Experiences and Operational Results with a Chromium-ore Pelletizing Plant Based on the LEPOL Process

by E. LANKES* and W. BOEHM* (presented by Mr Boehm)

SYNOPSIS

The subject of this paper is a LEPOL plant that is used for the pelletizing of fine chromium ores and chromium-ore concentrates. The construction of this plant was preceded by extensive trials in which excellent results on the feasibility of the process and the quality of the product were obtained. The results of the trials were subsequently confirmed for a period of more than one year during the operation of an industrial plant.

INTRODUCTION

The demand for metals is steadily increasing on a worldwide scale. So that this demand can be met, deposits must be opened up and mined, and, before being smelted, the ores must be subjected to mineral-dressing processes because their metal content is relatively low or because their structure makes this necessary. A number of hydrometallurgical processes have already become known or are being developed to meet this problem. However, the conventional method, by which non-ferrous ores are charged in the form of lumps to electric reducing furnaces and are melted down to a ferrous alloy, continues to take the first place.

A necessary condition to the process technology is that the furnace must be charged with a lumpy material. This often necessitates a previous agglomeration process, since the ores available either can be profitably processed only in the form of concentrates or naturally have a large proportion of fines. Rich deposits of lumpy ore are no longer available in sufficient numbers or in adequate yield to meet the increasing demand for metals.

One possibility for the agglomeration of fine-grained ores is pelletizing. The pelletizing of iron ores or iron-ore concentrates has been practised industrially and in large units for many years, and this process is now becoming more and more important also for the processing of non-ferrous ores.

Polysius A.G. has been working on the problem of pelletizing ever since the 1920s. Since then, it has developed a travelling grate that has attained great importance under the tradename of LEPOL plant. Polysius has built more than 400 LEPOL plants, which are used predominantly in the cement industry.

As a result of its expertise and experience with the existing plants, Polysius has been supplying pelletizing plants for the ore-processing industry for over ten years. LEPOL plants have been built for the pelletizing of iron ores, nickel ores, and phosphates, and individual LEPOL grates have been designed and supplied for direct-process reduction plants.

In 1970, Polysius secured orders for the construction of a LEPOL plant for the pelletizing of chromium ores. This plant, which was commissioned by us at a German metallurgical company – the Gesellschaft für Elektrometallurgie (G.f.E.) – at their factory in Weisweiler, Federal Republic of Germany, and the planning of this plant and the preceding investigations, form the subject of this paper.

To start with, we shall give a brief explanation of the principle of the LEPOL process, also known as the 'Grate-kiln Process'. The LEPOL plant consists of a combination of travelling grate and rotary kiln. The chain of the travelling grate is fed with pellets, which are dewatered, dried, and preheated while passing through the grate chambers, before being brought up to the necessary final temperature in the rotary kiln. The hot exit gases of the rotary kiln are available as thermal energy, and are sucked through the pellet layer on the grate chain. During the preheating of the pellets, a hardening process takes place, reducing the accumulation of dust on the way to the rotary kiln to a minimum. Details of the design and operation of a LEPOL plant are given later in this paper.

TESTS WITH CHROMIUM ORES

Prior to the planning of the chromium-ore pelletizing plant, it was necessary to conduct a number of tests. These were carried out at the Polysius experimental station, and they consisted of a variety of small trials on a laboratory scale, followed by a trial on a large scale, during which 400 tonnes of chromium-ore pellets were produced.

These tests were designed to provide some information on the grinding fineness best suited to pelletizing, the behaviour of the material during pelletizing, the type and effectiveness of binding agents, the behaviour of the pellets on the grate, the burning temperatures in the rotary kiln, and the quality of the pellets.

The investigations were extended to chromium-ore fines and chromium-ore concentrates of various origins. In separate testing sections, Turkish Kavak concentrate, Russian ores, Transvaal ores, and Dyke ores were subjected to test. The large-scale trial was run with a blend of flotation concentrate and hearth concentrate.

