ^{o}C.

3.35 Grate Cooler

The grate cooler is designed by Claudius Peters in the Federal Republic of Germany as type KK 425, 4 plates wide and 25 plates long inclined grate. Two chambers.

The cooler fan has following data:

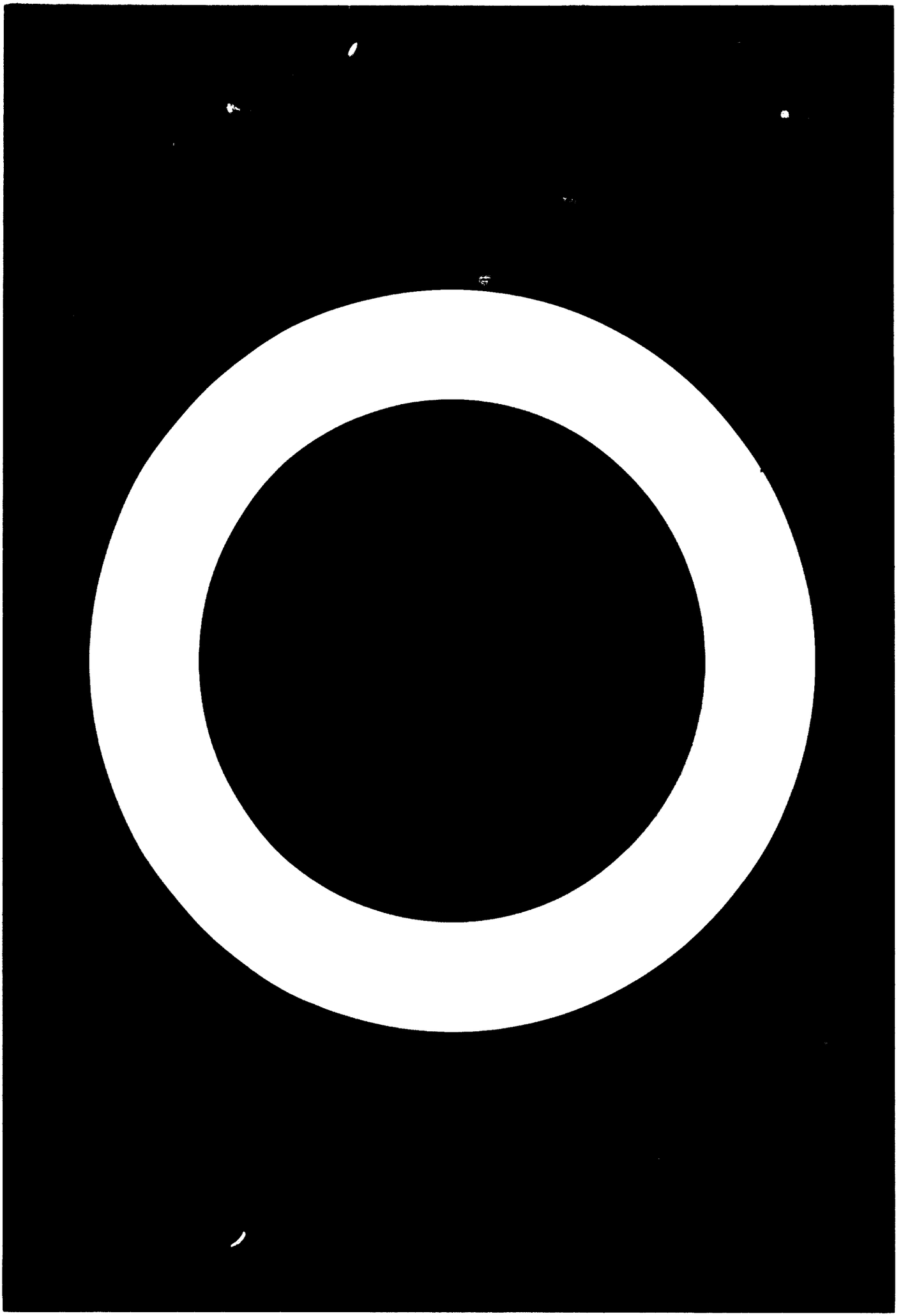
N = 220.3 kW
V = 11.1 m^3/sec = 39,960 m^3/h = 35,365 kg air/h
P_t = 250 mm WG
Weight of air = 1.2 kg/m^3
n = 940 RPM

All plates above the first chamber have been exchanged and new bushings installed at the lower roller support.

Unfortunately there was not enough time to make a new partition wall between I and II chamber. The new wall should be in two parts allowing for expansion.

Due to the drastic cut in consumption of primary air, from about 12% to 3%, more air is available for the cooler.

It is hoped that the plates will have a prolonged life.



