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Enakievo Metallurgical Plant
in Enakievo

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PREFACE

This report documents an environmental audit conducted at the Enakievo Metallurgical Plant by a team of Ukrainians that were trained by the Environmental Policy and Technology Project on audit protocol and site investigation techniques, with emphasis given to identifying pollution prevention opportunities The management of this facility has granted permission to conduct a brief, on-site inspection of their operating facility for the purpose of obtaining a critical, independent assessment of the overall operations with emphasis given to identifying pollution prevention opportunities The purpose of this report is to provide guidance to the facility in defining technologies that could be implemented, resulting in better management of their wastes and pollution A number of pollution prevention investment opportunities that can be categorized as plant modernization projects are identified herein. It is recommended that this report be shared with financial lending institutions like the World Bank in order to develop detailed investment strategies that will assist this facility. It should be emphasized that the report and its conclusions should be viewed as preliminary, and further, the recommendations, critical assessments, and conclusions are confidential to Enakievo and USAID.

DISCLAIMER

The audit has been implemented and the report prepared as a task assigned under the Environmental Policy and Technology Project (EPT), a program funded by the United States Agency for International Development. The study and recommendations made in this report are based on observations made by an independent audit team that has been trained by the EPT Project to conduct environmental site assessments. All members associated with this task have used best judgements and experience in formulating the recommendations and conclusions of this study. However, reviewers of this report must note that the information presented herein are based on data collected and observations made at the time of the audit and hence, the report does not necessarily, nor is claimed to accurately characterize the subject facility. Lack of certain information as well as the opportunity to conduct a long term audit over time restricts this report to initial impressions and therefore conclusions and recommendations could be inaccurate or challenged by subsequent audits. Finally, the report should not be viewed as either an endorsement or negative evaluation of the facility, its operation, and/or the management of Enakievo by the EPT Project or USAID, nor does it contain information which can confirm any violation of statutes, regulations, or release limits in any way imposed on this facility.

ACKNOWLEDGMENTS

The report has been prepared by a group of Ukrainian tranees under the guidance of the Environmental Policy and Technology (EPT) Project which is a USAID multi-year contract to a team managed by CH2M HILL International Services, Inc. (CH2M HILL) to support implementation of an environmental assistance program to republics of the former Soviet Union. The author/s of this report wish to express their heartfelt gratitude for invaluable guidance and direction received from the EPT Project and in particular, the Donetsk Resident Project Manager, Dr. Nicholas P. Cheremisinoff.

The Audit Team:

Anna Sergeevna Tushkanova

Oleg Tokarev

Viktor Tushkanov

Valeri Sapronov

Alexander Dotsenko

Alexander M Marchenko

Elvira Golub

SECTION 1

EXECUTIVE SUMMARY

This report documents an on site investigation of the Enakievo Steel Metallurgical Plant. The purpose of this audit was to identify potential pollution prevention opportunities that could result in significant savings to the manufacturing operation and to develop and apply a generalized approach and methodology to conducting environmental site assessments or audits for the steel industry in Ukraine. Information in the form of data, photographs, interviews with management and operating personnel, and in some cases field measurements were collected by an independent auditing team that was organized and trained by the Environmental Policy & Technology Project (EPT), a program which is funded by the United States Agency for International Development (USAID). The information and recommendations of this report have been treated confidential to Enakievo and are not for general public knowledge. There are however significant modernization projects identified in this study which if implemented could result not only in major reductions in pollution, but drastic improvements to the profitability of the operation and hence help ensure the operation's sustainability. In this regard it is recommended that the report be shared with financial lending institutions like the World Bank and European Bank of Reconstruction and Development, or private investment sources that are seeking Ukrainian enterprises to invest in It should be noted that recommendations and estimates based on potential savings for pollution prevention opportunities should be viewed as approximations only, and at best, order of magnitude estimates of the investment requirements. Limited resources and time have restricted a more detailed set of recommendations. Specific projects identified will require more careful and detailed engineering studies and business evaluations. Finally, a small scale pilot demonstration project to illustrate the benefits of pollution prevention audits and management practices has been identified from the audit. This project and a detailed engineering estimate are included in the report , along with recommendations that USAID provide the necessary funding for this pilot demonstration.

SECTION 2.

OBJECTIVES OF THE AUDIT

2.1 The Environmental Site Assessment

The audit performed at the Enakievo Plant was an environmental site assessment (ESA) aimed at identifying pollution prevention opportunities that could result in significant savings in operating costs, product quality improvements, manufacturing efficiencies, while at the same time resulting in reductions in harmful emissions to the environment. In more specific terms, the objectives of this audit which the EPT Project is recommending as the standardized set of objectives for all subsequent audits conducted are:

- to help develop a structured approach to environmental management policy
- to address multi-media issues and relate them to environmental management needs
- to introduce the concept of intra-plant pollutant trading on multi-media basis
- to effect a common sense approach prioritization environmental management efforts taking into account economic, human resource and technological barriers to success
- to emphasize the need for environmental management credibility for the Iron and Steel global market as' well as the major lending institutions through ISO 14000 certification and development of an environmental management system (EMS)
- to shift management focus from polluted-site cleanup and pollution control to pollution prevention (P2).

2.2 Facility Documentation

A further objective of the audit was to document the manufacturing equipment and systems at the audit site, the historical use and the environmental damage to the site, the ongoing operational management approach that affects the environment, the human, technology and communication factors that impact environmental management effectiveness. To this objective, some insight into the mentality of current management is also noted in the report, for without management commitment it is not possible to implement an effective environmental management system.

2.3 Materials-Use Documentation

A further objective of the audit was to identify all process starting feed materials, quantify them and to characterize them and their ultimate fate in the manufacturing process using process and materials flowsheets. This type of documentation enables accurate identification, characterization and quantification of sources of pollutant releases and toxic wastes.

2.4 Pollution Prevention Design

For each identifiable pollutant release and process waste, design of procedures or systems should be recommended for :

- pollutant minimization - by process material change, inventory control, process conditions changes, product modification or maintenance enhancement;
- recycling of pollutants - within the manufacturing operation;
- reclamation of pollutants -for other uses external to the mill;
- pollutant release mitigation.

2.5 Pollution prevention demonstration projects

Finally, through execution of all of the above tasks, the objective is to identiiy one or more pollution prevention projects for demonstration under the USAID program with a view to future large-scale pollution prevention projects implemented under major lending institution funding.

SECTION 3.

IRON AND STEEL MILL AUDIT PLAN AND PROTOCOL

The specific objectives for conducting the audit at the Enakievo mill can be summarized as follows :

- To describe the mill's overall operations, identify operating units within the mill on a process flowsheet, and to identify the flow of materials through the mill

- To identify all significant wastes and air releases and to identify their points of generation on the process flowsheet.

- To characterize these releases and wastes through knowledge of the process, and in some cases by limited sampling and analysis.

- To provide an initial evaluation or assessment of the economic viability for the following three areas:

for recycling the wastes or releases within the mill, or for reclamation (i e , use external to the mill), or for reduction of the wastes or releases by process, or materials modification

The following is the *Protocol* developed and applied to the audit. It is recommended that this procedure be followed on all subsequent audits:

Step 1. Meet with the Mill Management and the Environmental Manager for whatever length of time is required for the purposes of accomplishing the following:

- To agree on the audit procedure (modifications may be necessary based on constraints, including safety related issues, within the plant)

- To review the specific information needs or requirements of the audit team (such as process flow sheets, reported releases, inventory of materials, flow rates, operating limitations, etc.) An extensive list of data needs typically examined in the audit can be found in the *Workbook on Conducting the Environmental Audit for Pollution Prevention and Waste Management (1997).* This publication was prepared for environmental auditors under the EPT Project and is available at the Technical Information Center in Donetsk. The meeting should be geared towards reducing the list to a manageable number of issues that will satisfy the requirements and objectives of the audit. At the same time, the meeting will identify areas where management simply does not have reliable information, and hence can identify plant needs in terms of managing their wastes, and subsequently identifying a specific area of the manufacturing process where the audit team may wish to spend additional attention to.

- Draw a process flowsheet of the mill showing the significant waste and release generation points. *Note - the flowsheet is an essential tool to be used both during the actual audit and in analyzing the information collected The audit team should use this as their road map while inspecting the mill and in formulating recommendations for particular processes*

- Identify who will conduct the audit for the mill management and what specific

assistance and cooperation will be needed. The manager should assign one or more specialists or operating personnel to accompany the audit team and should agree on full cooperation during the physical inspection.

- Establish a schedule for a pre-site visit and for the actual audit

Step 2. Conduct a Pre-site visit. The lead auditor, or if appropriate, the audit team should visit the facility for up to a one-day *walk-through* The purpose of this initial visit is to accomplish the following·

- To ensure that the process flow sheet developed accurately characterizes the mill operations.

- To enable a judgement that sufficient time and manpower has been allocated for the physical inspection to obtain all the data needs identified in *Step 1.*

- To identify specific areas or processes where sampling may be necessary, and if sampling points are identified, to assess how many samples are needed and what analytical support will be needed, as well as the size of samples and methods of preserving samples in the event that post analysis is needed.

- To assess safety precautions that the audit team needs to take, including identifying and becoming familiar with any safety rules and procedures that the mill enforces.

Step 3. Conduct the Audit For the audit conducted at Enakievo the major documentation and data needs are based on visual observations. This audit follows a logical progression through the mill based on the flow of materials for manufacturing steel. Hence the team followed the process flowsheet during the inspection. This approach provided a further verification and corrections to the process flowsheet describing the operations, and was heavily supported by video and still photographic evidence During the inspection, the team was instructed to focus on the wastes and release generation points that were identified in *Step 1.* These *points* were assigned a numeric code on the flowsheet and a data log was created to record specific observations and data. Photographs of the releases were obtained and an additional numeric code applied so that the photographs and video could be matched to the identification number assigned to each release point on the process flow sheet. This procedure helps to facilitate post analysis of the information gathered during the environmental site assessment.

Step 4. Post Analysis. For each waste and release, the team collectively characterized the wastes and releases based on their knowledge of these streams, and in terms of the physical forms, characteristics and chemical composition. The amount of time required to perform this step depends on the quantity of information collected and the complexity of the process, as well as the constraints placed on the audit. In this case study, twenty days was allotted to post analysis of the information. This enabled the team to prepare preliminary recommendations and to further identify additional data needs that a subsequent, more detailed audit might address. As part of this step, a preliminary meeting with the mill management, and in particular the environmental engineer representing the facility is advisable. The purpose of this meeting is to review some of the preliminary recommendations and to ensure that the audit team has accurately characterized the process and discharge streams. This also provides an opportunity to obtain initial reactions or impressions from the mill management on the overall value of the audit to them. For this audit, a four hour post meeting enabled the team to obtain some cost and engineering estimates on several pollution prevention opportunities identified during the study

Step 5. The Audit Report The final documentation of the study and its recommendations should be made. One of the objectives of this study is to provide Azovstal and facilities like it, a standardized approach and format for conducting *self-audits*. The EPT Project recommends self-audits because it is the best known approach for implementing an effective environmental management system that is aimed at improving the profitability and sustainability of the mill. The self-audit basically means that the mill management commit to having pollution prevention type audits conducted on a regular basis. We recommend two types of self audits. The first type, is in essence what has been conducted in this study. That is, inviting an independent team to conduct the audit, with the close cooperation of management. An independent audit team will indeed provide the most objective and critical assessment of the operations. It should however be agreed that such a study be treated as confidential information to the facility, especially if the services are paid for. Such documentation is clearly the property of the enterprise if it has contracted the services of an external audit team to provide a critical evaluation of its operations and environmental problems. This further means that the enterprise management will have the latitude to decide on the circulation of such a document (meaning, for internal use to improve operations, or if evaluations are highly favorable, to use as a basis for attracting financial resources for modernization and investments). The second type of self audit is simply to establish an internal team, comprised of process and environmental engineering department personnel. This audit team can apply the same principles presented in this report to identify incentives for pollution prevention. Small audits conducted internally within an organization can provide a basis for incremental improvements or incentives, and if conducted on a regular basis, with application of small scale modernization projects supported by management, can result in significant improvements with time. It is recommended that the general format for the report presented herein be applied in the final documentation. The approach taken in the study and in the report is to make comparisons to cleaner technologies. Hence comparisons are made between the technologies used at Enakievo and those used in the United States where strict environmental enforcement has driven the application of *green products and clean technologies* This comparison also enables a basis for an economic evaluation since the cost for existing clean technology is well known in the United States.

SECTION 4.

IRON AND STEEL PRODUCTION: STATE-OF-THE-ART U.S. TECHNOLOGY

The production of steel at a typical integrated iron and steel plant is accomplished using several interrelated processes The major operations are: (1) coke production, which is carried out external to steel mills in the Ukraine with merchant coking enterprises, (2) sinter production, (3) iron production, (4) iron preparation, (5) steel production, (6) semifinished product preparation, (7) finished product preparation, (8) heat and electricity supply, and (9) handling and transport of raw, intermediate, and waste materials.