Grinding Tests

Grinding tests were necessary to provide some information on the fineness of the ore-meal required for the production of pellets in a dish pelletizer and for trouble-free operation of the LEPOL grate. It is well known that pellets have a tendency to burst when being heated if manufactured from an ore-meal that is too fine, the reason being that the structure of these pellets is too compact to allow for trouble-free drying on a LEPOL grate.

The tests revealed that grinding to an oversize of about 10 per cent on a 90-micron testing sieve is adequate for pellets to be used on a LEPOL grate. The manufacture of pellets on dish pelletizers from a more coarsely ground material offered no problem, but these pellets did not have the strength needed for the burning process. The indica-

*Polysius A.G., Germany.

tion of a 'residue value' is of practical use only in connection with information on the specific surface of the ground product. For the pelletizing of chromium ores, it is desirable to obtain a specific surface of 2000 to 2500 cm^2/g (according to Blaine[1]) when the material is being ground.

The energy required for an adequate reduction by grinding is about 14 kWh/t for Transvaal and Russian fines and about 20 per cent higher for Kavak concentrate.

Pelletizing Tests

The pelletizing tests were carried out with various kinds of chromium ore in a pilot dish of 1000 mm diameter. The pelletizing process proper, i.e. the production of green pellets, did not present any difficulties for any of the ores, provided that arrangements had been made for largely continuous operation with respect to the material feed, the injection of water, and the fineness of the ore.

It turned out, however, that the pellets manufactured without binding agents did not possess adequate compressive and drop strengths to enable them to be fed to the LEPOL grate without trouble. The average compressive strengths of these pellets were only between 0,5 and 0,8 kg per pellet.

A substantial improvement in these strengths was attained by the addition of 1 per cent of bentonite. The compressive spot strengths of these pellets averaged between 1,1 and 1,5 kg per pellet. According to experience at Polysius, these strengths are adequate for the pellets to be fed to the LEPOL grate in a largely intact condition. After the pellets have been dewatered and dried on the grate, a hardening process takes place. It is important that the pellets are strong enough when passing from the grate into the rotary kiln. The pellets without bentonite attained a strength of about 5 kg per pellet at this point. After pellets of 1 per cent bentonite had been heated up to between 700 and 800°C, the strength was about 100 per cent higher – an average of 10 kg per pellet.

The same tendency was revealed in a number of tests during which 2 per cent of lime hydrate ($Ca(OH)_2$), instead of bentonite, was admixed.

In all these tests, a pellet diameter of between 10 and 25 mm was aimed at. The making of pellets of this size presents no problems once the dish pelletizer is properly set with respect to slope and speed, and the water nozzling system is arranged with care. The slope and speed of the plates are chosen as a function of the diameter of the unit. For the 1m-diameter pilot dish pelletizer, the slope was about 30 degrees from the vertical, and the speed amounted to about 25 rev/min.

Burning Tests

After the pelletizing tests, burning tests were carried out in the pot grate and grate simulator (Figure 1). The purpose of the small-scale tests was the determination of basic data for the establishment of the conditions for the large-scale test in the small LEPOL plant. The LEPOL grate of the experimental station has a surface area of roughly 2,5 m^2, and the kiln has an internal diameter of about 800 mm and a length of 10 m.

The tests revealed that pellets of chromium ores or chromium concentrates can be used on a grate if the abovementioned degree of grinding is adhered to. Drying