Annex I

PERSONS MET

Mr. Woldu	Ministry of Industry Head of Planning
Mr. Getnet W/Giorgis	Building Material Corporation Manager
Mr. Atnafseged Adamu	Building Material Corporation Technical Department
Mr. Wondwossen Kumssa	Addis Ababa Cement Plant Plant Manager
Mr. Samuel Awalom	Addis Ababa Cement Plant Chief Chemist
Mr. Bekele Abebe	Addis Ababa Cement Plant Chief of Maintenance

Annex II

JOB DESCRIPTION

POST TITLE	Cement Expert
DURATION	Two months
DATE REQUIRED	As soon as possible
DUTY STATION	Addis Ababa
DUTIES	The xpert will be assigned to the Government to assist and advise in evaluating Addis Ababa Cement Plant. Specifically, the expert will assess the problems in the different departments of the cement factory. The expert will also be expected to prepare a final report, setting out the findings of his mission and his recommendations to the Government on further actions which might be taken.
QUALIFICATIONS	Industrial engineer with relevant experience in the cement industry.
LANGUAGE	English
BACKGROUND INFORMATION	The Ethiopian Cement Corporation operates one cement factory in the Addis Ababa area and an asbestos cement plant for production of pipes and sheets. The Factory has now experienced some difficulties in the production and therefore requested UNIDO to send an expert for assessment of the cement plant operation.

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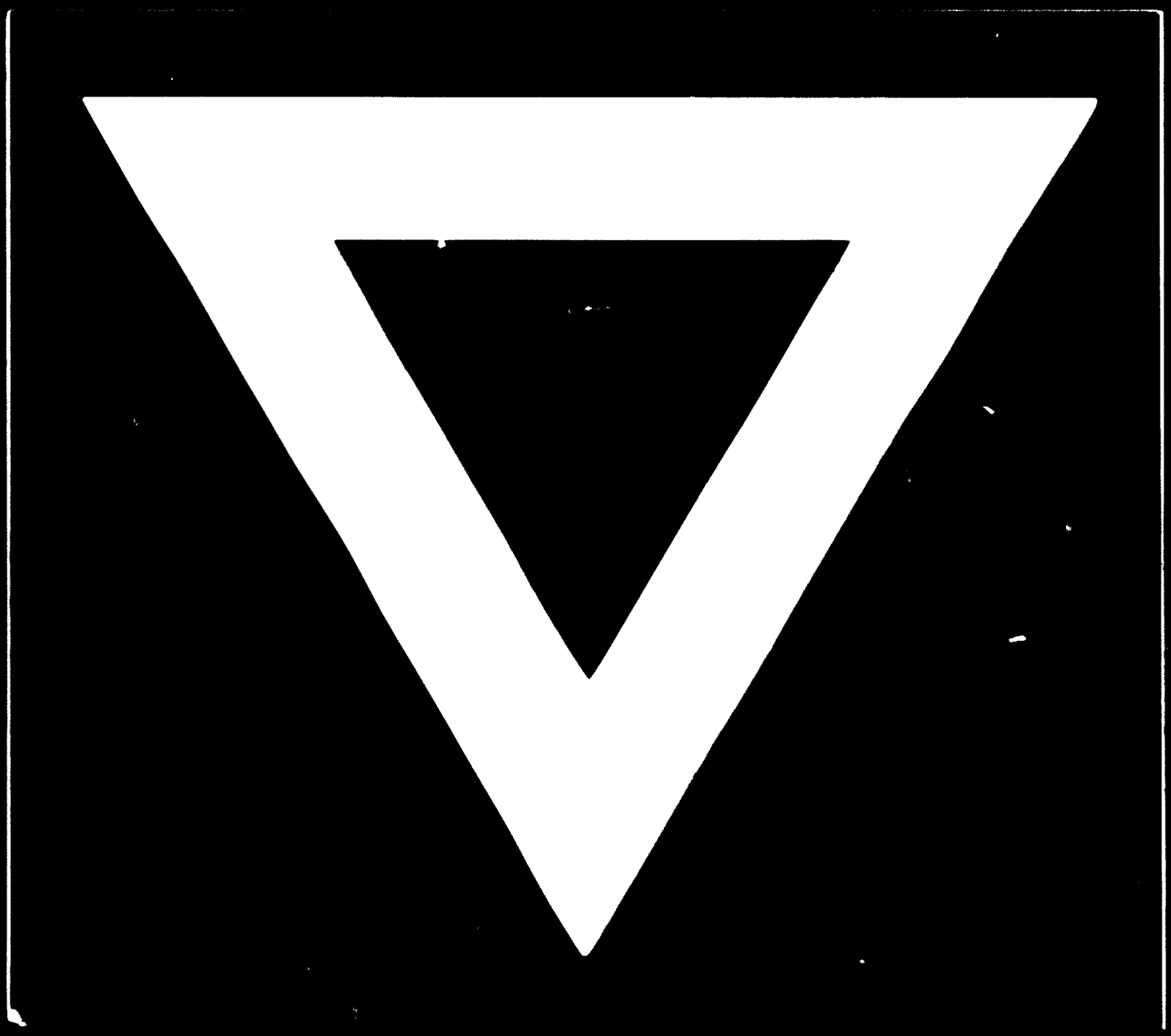

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