4.1 Sinter Production

The sintering process converts fine-sized raw materials, including iron ore, coke breeze, limestone, mill scale, and flue dust, into an agglomerated product, sinter, of suitable size for charging into the blast furnace. The raw materials are sometimes mixed with water to provide a cohesive matrix, and then placed on a continuous, traveling grate called the sinter strand. A burner hood, at the beginning of the sinter strand ignites the coke in the mixture, after which the combustion is self supporting and it provides sufficient heat, 1300 to 1480^0 C (2400 to 2700^{0}F), to cause surface melting and agglomeration of the mix On the underside of the sinter strand is a series of windboxes that draw combusted air down through the material bed into a common duct, leading to a gas cleaning device. The fused sinter is discharged at the end of the sinter strand, where it is crushed and screened. Undersize sinter is recycled to the mixing mill and back to the strand. The remaining sinter product is cooled in open air or in a circular cooler with water sprays or mechanical fans. The cooled sinter is crushed and screened for a final time, then the fines are recycled, and the product is sent to be charged to the blast furnaces.

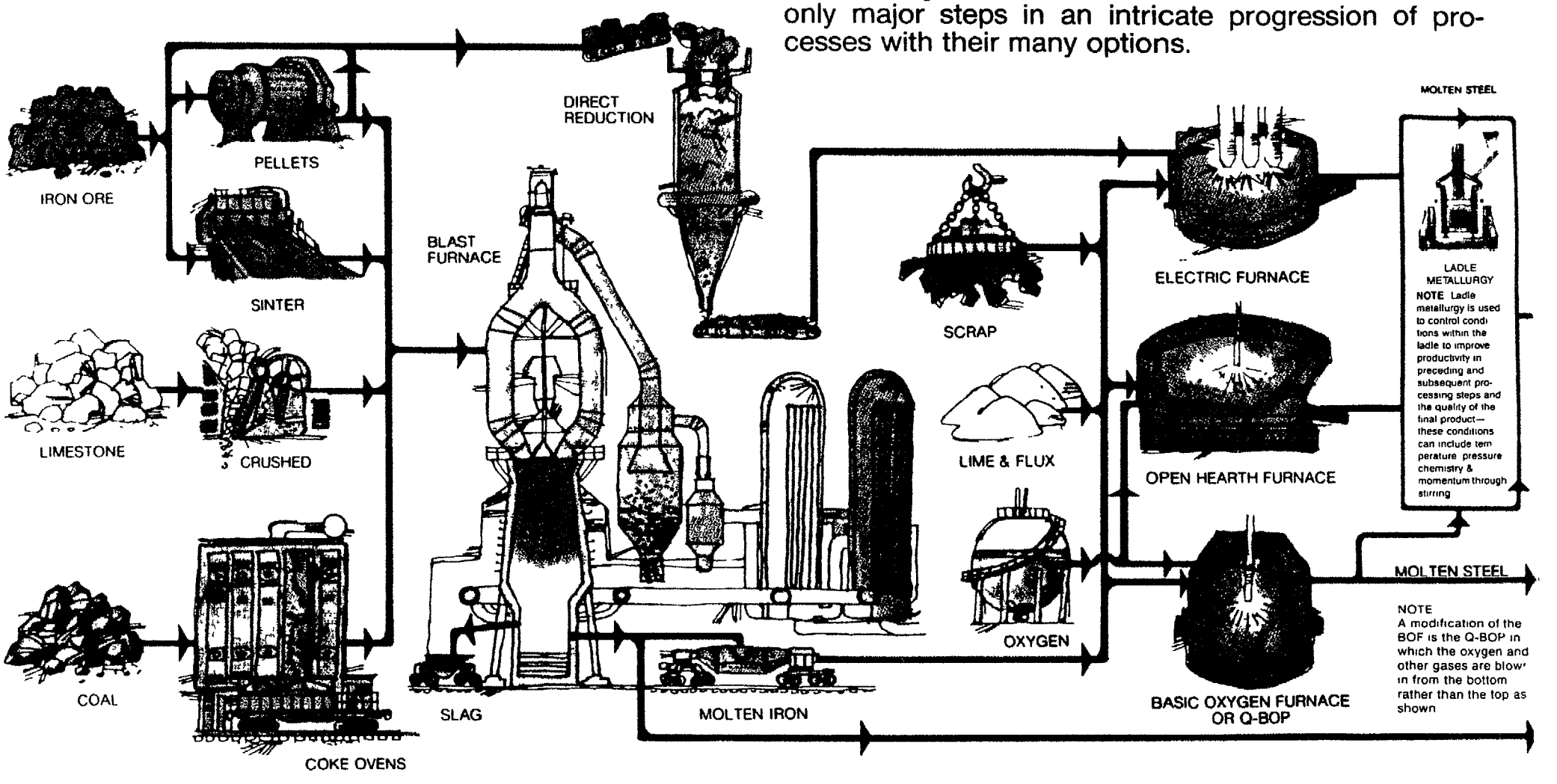
4.2 Iron Production

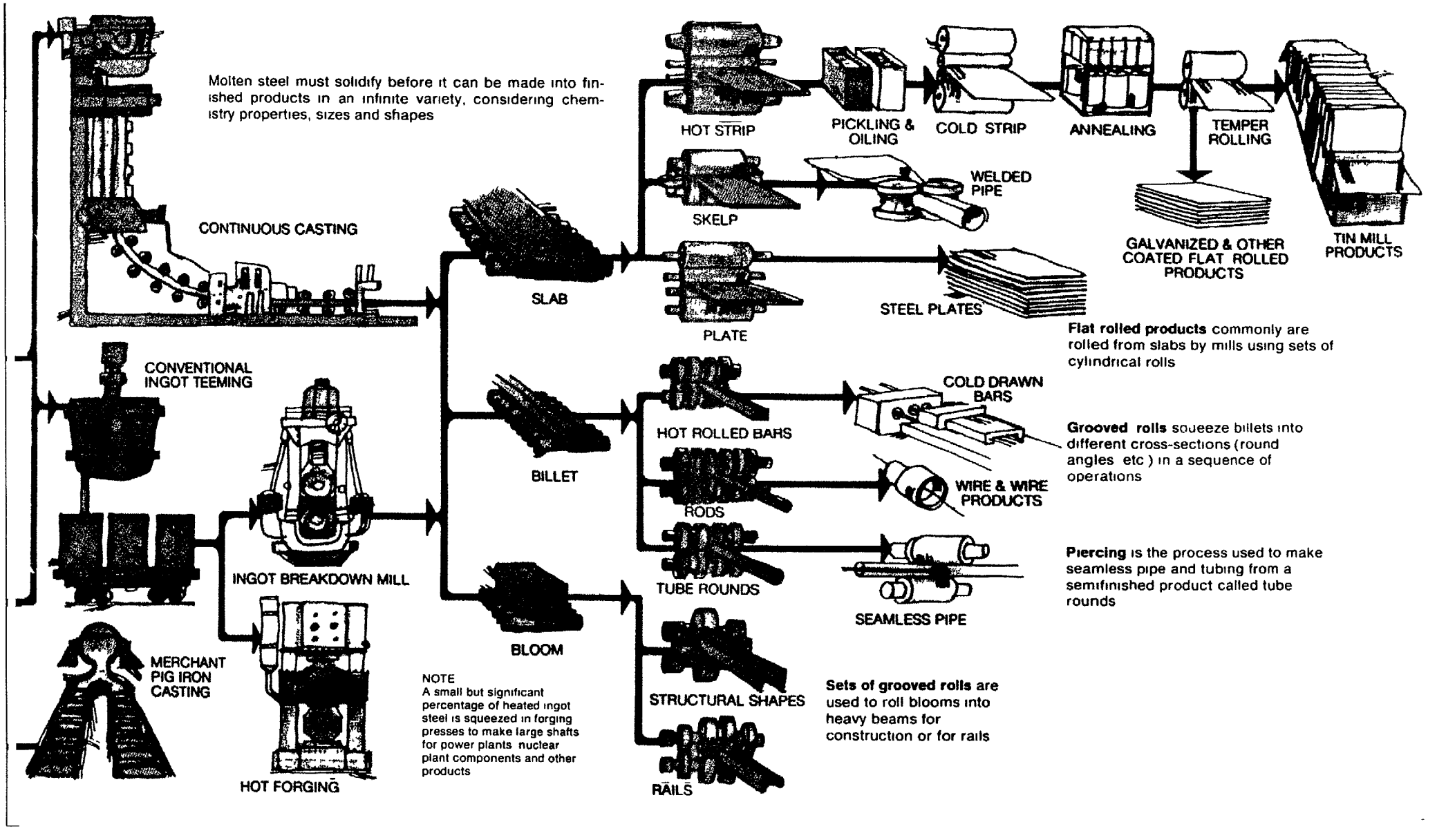
Iron is produced in blast furnaces by the reduction of iron bearing materials with a hot gas. The large, refractory lined furnace is charged through its top with iron as ore, pellets, and/or sinter, flux as limestone, dolomite, and sinter, and coke for fuel. Iron oxides, coke and fluxes react with the blast air to form molten reduced iron, carbon monoxide (CO), and slag. The molten iron and slag collect in the hearth at the base of the flimace. The byproduct gas is collected through offtakes located at the top of the furnace and is recovered for use as fuel.

The molten iron and slag are removed, or cast from the furnace periodically. The casting process begins with drilling a hole, called the taphole, into the clay-filled iron notch at the base of the hearth. During casting, molten iron flows into runners that lead to transport ladles. Slag also flows into the clay-filled iron notch at the base of the hearth. During casting, molten iron flows into runners that lead to transport ladles. Slag also flows from the furnace, and is directed through separate runners to a slag pit adjacent to the casthouse, or into slag pots for transport to a remote slag pit. At the conclusion of the cast, the taphole is replugged with clay. The area around the base of the furnace, including all iron and slag runners, is enclosed by a casthouse. The blast furnace byproduct gas, which is collected from the furnace top, contains CO and particulate. Because of its high CO content, this blast

a flowline of steelmaking

From iron ore, limestone and coal in the earth's crust to space-age steels — this fundamental flowline shows only major steps in an intricate progression of processes with their many options.




Molten steel must solidify before it can be made into finished products in an infinite variety, considering chemistry properties, sizes and shapes
CONTINUOUS CASTING
CONVENTIONAL INGOT TEEMING
INGOT BREAKDOWN MILL
MERCHANT PIG IRON CASTING
HOT FORGING
SLAB
BILLET
BLOOM
NOTE
A small but significant percentage of heated ingot steel is squeezed in forging presses to make large shafts for power plants nuclear plant components and other products
HOT STRIP
PICKLING & OILING
COLD STRIP
ANNEALING
TEMPER ROLLING
TIN MILL PRODUCTS
SKELP
WELDED PIPE
GALVANIZED & OTHER COATED FLAT ROLLED PRODUCTS
PLATE
STEEL PLATES
Flat rolled products commonly are rolled from slabs by mills using sets of cylindrical rolls
HOT ROLLED BARS
COLD DRAWN BARS
Grooved rolls squeeze billets into different cross-sections (round angles etc) in a sequence of operations
RODS
WIRE & WIRE PRODUCTS
TUBE ROUNDS
SEAMLESS PIPE
Piercing is the process used to make seamless pipe and tubing from a semifinished product called tube rounds
STRUCTURAL SHAPES
Sets of grooved rolls are used to roll blooms into heavy beams for construction or for rails
RAILS

furnace gas has a low heating value, about 2790 to 3350 joules per liter (J/L) (75 to 90 British thermal units per cubic foot ,Btu/ft^3) and is used as a fad within the steel plant. Before it can be efficiently oxidized, however, the gas must be cleaned of particulate. Initially, the gases pass through a settling chamber or dry cyclone to remove about 60 percent of the particulate. Next, the gases undergo a 1- or 2-stage cleaning operation. The primary cleaner is normally a wet scrubber, which removes about 90 percent of the remaining particulate. The secondary cleaner is a high-energy wet scrubber (usually a venturi scrubber) or an electrostatic precipitator, either of which can remove up to 90 percent of the particulate that eludes the primary cleaner. Together these control devices provide a clean fuel of less than 0 05 grams per cubic meter (g/m^3) (0.02 grains per cubic foot [gr/ft]). A portion of this gas is fired in the blast furnace stoves to preheat the blast air, and the rest is used in other plant operations.

4.3 Hot Metal Desulfurization

Sulfur in the molten iron is sometimes reduced before charging into the steelmaking furnace by adding reagents. The reaction forms a floating slag which can be slammed off. Desulfurization may be performed in the hot metal transfer (torpedo) car at a location between the blast furnace and basic oxygen furnace (BOF), or it may be done in the hot metal transfer (torpedo) ladle at a station inside the BOF shop, or using an independent separate desulfurization unit.

The most common reagents are powdered calcium carbide (CaC_2) and calcium carbonate ($CaCO_3$) or salt-coated magnesium granules. Powdered reagents are injected into the metal through a lance with high-pressure nitrogen. The process duration varies with the injection rate, hot metal chemistry, and desired final sulfur content, and is in the range of 5 to 30 minutes.

4.4 Steelmaking Process: The Basic Oxygen Furnaces

In the basic oxygen process (BOP), molten iron from a blast furnace and iron scrap are refined in a furnace by lancing (or injecting) high-purity oxygen. The input material is typically 70 percent molten metal and 30 percent scrap metal. The oxygen, reacts with carbon and other impurities to remove them from the metal. The reactions are exothermic, i.e., no external heat source is necessary to melt the scrap and to raise the temperature of the metal to the desired range for tapping.