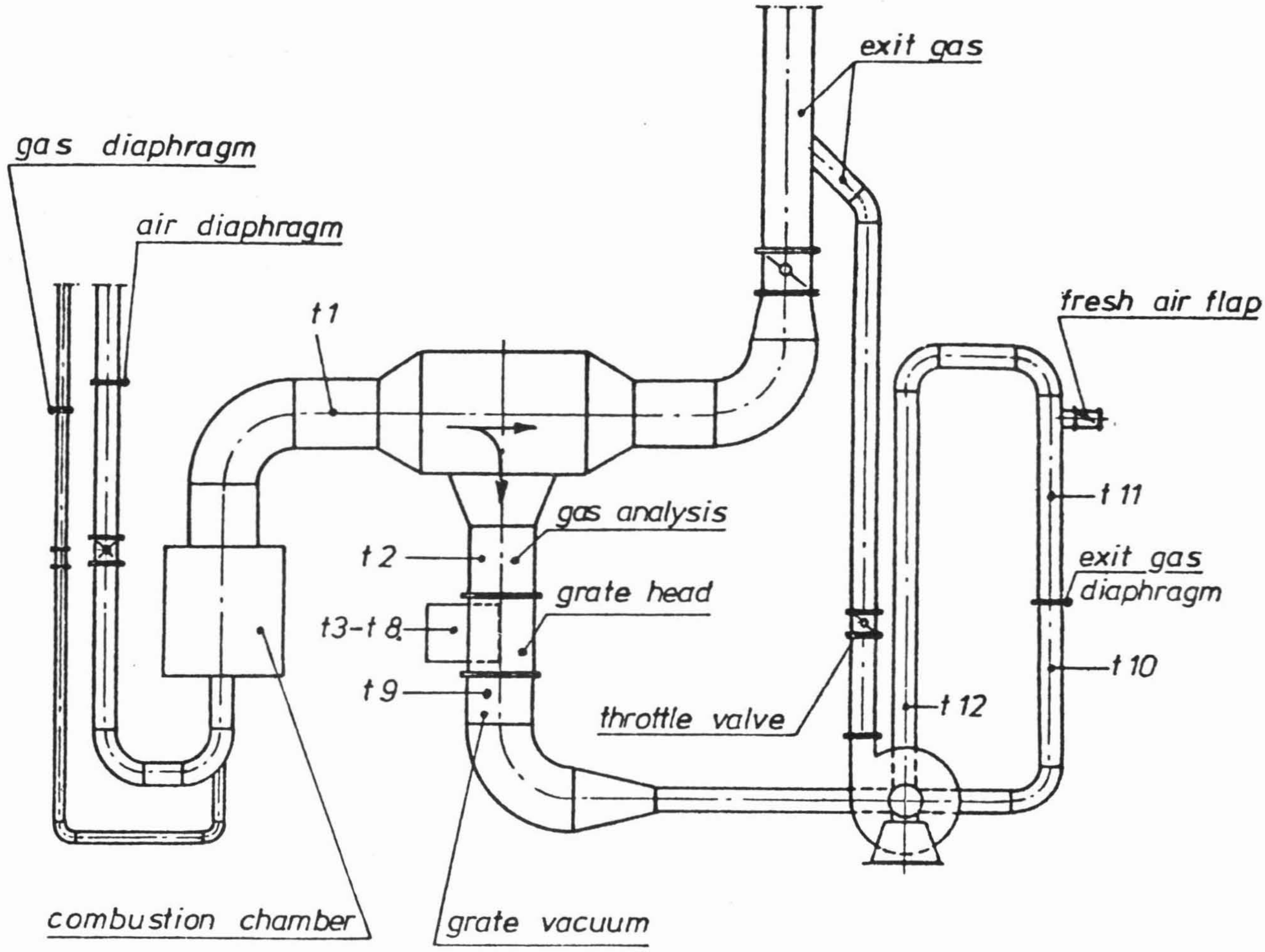


Figure 1
The grate simulator

temperatures of about 250°C in the first sections of the grate do not result in a destruction of the pellets. At the transfer point from grate to rotary kiln, compressive strengths of 10 kg per pellet can be attained, with material temperatures of 700 to 800°C. For Transvaal ore, it was even possible to attain strengths of about 20 kg per pellet at this point.

The hardening of the pellets by burning in the rotary kiln presented no difficulties. During the large-scale tests, burning temperatures of between 1500 and 1600°C were maintained. Caking occurred to a certain extent, but had no detrimental effect on the test, since the caked material largely collapsed by itself. The compressive strengths of the pellets at the outlet of the kiln averaged 250 kg per pellet. The overall porosity of the pellets ranged between 30 and 35 per cent.