The large quantities of CO produced by the reactions in the BOF can be controlled by combustion at the mouth of the furnace and then vented to gas cleaning devices, as with open hoods, or combustion can be suppressed at the furnace mouth, as with closed hoods. BOP steelmaking is conducted in large refractory lined pear shaped furnaces. Conventional BOFs have oxygen blown into the top of the furnace through a water-cooled lance. A typical BOF cycle consists of the scrap charge, hot metal charge, oxygen blow (refining) period, testing for temperature and chemical composition of the steel, alloy additions and reblows (if necessary), tapping, and slogging. The full furnace cycle typically ranges from 25 to 45 minutes.

4.5 Steelmaking Process: The Electric Arc Furnace

Electric arc furnaces (EAF) are used to produce carbon and alloy steels The input material to an EAF is typically 100 percent scrap. Cylindrical, refractory lined EAFs are equipped with carbon electrodes to be raised or lowered through the furnace roof. With electrodes retracted, the furnace roof can be rotated aside to permit the charge of scrap steel by an overhead crane. Alloying agents and fluxing materials usually are added through the doors on one side of the furnace. Electric current of the opposite polarity electrodes generates heat between the electrodes and through the scrap. After melting and refining periods, the slag and steel are poured from the furnace by tilting.

The production of steel in an EAF is a batch process. Cycles, or "heats", range from about 1-1/2 to 5 hours to produce carbon steel and from 5 to 10 hours or more to produce alloy steel. Scrap steel is charged to begin a cycle, and alloying agents and slag materials are added for refining. Stages of each cycle normally are charging and melting operations, refining (which usually includes oxygen blowing), and tapping.

4.6 Open Hearth Furnaces

The open hearth furnace (OHF) is a shallow, refractory-lined basin in which scrap and molten iron are melted and refined into steel Scrap is charged to the furnace through doors in the furnace front. Hot metal from the blast furnace is added by pouring from a ladle through a trough positioned in the door. The mixture of scrap and hot metal can vary from all scrap to all hot metal, but a half-and-half mixture is most common. Melting heat is provided by gas burners above and at the side of the furnace. Refining is accomplished by the oxidation of carbon in the metal and the formation of a limestone slag to remove impurities Most furnaces are equipped with oxygen lances to speed up melting and refining. The steel product is tapped by opening a hole in the base of the furnace with an explosive charge The open hearth steelmaking process with oxygen lancing normally requires from 4 to 10 hours for each heat.

4.7 Semifinished Product Preparation

After the steel has been tapped, the molten metal is teemed (poured) into ingots which are later heated and formed into other shapes, such as blooms, billets, or slabs. The molten steel may bypass this entire process and go directly to continuous casting operation. Whatever the production technique, the blooms, billets, or slabs undergo a surface preparation step, scarfing, which removes surface defects before shaping or rolling. Scarfing can be performed by a machine applying jets of oxygen to the surface of hot semifinished steel, or by hand (with torches) on cold or slightly heated semifinished steel.

SECTION 5

DESCRIPTION OF ENAKIEVO IRON AND STEEL PLANT

5.1. Overview.

Enakievo Iron and Steel Plant was founded on the 19th of July in 1897 (fig.1,2) Enakievo Iron and Steel Plant specializes in the production o f bar, billets, steel ingots and pig iron.

The plant consists of :

- agglomeration shop with 4 traveling-gate sintering machines
- blast furnace shop equipped with 4 blast furnaces
- converter shop with 3 converters 170 tones each
- roughing shop - blooming mill "1250"
- section rolling shop #2 that has 3 rolling mills "550", "360" and "280"
- section rolling shop #3 that has mill "250" and continuous rolling mill;
- additional shops: shaped-casting, lime-burning, railway, tar-bonded dolomite, pile-driving, mechanical, gas, metalwork and Central Heating and Power Plant- Gas-Vapour System.

Iron ore, iron ore concentrate, dolomites, coke and ferroalloys are used as raw materials during the production.

The projected activity of EMP amounts to:

- agglomerate - 2,85 million tons per year
- pig iron - 2,8 million tons per year
- steel - 3,0 million tons per year
- rolled stock - 2,8 million tons per year

The actual productivity of the plant is 40% from the projected activity.

In 1996 the planned productivity amounted to:

- rolled stock - 1,5 million tons per year
- slabs - 1 million tons per year
- steel bars - 3 million tons per year
- pig iron - 250.000 tons per year

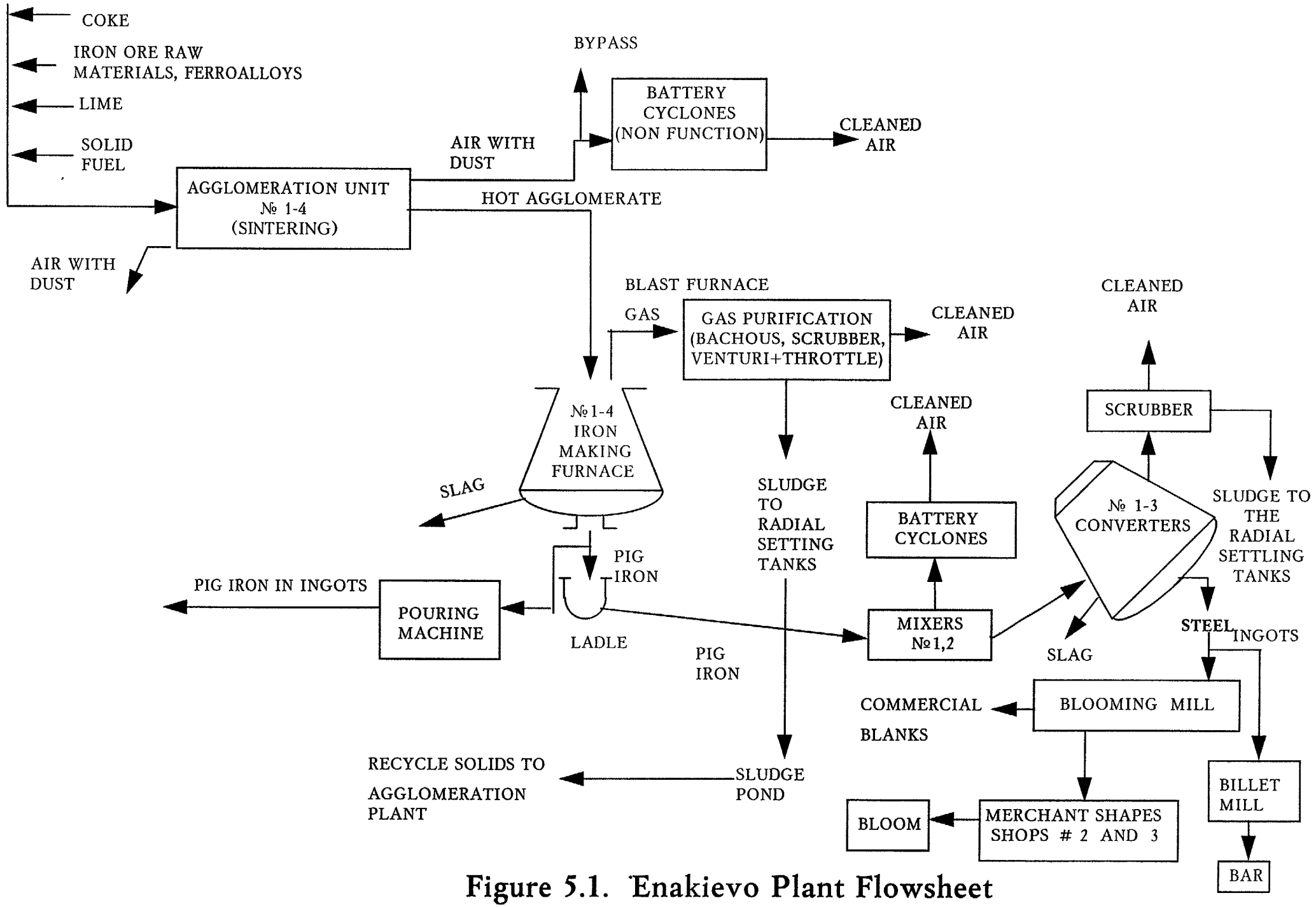


Figure 5.1. Enakievo Plant Flowsheet

8 000 people work at the facility.

5.2. Agglomeration (sintering) shop.

The agglomeration shop, that is included into EMP, was founded in 1936. The shop is designed for recycling of ore, concentrates and sludges of gas cleaning of blast furnace and converter shops, slags from the rolled stock shops, blast furnace dust and other iron-containing materials (fig.3)

The agglomeration shop includes an area of charge preparation, where the blending of charge takes place, and also 4 agglomeration lines (sintering area is 52,5 m^2). The projected productivity is 2,85 million tons of agglomerate per year. In 1995 they produced 1,147 million tons of agglomerate, which is 40% of the design productivity.

There are dust capturing devices on the cold and hot sides - battery cyclones. At the place of agglomerate unloading there are hoods for dust capturing , but they are corroded and do not work.

5.3. Blast Furnaces. The Iron -Making Process.

The blast furnace shop consists of 4 blast furnaces (blast furnaces # 1,3,4,5). The blast furnace#2 was shut down. Three blast furnaces have the capacity of 1033 c.m., the fourth one - 1476 c.m. (fig. 4,5,6) The projected productivity of all the blast furnaces is 2.8 million tons per year. The last blast furnace #5 was constructed in 1966. In 1995 EMP produced 1005737 tons of pig iron, which is 35,9% of the design productivity.

Agglomerate, pellets and fluxes are used during the production of cast iron. Coke and natural gas are fuel for it. Earlier, coke was supplied by Enakievo By-Product Coke Plant, the industrial area of which is neat EMP. (fig.7,8,9,10). But currently, in connection with the reconstruction that is performed in the By-Product Coke Plant and recession in production associated with lack of raw materials, the productivity of the By-Product Coke Plant is not enough for supplying coke to the EMP. The plant gets coke from other suppliers: Gorlovka, Makeevka, Avdeevka and Yasinovskiy By-Product Coke Plants.

Currently, only 3 blast furnaces of the EMP are in operation (one of the blast furnaces is being reconstructed). The plant tried to carry out the reconstruction with their own money, but they failed and reconstruction works were stopped.

The gas cleaning units of technological gases were installed during the construction of the blast furnaces. Each blast furnace has a dry dust catcher, a scrubber, a Venturi tube and a throttle group. Caught blast furnace dust is first collected in the casting yards and then it is used for production of agglomerate. There is no department for desulfurization of pig iron in the EMP Pig iron in ladles is directly sent to the mixer department of the oxygen-converter shop.If pig iron contains a great quantity of sulphur, the process of desulfurization is conducted in the converter shop. Such technology decreases the quality of steel.

Part of liquid cast iron is fed to the pouring unit for processing it into ingots which is a commercial product. EMP sells its pig iron for $ 105 to 115 per ton. Depending on the quality of cast iron the price may increase up to $160 per ton.

5.4. Basic Oxygen Furnace Bessemer Converter.

The converter shop was constructed in 1968 (fig. 11,12). The mixer department of the EMP is included into the oxygen-converter shop. The mixer department is equipped with 2 mixers. Usually only one mixer is in operation. The converter department has 3 converters. Each converter has a capacity of 170 tons. In 1995 the plant produced 1.001.041 tons of cast iron that amounted to 33,36% from the design productivity. The design productivity of the converters is 3 million tons per year. Gas outlets of each converter are equipped with a scrubber, Venturi tubes and a safety trap.

5.5. Lime-burning department.

The department is equipped with 4 furnaces for lime burning. Behind the furnaces, 4 electric precipitators for lime dust capturing are installed. The precipitators are reconstructed now. (fig. 13,14)

SECTION 6.

ENAKIEVO PLANT WASTES AND RELEASES.

6.1. Overview.

EMP is located in Donetsk Oblast in the town of Enakievo with the population of 100.000 people. According to the latest data, the plant occupies 285,4 hectares, the area of sanitary-protected zone is 329,55 hectares. The sanitary-protected zone around the plant is 500m, there is practically no population there. Buildings and constructions in the sanitary-protected zone are either dismantled in part, or leased to small, private or other enterprises.

EMP sources emit the following substances into the atmosphere:

- suspended substances, carbon oxide and sulfur dioxide. the sources of their emissions are the blast furnace shop, the agglomeration plant and the converter shop.
- nitrogen oxides - from the agglomeration plant and other shops that consume energetic fuel.
- hydrogen sulfide - from the shop of slag recycling.

Emissions of hazardous substances in EMP are conducted by organized sources mainly. There are 146 organized sources of emissions and 36 non-organized sources of emissions in the plant. 71 sources have gas cleaning units. 25 of them operate effectively, 46 does not work practically.

The agglomeration plant and the blast furnace shop are the main sources of atmospheric pollution in EMP.

The gross emissions of hazardous substances in 1995 and for six months of 1996 amounted to 61066.305 and 29604.57 tons per year respectively. In 1995 discharges of solid substances amounted to 6371.550, gaseous substances - 54694.755 tons per year. For the first six months of 1996, the discharges of solid substances amounted to 3091.747 tons, the gaseous substances - 26512.827 tons.

The fines that the plant paid for exceeding the limits of emissions of hazardous substances into the atmosphere in 1996 amounted to $500.000.

EMP constantly carries out environmental protection activities. As a result of it, the following progress was achieved in 1996:

- compared with the limit, emissions into the atmosphere were decreased by 25200 tons.
- discharges of waste water were decreased by 125.000 tons
- recovering of iron - containing wastes and their utilization was increased by 1283.000 tons
- 53,7 thousand tons of slag was captured from the waste waters of rolled stock shops

- 25 tons of oil products were captured for utilization.

Currently, the joint sludge pond (tails storage of EMP and Enakievo By-Product Coke Plant) is a problem for EMP. It was built in 1963. The initial capacity was 1,35 million c.m. The sludge pond was designed for iron containing sludges, sludges of wet gas cleaning of blast furnace and converter shops and rejects from the mining factory of Enakievo By-Product Coke Plant. It is located in the ravine of Belikov Yar, 4,5 km from the plant. In 1979 the second phase of the sludge pond was constructed with the capacity of 2,65 million c.m. The third phase was constructed in 1986 and the capacity of the sludge pond was increased by 2 66 million c.m. From October 1995, taking into consideration the situation with the joint sludge pond EMP stopped discharging sludges into it. A total amount of iron containing sludges in the pond is 5-6 million tons. The sludges are contaminated with wastes from the By-Product Coke Plant. The sludge pond is in an emergency condition. It is planned to carry out the works on the increment and strengthening of the sludge pond, and also dividing the sludge pond into sections in order to process and utilize sludge wastes in the agglomeration production. But so far there are no feasible projects of the accumulated wastes utilization. Currently, iron containing sludges and sludge waters are discharged into the Avilov sludge pond.

More than 11 years ago in 1986-1987 the construction of the shop for utilization of iron containing wastes of current production was started (fig.15,16). The plant spent 138256 million coupons on the construction of the shop in 1995. In order to finish the construction, the plant needs 3 million USA dollars. The management of the plant doubts that there is a necessity to finish the construction of the shop because the technology of this project is not up-to-date. The design is going to be reviewed according to more modern technology.

The data given in this chapter does not enable us to make decisions about the investments. Each case requires a detailed study.

6.2. Agglomeration

Dust of charge materials and exhaust agglomeration gases with the high content of sulfurous compounds, carbon and nitrogen oxides are the main hazardous substances that form in the agglomeration production during the preparation of charge materials for the agglomeration, their transportation to the agglomeration units, agglomeration of charge, crushing, screening and unloading of the agglomerate into the hoppers. The main part of the emissions goes through the stack (fig.17). A unit of agglomerate sintering is equipped with 4 lines. Two lines are usually in operation, 2 are not. (fig. 18,19,20, 21).

The cleaning of the technological gases that is generated under the blowing in of the agglomeration charge is carried out in the multicyclones. The equipment is very old and ineffective and it must be replaced. (fig.22). The stock yard is the greatest source of non-organized emissions where charge is blended. (fig.23) There are hoods for dust capturing in the places of agglomerate unloading, but due to high abrasivity of this dust, the hoods were damaged, and at present they are out of order. Now a lot of dust is emitted into the atmosphere during the loading of agglomerate into the cars. (fig.24)

Currently, the following wastes are used fully as agglomerate charge additives :

- blast furnace dust
- lime dust

- slags of initial settlers of rolled stock shops.
- slag is placed in the horizontal settlers. In 1995 38062 tons of slag were generated.

Some part of slags of secondary settlers of rolled stock shops is used. All these materials without any treatment go to the production In the process of transportation, during the unloading from cars and stacking much dust is emitted into the atmosphere. It affects the environment and conditions of work.

The construction of the shop for wastes utilization will give an opportunity to exclude the stacking of sludges of gas cleaning of blast furnace and converter shops and at the same time use the given wastes in the charge of the agglomeration plant as the second raw material and it contributes to the economical use of iron ore.

Currently, the EMP carries out the reconstruction of the slime pond. The second section of it is cleaned out from the sludges that are used in the agglomeration charge. The sludges by truck or by railway road are sent to the agglomeration plant for utilization. Before feeding into the charge , dry lime is added to sludges. 250 kg of sludge is required for one ton of charge. The first section of the slime pond is filled with sludge pulp. As a result of this operation, the plant has not paid for a long time for placing of blast furnace and converter sludges in the environment because usage of sludges exceeds their generation. Besides, the capacity of the cooling pond increases due to pumping the sludge pulp into the first section and due to better cooling of recycled water that goes to the cooling pond. Cooling of metallurgical units improves.

6.3. Blast Furnace.

Dust of charge components and gases with high contents of carbon oxide, sulfur compounds and nitrogen oxides are the main pollutants in the blast furnace production which are generated during the intake, processing of charge materials and the output of smelting products (pig iron and slag). The main sources of emissions are the casting yards of blast furnaces, skip pits and units for materials loading (fig. 25,26)

The blast furnace shop of EMP is the second largest source of pollution, after the agglomeration plant. (fig.27)

Currently, dust content of gases that are emitted through the aeration lanterns of the casting yards during the discharge of metall from the blast furnaces is 2-4 gm./c.m. Relying on U.S. experience the places with higher dust emissions are equipped with hoods in order to localize the hazardous substances with the subsequent cleaning of air from dust in the electrostatic precipitators. But the substitution of wet gas cleaning operations for dry gas cleaning operations will require large investments (about 2 million USA dollars to install one precipitator).

Nitrogen dust suppression could be an important component in reducing emissions from the blast furnaces. But this method is not applicable because the plant does not have sufficient capacities to produce nitrogen.

Blast furnace dust that generates in the blast furnace production is first accumulated in the stock yard. Usually, the quantity of blast furnace dust amounts to 2% from cast iron production But EMP is not equipped with aspiration systems in the casting yards, the quantity of the captured blast furnace dust amounts to 1.3 - 1.4 % from the production of cast iron. Captured blast furnace dust is completely used at the facility as an additive to

agglomeration charge. In 1995 during the production of 16006 tons of cast iron, 13.5 thousand tons of blast furnace dust was utilized in a year

It is a common practice in EMP during the drastic differences in the work of blast furnaces to burn completely blast furnace gases. This practice is employed when they do not have enough time to alter the operating conditions of waste-heat boilers of blast furnace gas. During this process not only valuable product is lost, but the atmosphere is polluted with the products of burning (fig. 28,29).

In order to clean blast furnace gas, recycled water is fed to the scrubbers and Venturi tubes. Recycled water is polluted with mechanical components - fine fractions of charge, phenols, toxic cyano- and thiocyanate compounds The dust that is captured in the gas cleaning facilities, goes in the form of sludge pulp to the radial settlers of the blast furnace shop (fig. 30,31,32) and then to the sludge pond. The quantity of sludges of gas cleaning of the blast furnace shopwas 265 thousand tons per year in solid materials in 1996. The main components of sludges are Fe_2O_3 (74,5%) and CaO (12%).

The slag that is generated during the blast furnace production is placed in the blast furnace dumping grounds, from where it goes to further processing. The quantity of slag is 252 thousand tons per year. The blast furnace slag is recycled in the moving crushing-sorting installation where we get usual and granulated slag. In 1995 603,6 thousand tons of slag were generated and only 497,2 thousand tons were used. In 1995 the percentage of the utilization of blast furnace slag amounted to 82,37% Blast furnace slag is sent by the plant to some other organizations and it is then used as building materials. The unit of making cinder blocks out of blast furnace slag operates at the plant.

In the blast furnace shop hearth cinder is also used for the production of pig iron that is at first accumulated in the bin trestle. 5290 tons were generated in 1995, 5657 tons were used . (the percentage of utilization amounted to 107%).

6.4. Basic Oxygen Furnace (BOF)

Oxygen- converter shop of EMP has the following departments:

- mixer department
- converter department

Problems with the cleaning of exhaust gases in the mixer departments do not exist in USA because pig iron is transported from blast furnaces in the mixer-carriers.

Following are the technological operations in the mixer department of EMP: slag flushing from the blast furnace ladle, pouring of pig iron into the mixer, pig iron flushing from the mixer into the steelmaking ladle. The department is equipped with 2 mixers (one of them is in operation, the other one is not). During the flushing from the mixer, the discharge of a great amount of pollutants into the shop takes place (fig.33,34) Gases discharged into the aeration lantern of the mixer department have a high dust content. Mixer department is equipped with gas-cleaning installations - multicyclones (fig 35,36) that do not work effectively. The issue of graphite capturing is not solved (the floors in the mixer department are covered with a thick layer of graphite).

The reduction of discharges of iron-containing dust and sublimates during the pouring of pig

iron into the mixer and its flushing from the mixer can be achieved by means of periodical feeding of technical nitrogen to the place of dust emissions. But the practical application of these practices is impossible because EMP does not have sufficient amounts of nitrogen.

In USA there are 2 tendencies of dealing with dust emissions during the turn-down of converters: the first one is to capture and clean gas emissions, the second one is to improve the technology of converter loading and scrap preparation. The systems of local gas suctions are sometimes used together with partial or complete ventilation of the shop for the suppression of non-controlled discharges. During the construction of suction system the volumes of drawn in air must be reduced to the minimum. Semi-hermetically sealed covers equipped with sliding doors for the charging of scrap and pouring of pig iron are also used.

Converter department of EMP is equipped with 3 converters - 170 tons each, volume - 135 c.m. According to the design 2 converters must be in operation and at the third converter the change of lining is conducted. But at the moment only one converter is in operation, the second one is in reserve, and at the third one lining is changed. (figures 37,38,39). The design productivity of the converter is 3 million tons of steel annually, the actual productivity is less than 40% of this figure. During the charging of scrap into the converter (figure 40,41,42) and pouring of pig iron into it (figures 43,44) significant discharge of pollutants into the shop takes place. Also during the flushing of steel from the converter (figure 45) and technological operations of the metal blow with nitrogen (figures 46,47), discharge of pollutants takes place None of these sections is equipped with protective hood. Polluted gases in the shops are discharged into the atmosphere through the aeration lantern (figure 48). Technological gases after gas cleaning operations are discharged into the atmosphere through the stack (fig 49).

Water from the recycling system of gas cleaning installations of the oxygen-converter shop is used for the cleaning of technological gases. Sludge that is generated first gets to the radial settlers (there are 3 radial settlers of the gas cleaning operations of the converter shop in the plant They were built in 1969-1970 (figure 50) and then to the plant sludge pond. Amount of sludge that is sent to the sludge pond amounted to 73 thousand tons of solid matter in 1996. The basic components of sludge are Fe_2O_3 (79%), CaO (9,2%), MgO (1,5%).

Converter slags that are generated are placed at the converter spoil heaps and later are used to get crushed stone and as fluxes in the agglomeration and blast furnace shops. The percentage of utilization in 1995 amounted to 95,8%. 155,666 thousand tons were generated: 148,853 thousand tons were used. In 1996 173 thousand tons of converter slags were generated.

6.5. Lime-burning Department.

EMP together with "Spake" company (France) in the lime-burning department works out the environmental project that concerns the reconstruction of electrostatic precipitators behind limestone burning ovens # 1,2,3,4. 3-section electrostatic precipitators used to be installed here with the increased interelectrode space and with low efficiency of cleaning. Designing works directed at the reconstruction of electrostatic precipitators were conducted by "Spake" company. According to the design the efficiency of lime dust capturing is 99,8%. 620 tons of lime dust per year will be captured. The total cost of the project is 4,7 million USA dollars. This sum includes the cost of the project itself, also the cost of the part of equipment supplied by "Spake" company (electronic "inside" of the electrostatic precipitators and their casing). Part of the equipment will be manufactured by the plant itself, it will also assemble the equipment. According to the design, reconstruction will be carried out in parts without interruption of the production process. It is envisaged to carry out the cleaning from lime

dust in 2 stages: 1st step - cyclone group is installed where not only large particles are captured, but also the speed of the polluted gas is decreased; 2nd step - cleaning in the electrostatic precipitators (figure 51).

Putting into operation of an electrostatic precipitator a year was envisaged in the design. Electrostatic precipitators behind ovens # 3,4 were put into operation in 1995 (figures 52-55). At present the works on the construction of electrostatic precipitator behind ovens #1,2 are conducted (fig.56) These works are about to be completed. If the funds are available, electrostatic precipitators can be put into operation at the end of the second quarter of 1997. But to finish the work EMP needs to attract 600 thousand USA dollars in investments, because the variant when the plant pays by means of their products was rejected by "Spake".

SECTION 7.

RECOMMENDATIONS.

7.1. Overview and General Recommendations.

The project of Maximum Acceptable Concentration was developed for the EMP in 1992. It will be in effect to 1997. The term of achieving MAC is 1996. But due to non-completion of a number of measures, standards concerning discharge of suspended substances were not achieved. But in connection with non-compliance with MAC, the activities regarding solid waste discharges it was not achieved.

The plant applied to the State Department for the approval of the limits to 1996-1997, based on the actual discharges in 1995. However, the limits to 1996 were approved on the level of the draft of MAC normatives. For the exceeding of limits on the discharges, emissions and placement of production wastes, the plant paid 500.000 USA dollars to the State Department.

Currently, Ukrainian Scientific Center conducts an inventory of hazardous discharges in order to develop a new draft of MAC.

The plan of activities for environmental protection is available. But among 7 items that concern the protection of the atmosphere, 3 items were not carried out.

- reconstruction of a unit of air heaters of blast furnace#2. The term of the completion of works is extended to July 1997

- reconstruction of gas cleaning units of technological gases of the furnaces of lime burning and installation of electrostatic precipitators "Spake" were carried out partially. The term of the completion is extended to the first quarter of 1997.

- additional moistening of charge materials (sludges) in the stock yard of the agglomeration plant will not be conducted since the moisture of raw materials is enough for the production.