Microscopic examinations of the burnt pellets and differential thermal analysis gave some information on the reactions of the pellets during the burning process and on the reasons for the development of strengths. It was revealed, for example, that the serpentine disintegrates at temperatures between 500 and 700°C (i.e., during the preheating process on the LEPOL grate), thereby causing a more intimate interlocking of particles as well as a solidification of the structure.

During the burning process in the rotary kiln, a collective crystallization of the chromite takes place. Furthermore, highly refractory magnesium ferrites and silicate smelts are obtained. The liquid phase, the proportion of which depends on the CaO content of the ore, produces an extensive cementing of the ore grains by bridge formation.

Particular attention was paid to the cooling of the burnt pellets, and it was found that the material being burnt is highly sensitive to cooling. Whereas no deterioration in strength was observed during a slow-cooling process extending over several hours, the compressive strength of the pellets was 50 per cent below the initial figures when cooling took place in the atmosphere. When pellets are quenched with compressed air, their strength drops to about 40 per cent, and, when quenched with water, to about 30 per cent of the strength they had on leaving the kiln.

INDUSTRIAL PRODUCTION OF CHROMIUM-ORE PELLETS

After the tests mentioned above, an industrial LEPOL plant for the production of pellets from chromium ores or concentrates was erected at the Weisweiler factory of G.f.E. The plant, which is designed for a rated output of 250 t/d of finished pellets, was commissioned in 1972.

Its major sections are as follows (Figures 2 to 4):

(1) grinding plant,
(2) silo storage,
(3) LEPOL plant with cooler, and
(4) screening of pellets.

Grinding Plant

The ore fines are taken from the ore stockpile to the sub-surface bunker, from where they are conveyed to a surge bin by means of a vibrating conveyor and a skip hoist. The bin installation before the mill consists of four single bins, two of them to take the fresh ore, and one each for additives and return material from the plant. For the checking of the bin level, each bin is equipped with one maximum-level and one minimum- level indicator.

The dosing equipment of the mill comprises a total of four dosing machines, one for every bin, which are controlled from a common control cabinet. Two collecting belt conveyors below the dosing machines take the chromium ore (including any additives) and the return material to the mill, where it is introduced by double-flap valves for air-tight sealing.

A two-chamber separator mill with central discharge facilities, called a double rotator, which is fitted with classifying liners and is preceded by a drying chamber, serves as the grinding unit. The material being ground, which is fed through the double-flap valve, passes into a drying chamber equipped with dispersion blades. The combustion chamber is heated by gas. The mill has an inside diameter of 2,4 m and a length of 9 m. It is dimensioned for a capacity of 20 t/h. The exit gas from the mill is sucked on by a waste-gas fan via the outlet housing on the circumference of the mill, and is directed into the waste-gas stack. Connected before the waste-gas fan are a