A new draft of MAC will include a list of activities for reduction of discharges that concern basic environmental problems of the EMP:

- cleaning of agglomerate gases in a reject part of agglomerate units.

- cleaning of waste waters from oil products.

Since 1996 the unit for desiccation of oil products of the rolled stock shops that accumulate on the horizontal settlers operates in the plant (fig. 57-59). Pipes with slots that are used in this unit do not provide an effective cleaning as the content of oil products in waste waters exceed MAC. Therefore, it is necessary for the plant to develop and implement effective measures for cleaning of waste waters from oil products for the reduction of pollution in the river Bulavin (fig. 60-61).

7.2. Agglomeration

The agglomeration shop was constructed more than 60 years ago. The equipment in the shop is very old and worn out and it needs to be repaired. In order to construct a new agglomeration complex with the applying of new technologies of burning and equipped with efficient gas cleaning units on all stages of the technological process, the plant requires about 200 million $ dollars But this problem is not going to be solved right now.

7.3. Blast Furnace

The plant requires about 50 million $ dollars for reconstruction of one blast furnaces depending upon the technology that is used in the blast furnace production and also depending on the applying of methods for the reduction of discharges from the casting yards, units for raw materials loading, equipment of gas cleaning facilities of technological gases. But it requires attracting large investments.

One of the variants is the substitution of wet gas cleaning for dry gas cleaning in the blast furnaces with the installation of the electrostatic precipitators for with the subsequent bricketing of wastes and their usage in the agglomeration plant. For the implementation of these activities, the plant needs 2 million USA dollars for one electrostatic precipitator. In total the sum amounts to 6 million $ dollars.

7.4. Desulfurization

The plant requires 30 million $ dollars for the construction of a desulfurizatiion department equipped with effective dust cleaning devices.

7.5. Basic Oxygen Furnace (BOF)

For the equipment of mixer department with the system of exhaust gas capturing and gas cleaning with the installation of hoods at the places of slag flushing, at the places of pouring and discharge of pig iron from the mixer, the plant needs 3 million$ dollars.

As one of the variants of technological operation we can consider the possibility of introducing a vertical guniting under which, the generated gases go to the gas cleaning units of the converter. 5 million $ dollars is needed to acomplish this task.

7.6. Lime-burning department

EMP requires 600 thousand $ dollars in order to install 2 electrostatic precipitators of "Spake" company behind furnaces #1,2.

7.7. Shop for the utilization of iron-containing sludges of the current production

The plant requires 3 million $ dollars for the completion of construction of this shop. For more details refer to item 2.1.

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Figures 57,58 - Unit for the desiccation of oil products in the horizontal ponds

Figure 59 - Discharge to the plant cooling pond

Figures 60,61 - Plant cooling pond

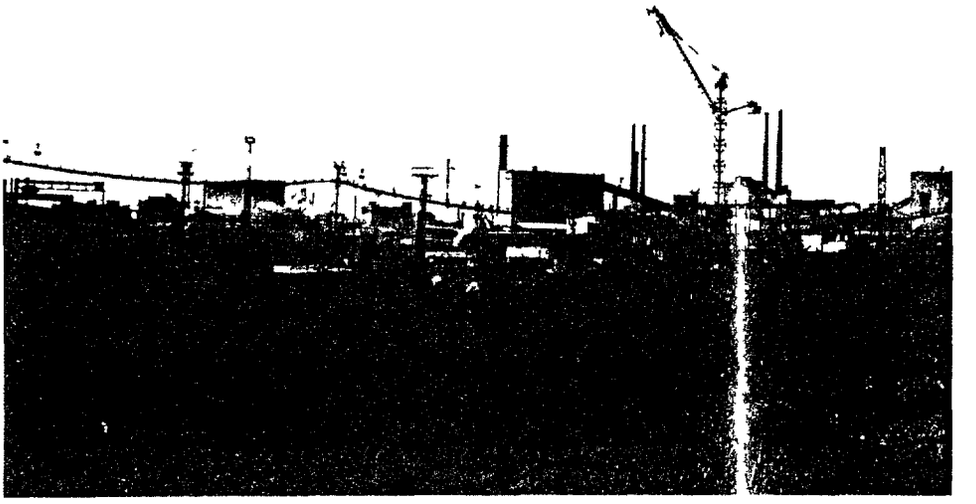

Figure 1. Overview of Enakievo Metallurgical Plant

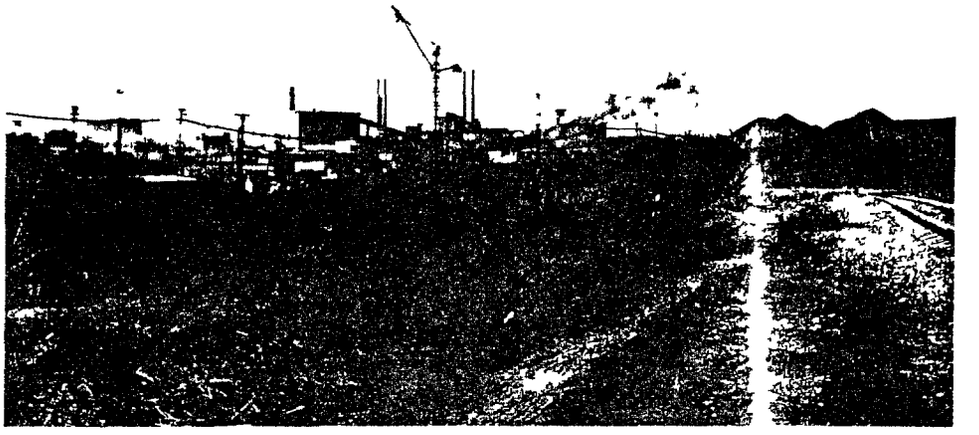

Figure 2. Overview of Enakievo Metallurgical Plant

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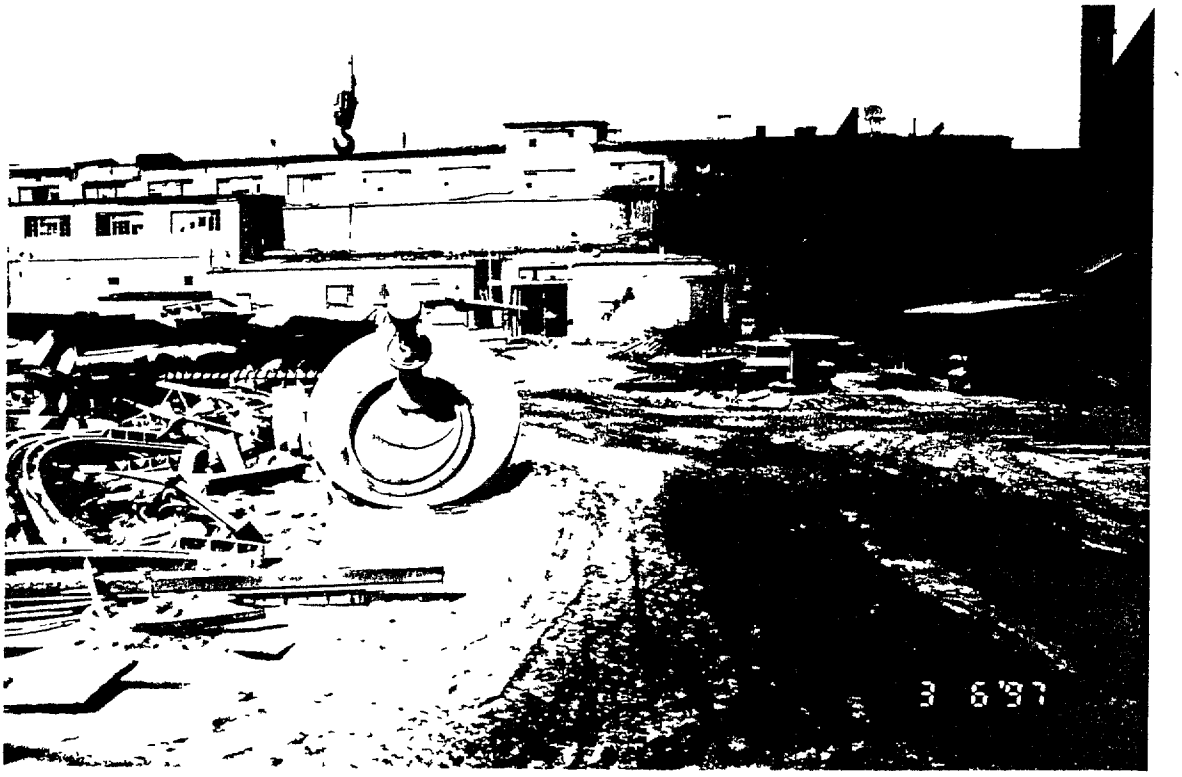

Figure 3. Agglomeration shop

Figure 4. Blast furnace shop

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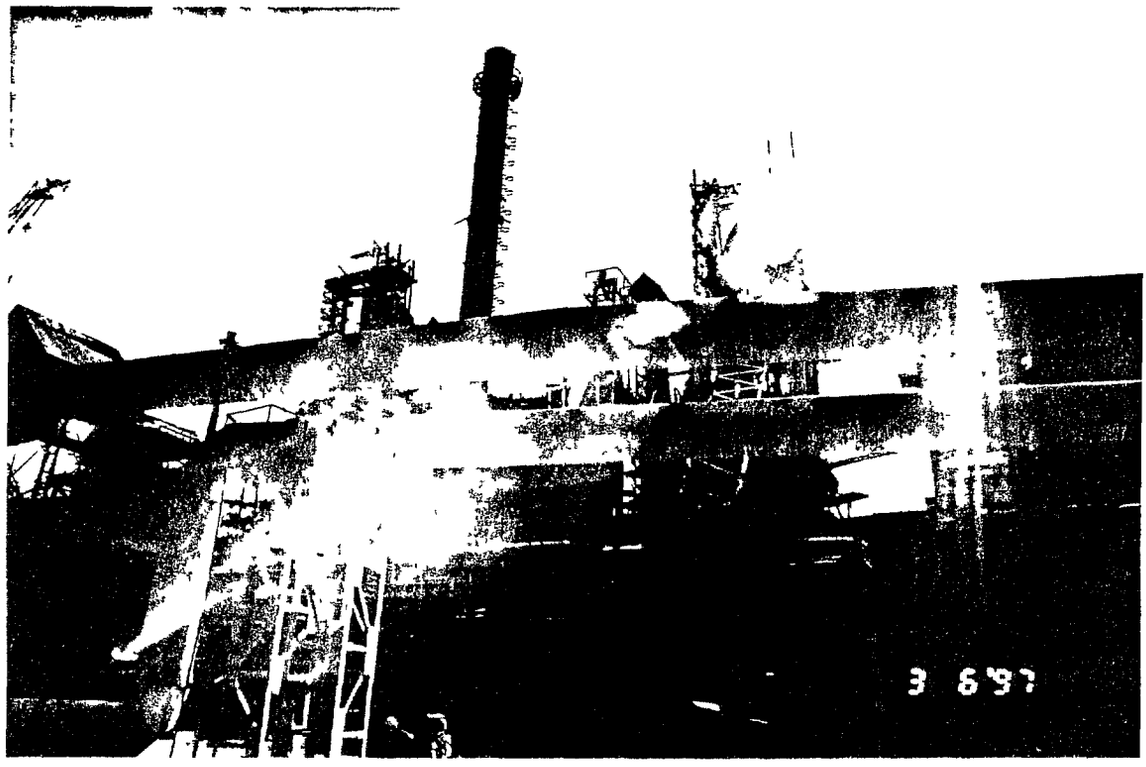

Figure 5. Blast furnace shop

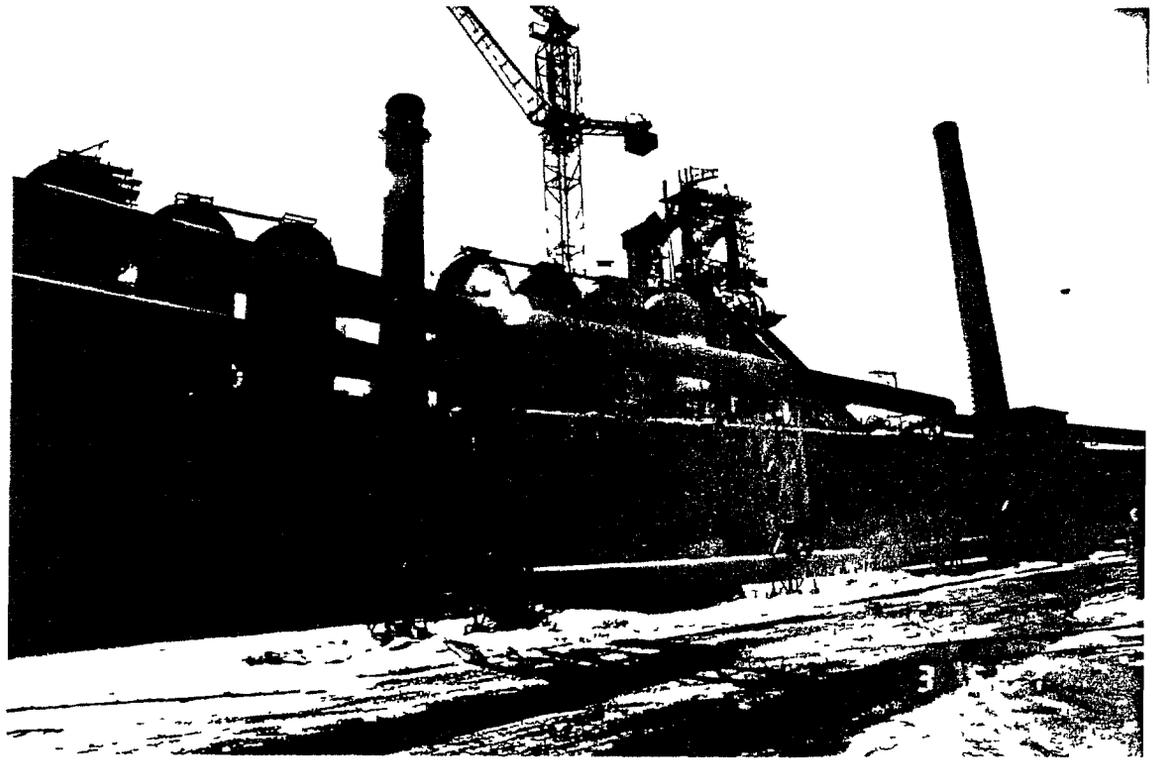

Figure 6. Blast furnace shop

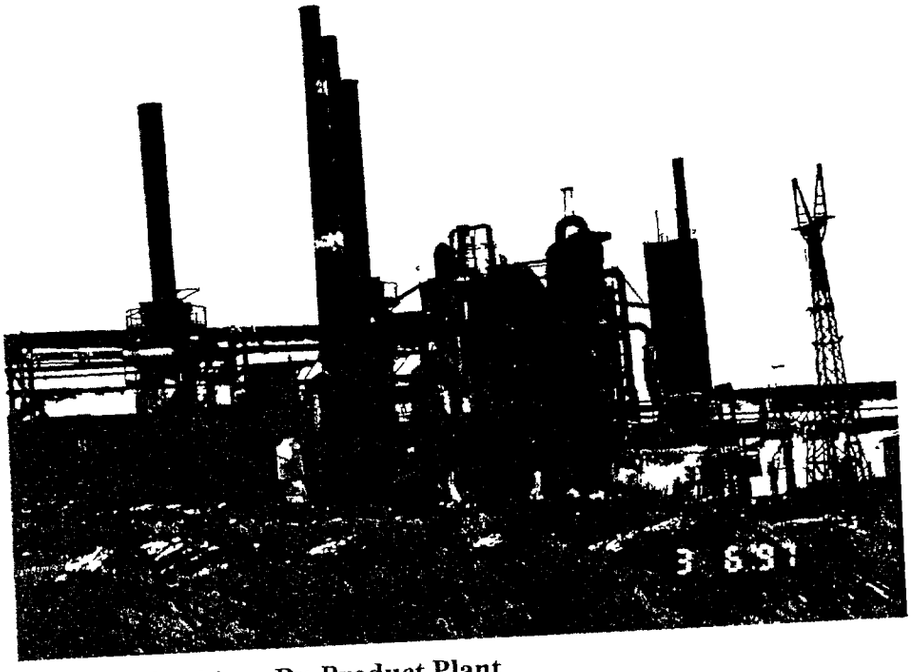

Figure 7. Enakievo By-Product Plant

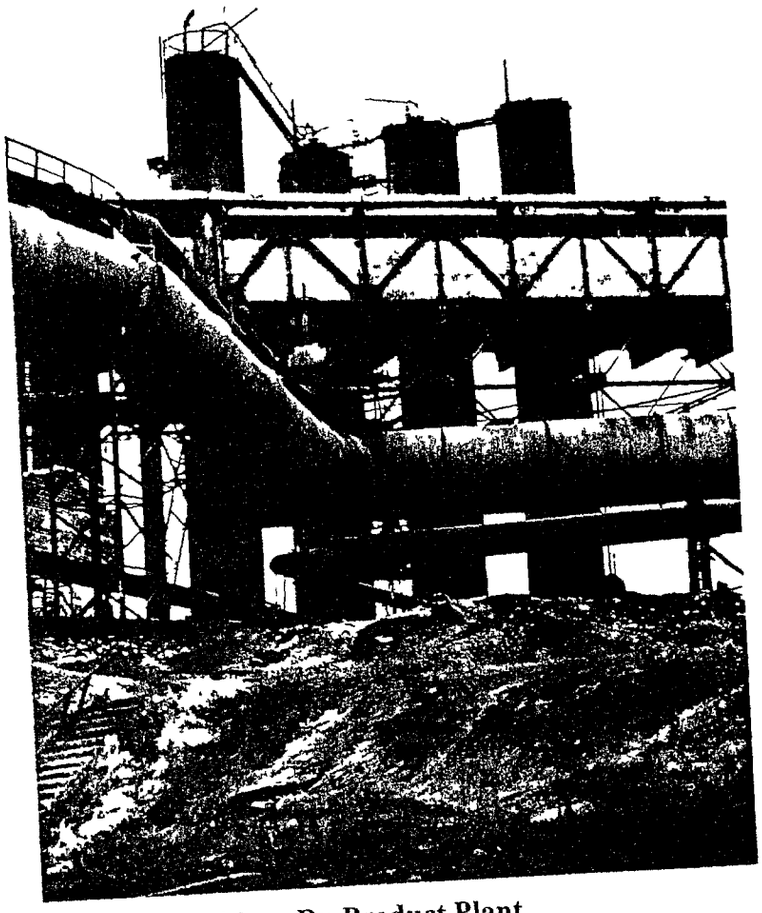

Figure 8. Enakievo By-Product Plant

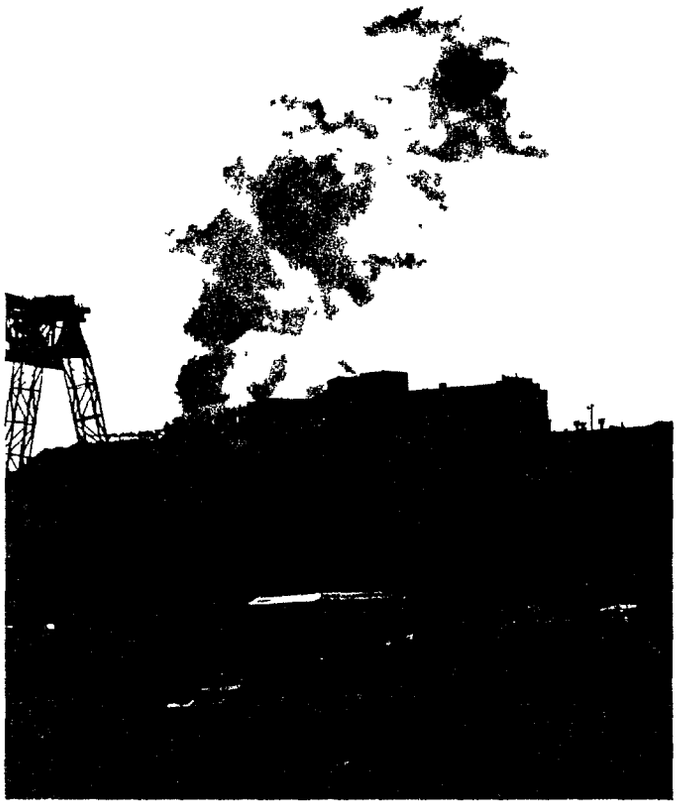

Figure 9. Emission into atmosphere from Enakievo By-Product Coce Plant

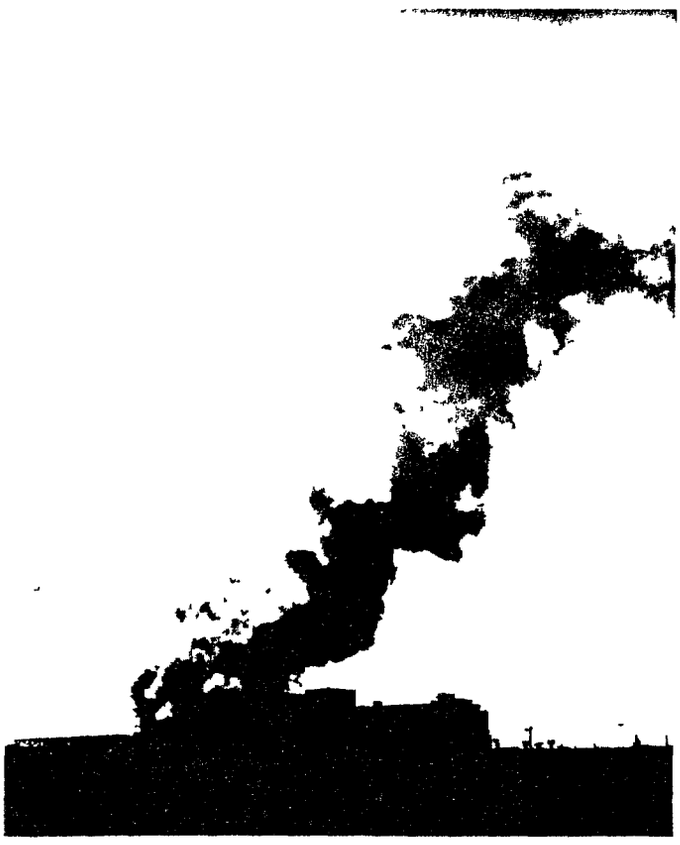

Figure 10. Emissions into the atmosphere from Enakievo By-Product Coce Plant

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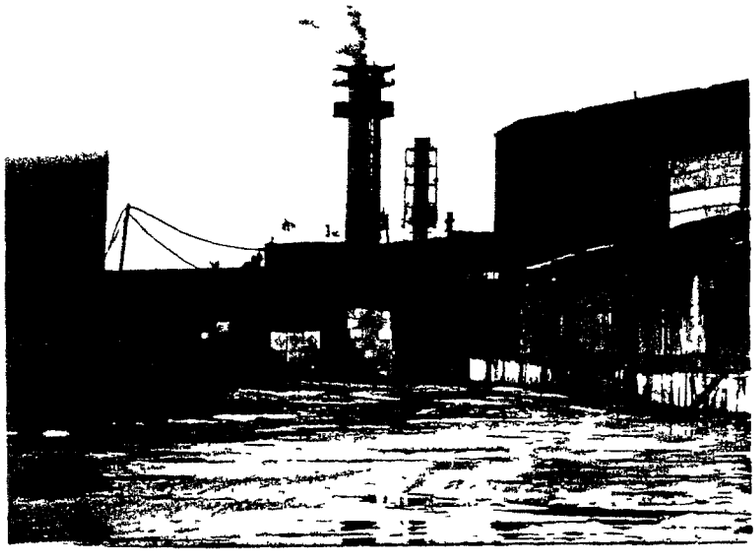

Figure 11. Oxigen-Converter Shop

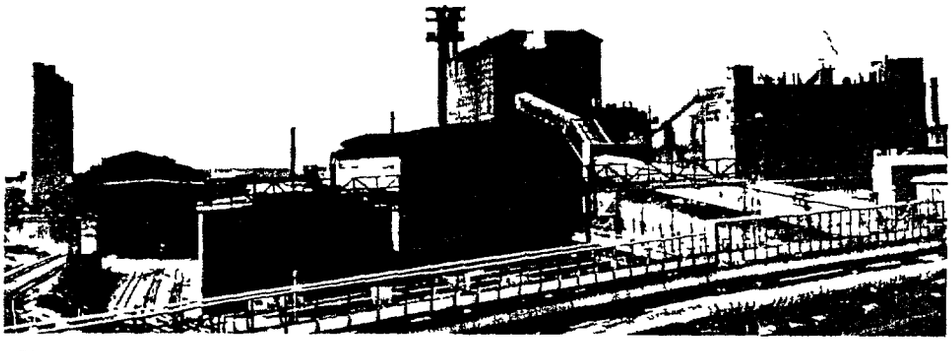

Figure 12. Oxigen-Converter Shop

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Figure 14. Lime Burning Department