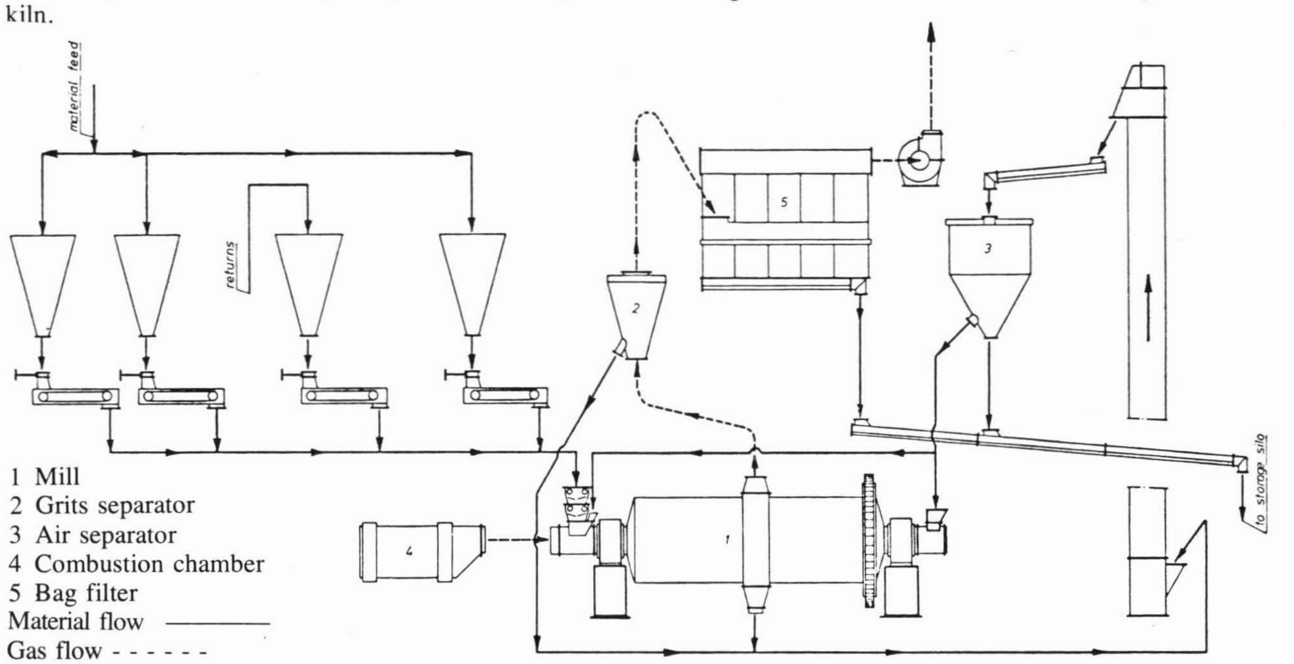


Figure 2
Grinding plant

grits separator, for primary dust collection, and a bag filter, for secondary dust collection. The grits separator is adjusted so that the fine meal remaining in the exhaust air after the separator corresponds to the finished meal in fineness. With the aid of the mill waste-gas filter, the dust-laden air raised by the handling equipment is also cleaned.

A lifting diaphragm at the end of the drying chamber raises the dry product, which is to be ground, into the grinding chamber proper. The material leaves the grinding chamber through a slotted discharge diaphragm and the discharge housing, and reaches a vertical conveyor via an aeroslide. The vertical conveyor in turn passes the product via a further aeroslide to the air separator, where it is separated into fine meal and grits. The fineness of the end-product can be regulated within a wide range by adjustable and exchangeable blades fastened onto the distributor plate of the separator, so that, for every ore blend, the most suitable grind can be given. Whereas the ore-meal and filter dust are conveyed to the silo installation by aeroslide, the grits are returned to the mill for final grinding.

Like the primary-grinding chamber, the secondary-grinding chamber is closed off by a discharge diaphragm provided with slots. After passing through the secondary-grinding chamber, the product falls through this slotted diaphragm and is conveyed to the separator together with the material coming from the primary-grinding chamber.

Silo Installation

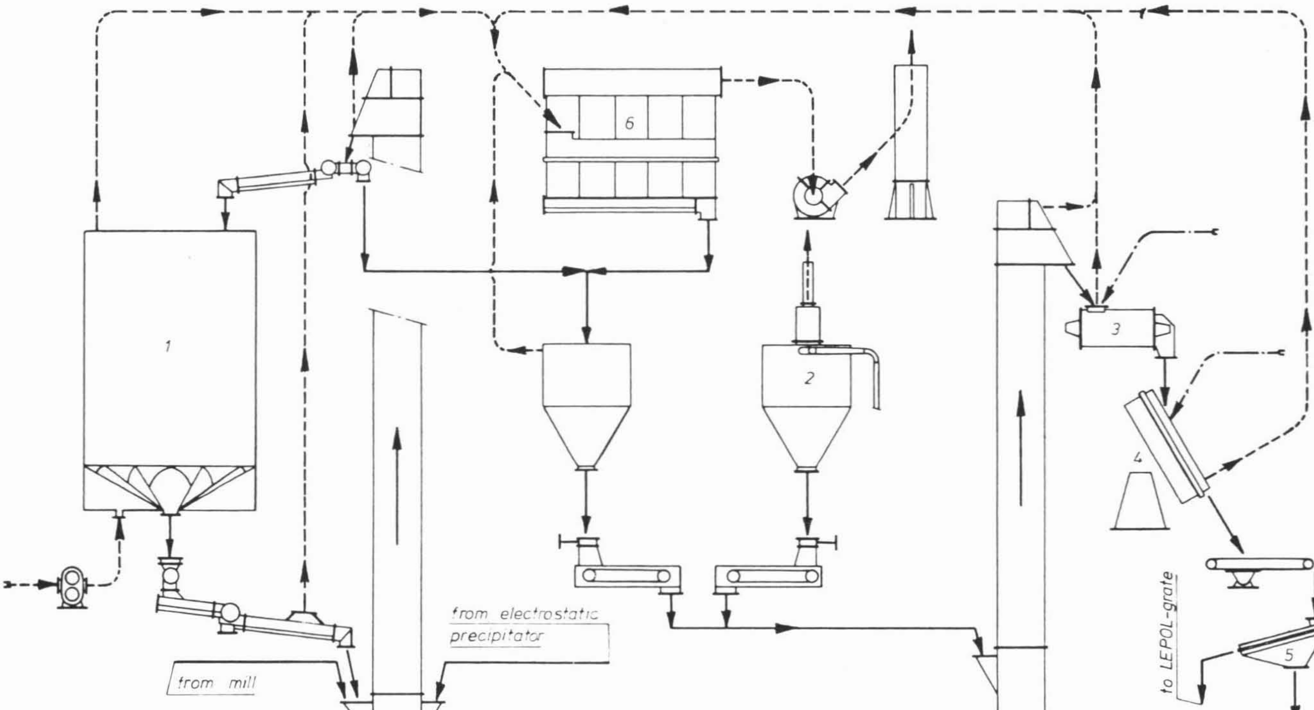
The storage silo consists of a cylindrical steel container placed on a concrete foundation, and has a capacity of roughly 700 m^3. Depending on the bulk density of the ore-meal and the degree of fluidization in the silo, the silo holds about 900 to 1100 tonnes – enough to operate the LEPOL plant for 2½ to 3 days. By an arrangement of air-distributor boxes underneath the silos, the air is blown through the silo floor, which is permeable to air, to give the material flow properties. In this manner, bridge or funnel formations are prevented, and a continuous outflow of material is ensured. In addition, the silo is equipped with a continuous level indicator, as well as with an audible and visible signalling device for the indication of maximum level.

The shut-off device on the silo bottom consists of a shut-off slide-valve and a dosing valve for the regulation of the outlet quantity. Connected after the dosing valve is a pneumatic conveyor (aeroslide), which takes the ore-meal to the vertical conveyor. Into this vertical conveyor, the aeroslide also conveys the finished product (ore-meal) discharged by the separator in the grinding plant. Owing to the fact that both material flows (that from the separator and that from the silo) are transported to silo level by a common vertical conveyor, a circuit can be built up via the aeroslide, so that there is continuous mixing of fresh meal and stored meal. In this way, a homogeneous ore-meal is available at all times.

The dust in the air coming from the silos and the conveying units is removed by a bag filter installed before the induced-draught fan for the removal of exhaust air.

LEPOL Plant

The pelletizing plant is charged from the surge bins (capacity 50m^3 each). One silo serves for the intermediate storage of the ore-meal and is charged via the vertical conveyor. The second silo is used for the storage of powdered additives or binding agents, which are delivered to the factory in tank vehicles and are discharged pneumatically into the surge bin. For the control of the bin level, both silos are equipped with maximum-level and minimum-level indicators.



Material flow————
Gas flow - - - - - - - - -
Water flow — - — - —

1 Storage silo
2 Silo for additives
3 Mixer
4 Pelletizing dish
5 Screen
6 Bag filter

Figure 3
Green-pelletizing plant

From these surge bins, the ore-meal and any necessary additives are reclaimed by means of dosing machines, and are conveyed into the mixer via a vertical conveyor and aeroslide.