Figure 15. Construction of the shop for recycling of iron containing wastes

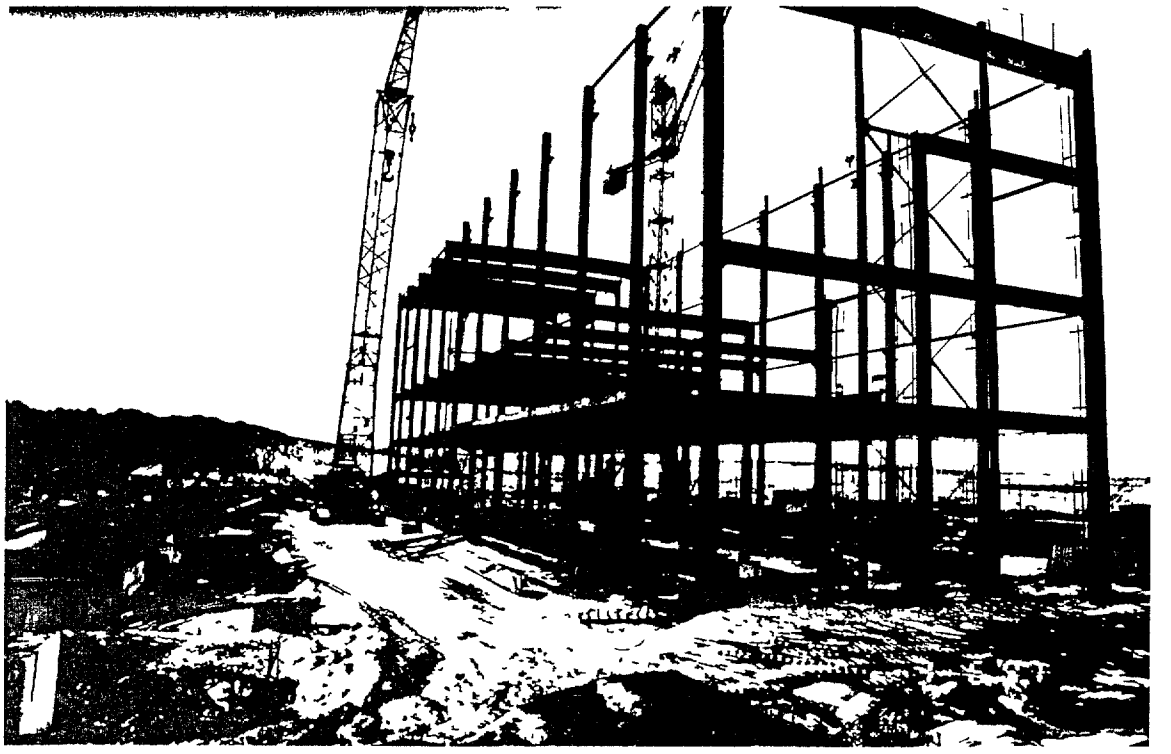

Figure 16. Construction of the shop for recycling of iron containing wastes

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Figure 17. Smoke stacks of the agglomeration shop

Figure 18. Process of agglomerate burning

Figure 19. Process of agglomerate burning

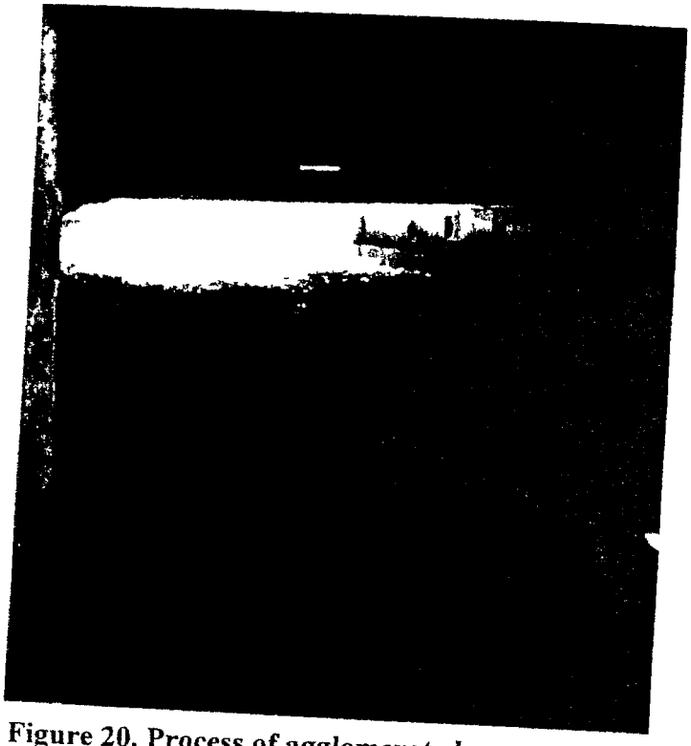

Figure 20. Process of agglomerate burning

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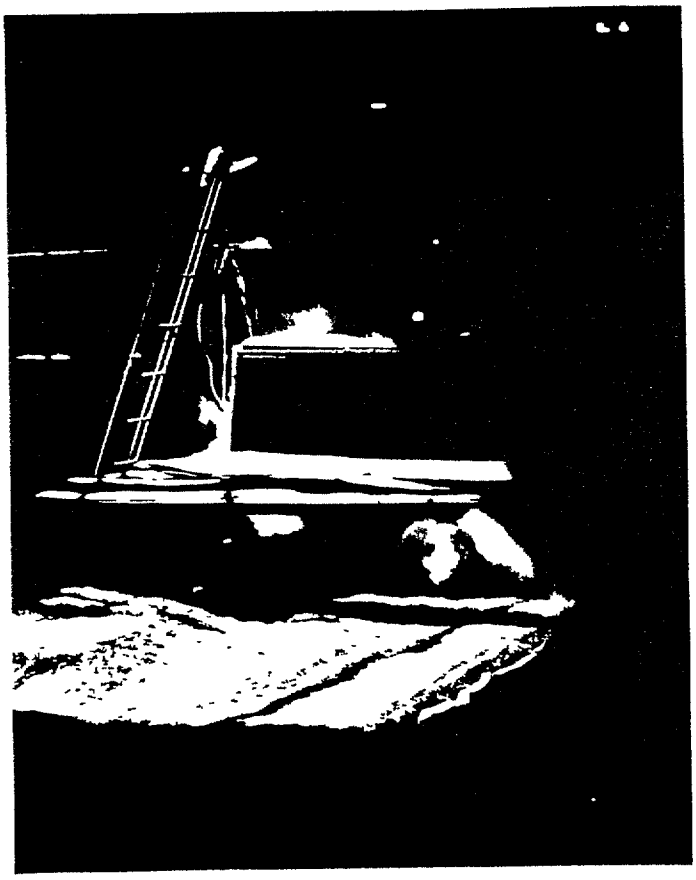

Figure 21. Process of agglomerate burning

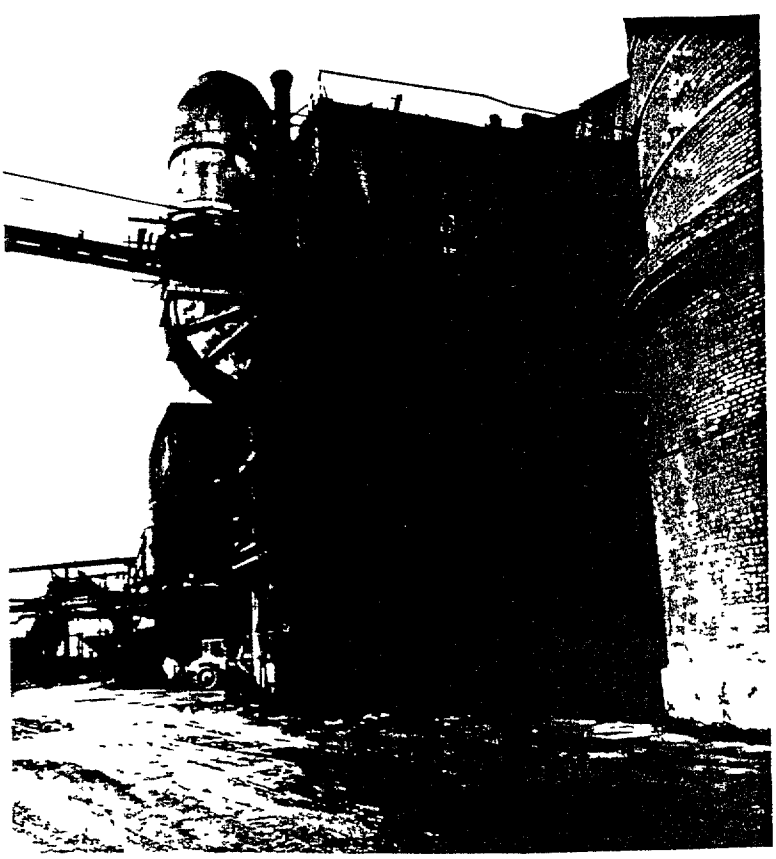

Figure 22. Construction of gas cleaning units for the agglomeration shop

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Figure 23. Casting Yard

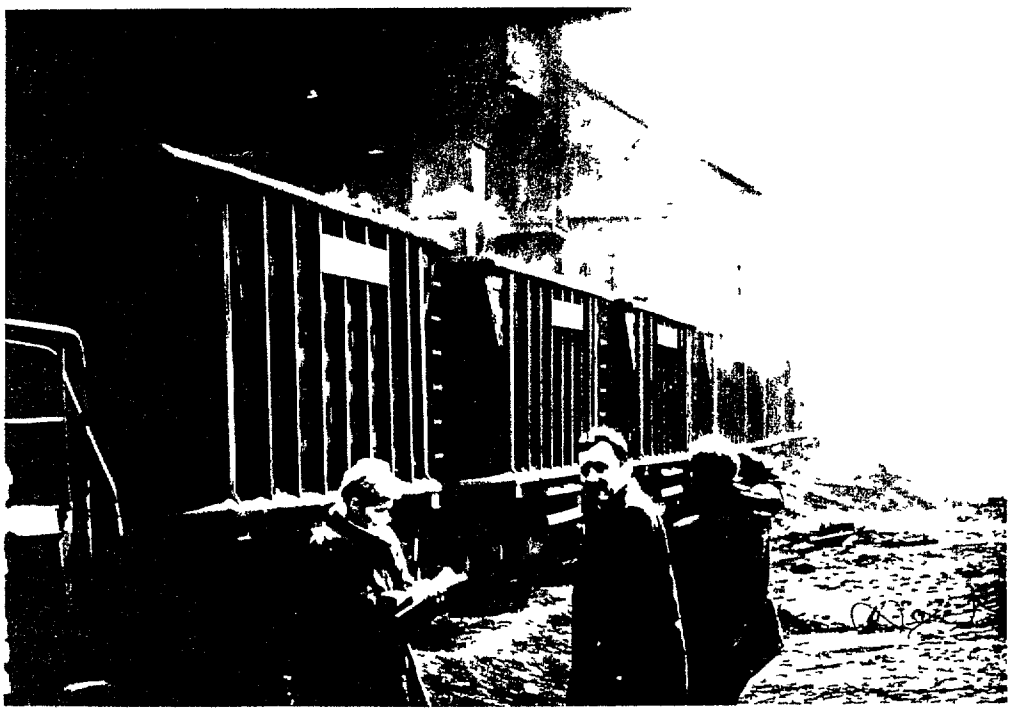

Figure 24. Place for charge unloading

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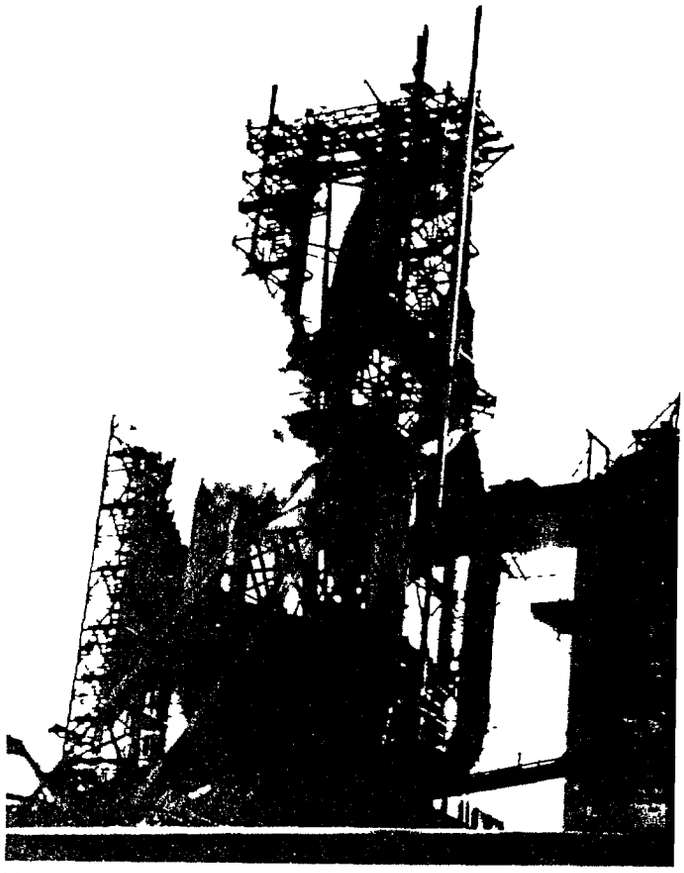

Figure 25. Emissions into the atmosphere in the place of loading the blast furnaces

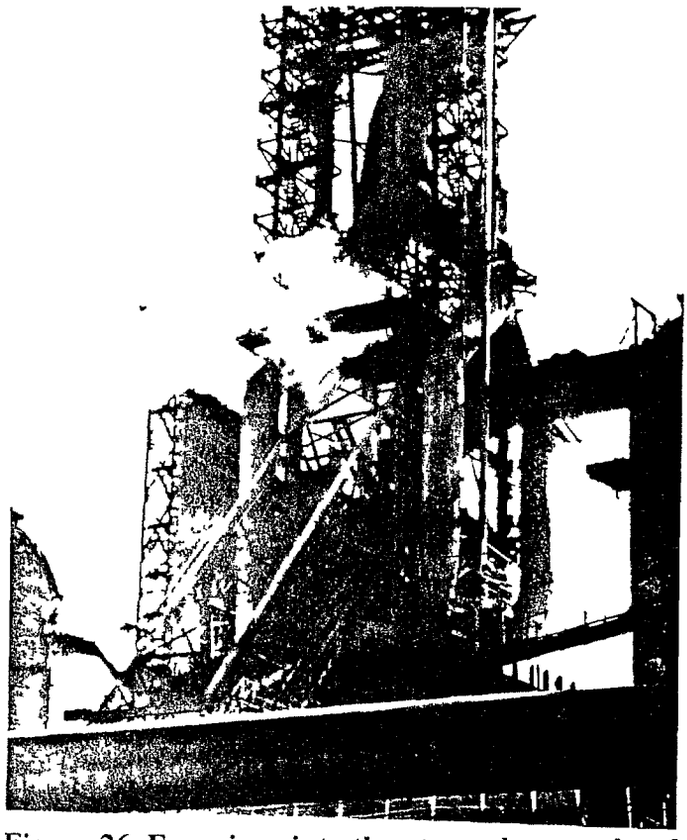

Figure 26. Emissions into the atmosphere in the place of loading the blast furnaces