In the continuous-flow mixer, the two components are blended, being moistened by added water. In this manner, a more-uniform wetting of the ore is achieved, as well as an improvement of the properties of the green pellets. Water is supplied to the mixer from a water tank by a dosing pump. The ore-meal thus prepared in the mixer, with a moisture of about 2 to 3 per cent below the optimum pellet moisture, is then directed to the dish pelletizer via a flexible inlet chute.

As pelletizing apparatus, we have a dish pelletizer of 3,2 m diameter, with adjustable rim. The most remarkable feature of the dish pelletizer is its compact design, being characterized by a centrally supported plate container and being driven by a multi-step gear unit.

A continuously working scraper device passes over the entire bottom of the plate, scraping off only small lumps, which are subsequently rounded again during the pelletizing process. The rest of the water needed for pelletizing is also supplied from the water reservoir by a proportioning pump.

Screening of Pellets

The green pellets leave the dish pelletizer and fall onto a slewing belt conveyor, by which they are uniformly spread over the entire width of the screen connected behind the dish pelletizer. This screen has the same width as the LEPOL grate (2,3 m) and feeds the latter direct with green pellets. This screen separates the fines smaller than 8 mm from the green pellets.

The depth of the material bed on the LEPOL grate is controlled by the speed of the grate belt. For this purpose, a control and measuring device is arranged in the feeding area. The device measures the bed depth and controls it by way of preselected set points via the grate speed.

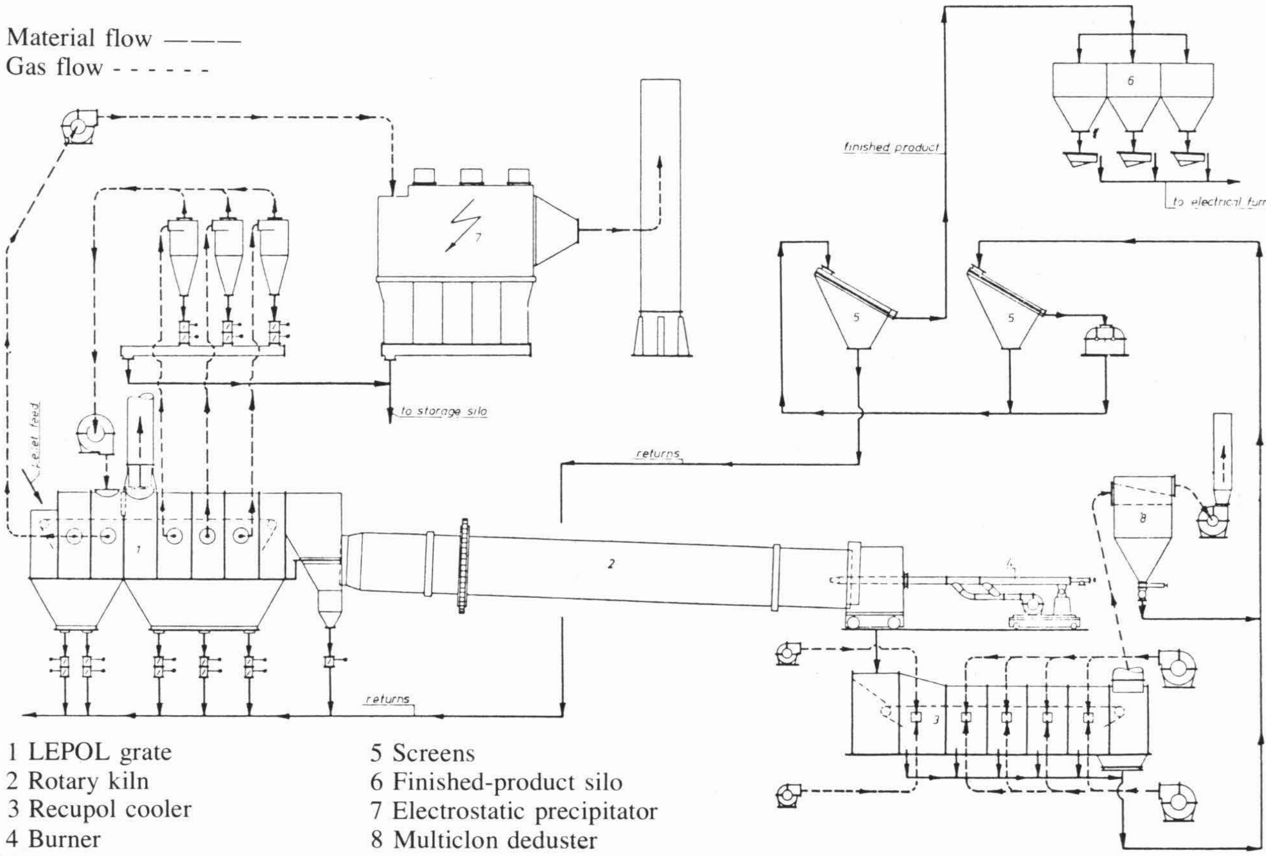
The LEPOL grate forms the first stage of the burning plant, and dries and heats the green pellets, thus utilizing the sensible heat of the exhaust gases up to shortly above the dew-point and giving the pellets enough strength in the process to withstand the mechanical stress in the rotary kiln without being destroyed.

The grate is 2,3 m wide and has a centre distance of 11,5m. An endless grate chain runs through the drying and hot chambers, which are separated by a diaphragm. The hot kiln-exit gases are sucked downwards through the layer of green pellets in the hot chamber and are pressed into the drying chamber by the fan. In the drying chamber, the gases are passed for the second time through the bed of green pellets and are then conducted at a temperature of 110 to 130°C to an electrostatic precipitator, where the dust is collected. The electrostatic precipitator is succeeded by a stack. The dust separated in the electrostatic precipitator passes into the vertical conveyor via an 'en masse' conveyor.

Part of the dust in the kiln-exit gases has already been separated by intermediate cyclone dust collection after the hot chamber and has also been conveyed to the vertical conveyor by way of an 'en masse' conveyor. The grate riddlings falling through the slots of the grate plates into the bunkers arranged underneath the grate chain are discharged by flap valves and passed into the bucket elevator by vibrating conveyor tubes. The bucket elevator takes the grate riddlings onto a recirculating-material belt conveyor and further into the grinding plant.

The pellets receive their final strength at a burning temperature of 1300 to 1500°C in the rotary kiln. The

Material flow ———
Gas flow - - - - - -



1 LEPOL grate
2 Rotary kiln
3 Recupol cooler
4 Burner
5 Screens
6 Finished-product silo
7 Electrostatic precipitator
8 Multiclon deduster

Figure 4
LEPOL Plant

trials, are not so considerable after all. The strengths after the cooler still amount to about 70 per cent of the initial figures.

The abrasive strengths show a tendency similar to that shown by the compressive strengths and are likewise dependent on the burning temperature. In trials carried out according to A.S.T.M. procedures, an abrasion of about 4 per cent was established for pellets burnt at about 1350°C, whereas these figures were below 1 per cent for the more strongly burnt pellets.

CONCLUSION

It should be stated in summing up that the production of pellets from chromium ores presents no difficulties in a LEPOL plant and has produced excellent results. After an operating period of more than twelve months, it can be said that the plant has fully met the demands made on it with respect to output and pellet quality. In addition, it has been shown that the choice of materials must be made with the utmost care if problems caused by wear and tear are to be avoided. On the other hand, the specific capacities can be increased for future plants. The rated output of 250 t/d can be exceeded in this plant by roughly 30 per cent.

In conclusion, it should be pointed out that the cooler can be dispensed with in plants of this type, provided that the local conditions permit direct feeding of the electric furnace with hot material. The profitability of the process as a whole can be increased by the adoption of this method. Plants with hot-charging facilities have been built in the past, so that the technical problems connected with them can be regarded as having been solved.

DISCUSSION

Question from the audience:

What are the minimum burning temperatures for the pellets?

Mr Boehm:

Pellets made from Transvaal chromite require a temperature of 1300 to 1350°C as compared with the 1450°C required for pellets made from Russian chromite.