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Figure 27. Emissions into the atmosphere in the place of loading the blast furnaces

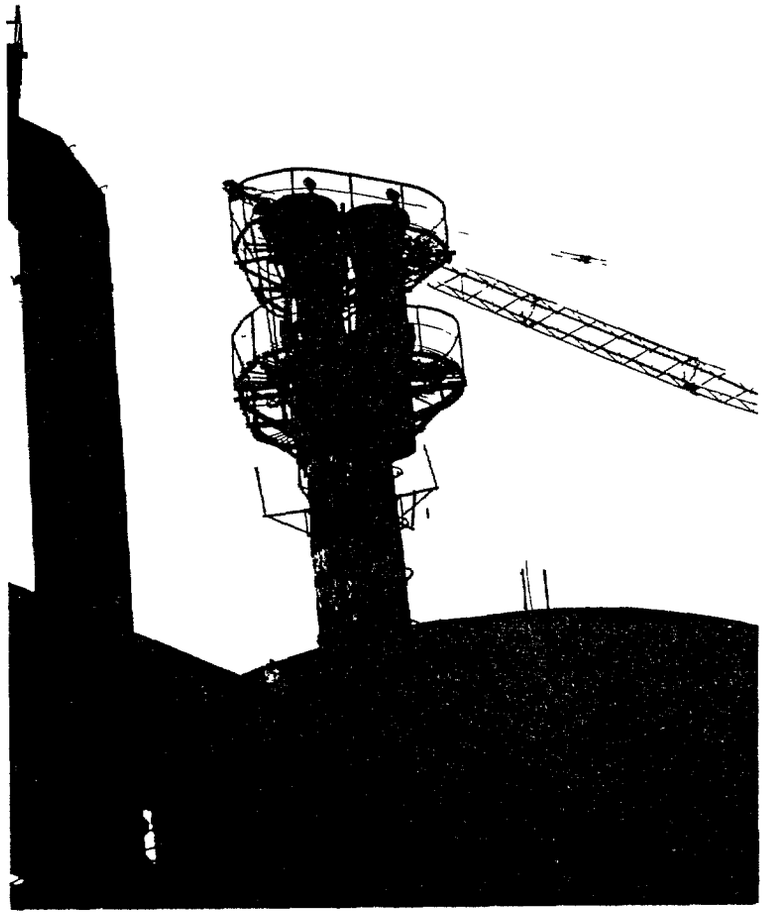

Figure 28. Blast Furnace Shop

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Figure 29. Blast Furnace Shop

Figure 30. Sludge waters of gas cleanig units from the blast furnaces

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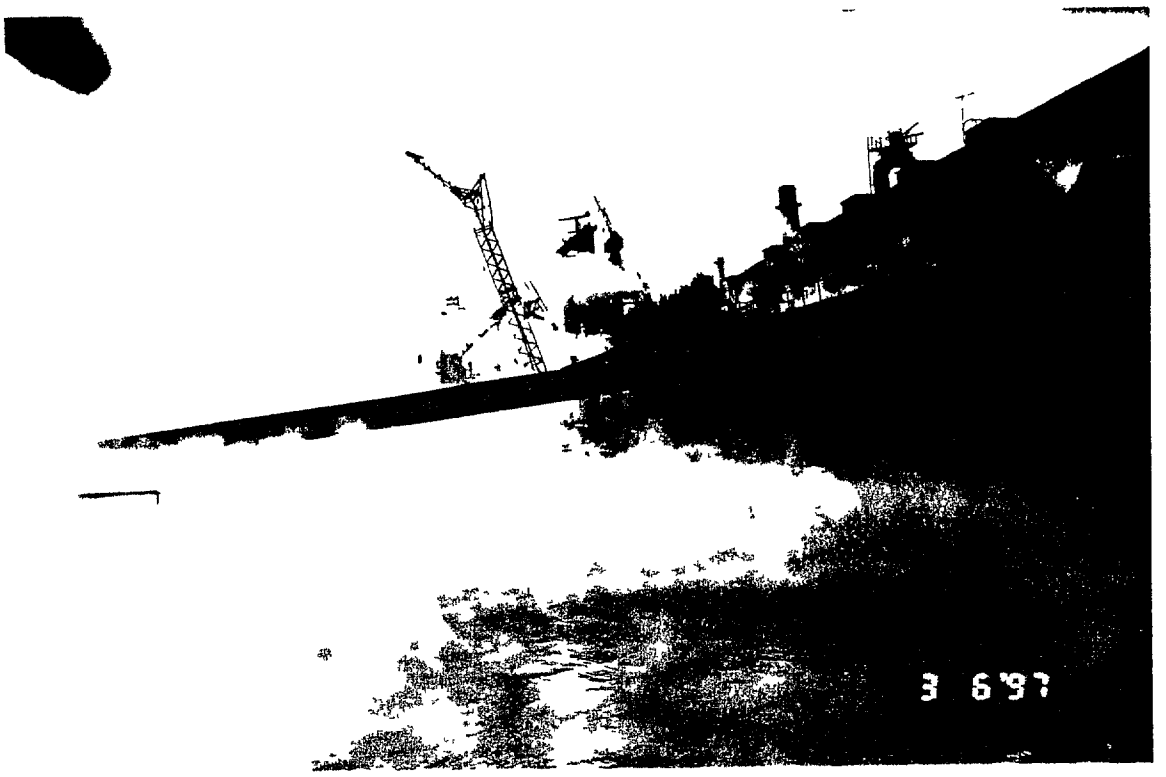

Figure 31. Radial settlers of gas cleaning units of the blast furnace shop

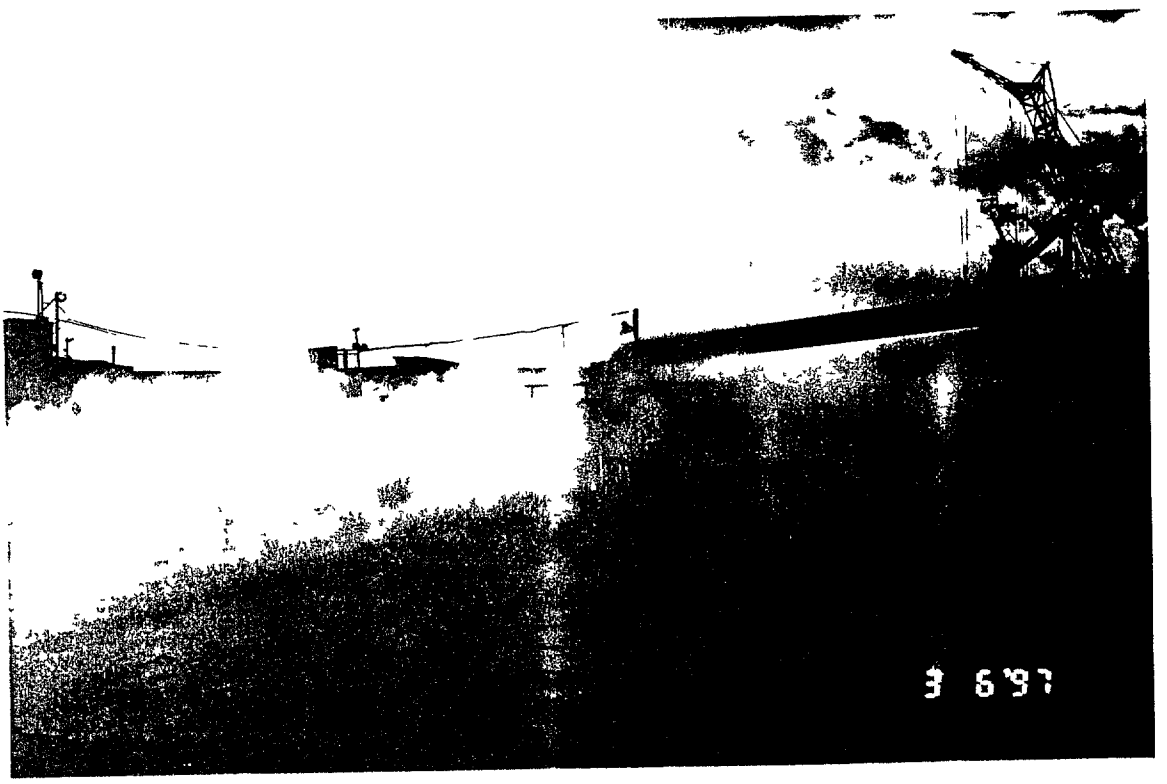

Figure 32. Radial settlers of gas cleaning units of the blast furnace shop

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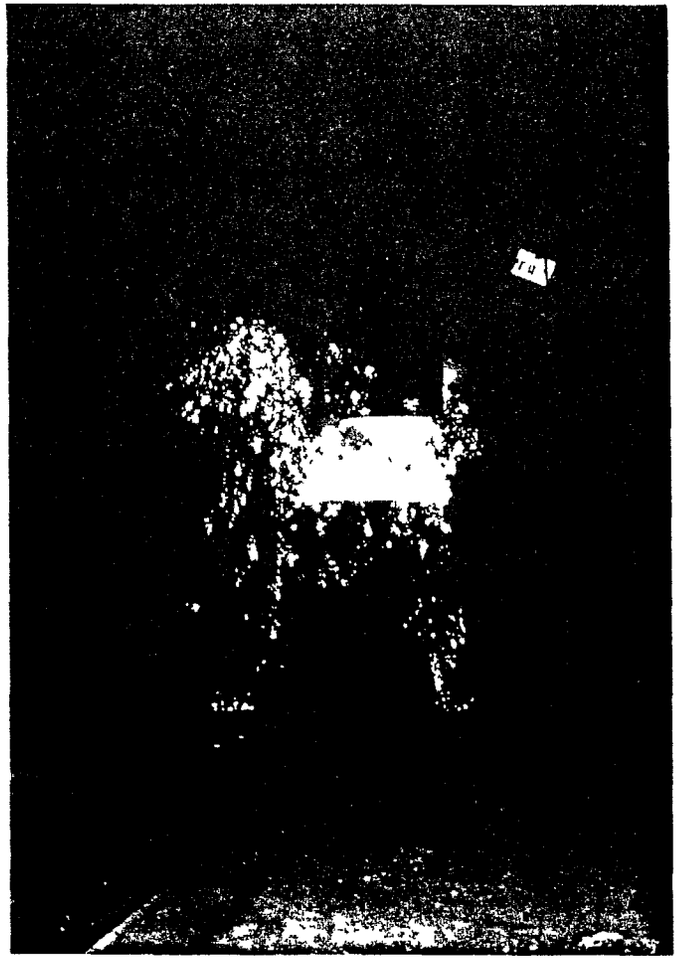

Figure 33. Discharge of pollutants from the mixer

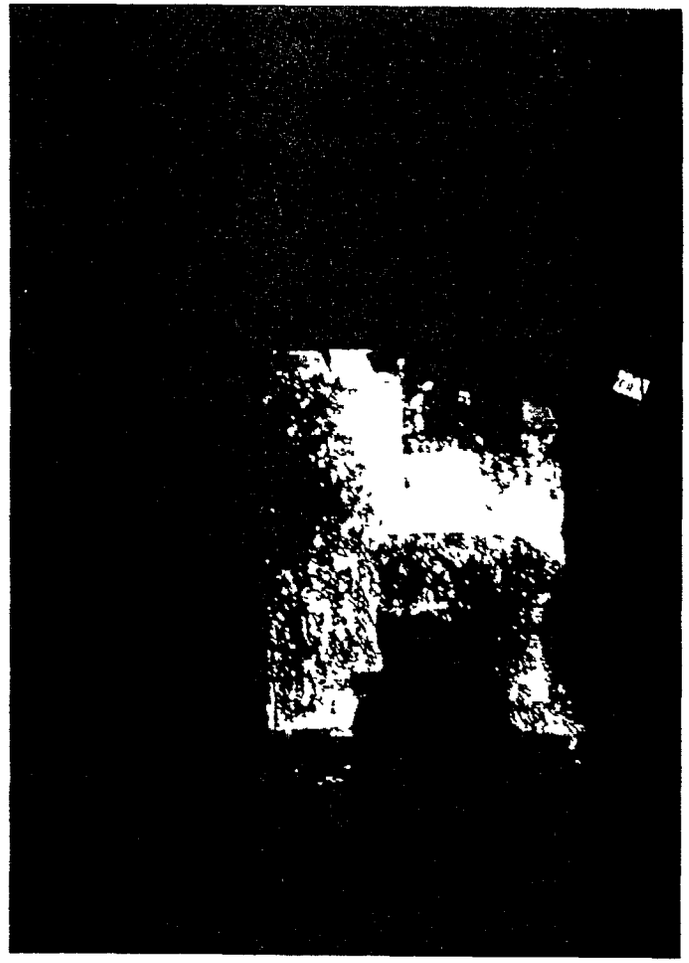

Figure 34. Discharge of pollutants from the mixer

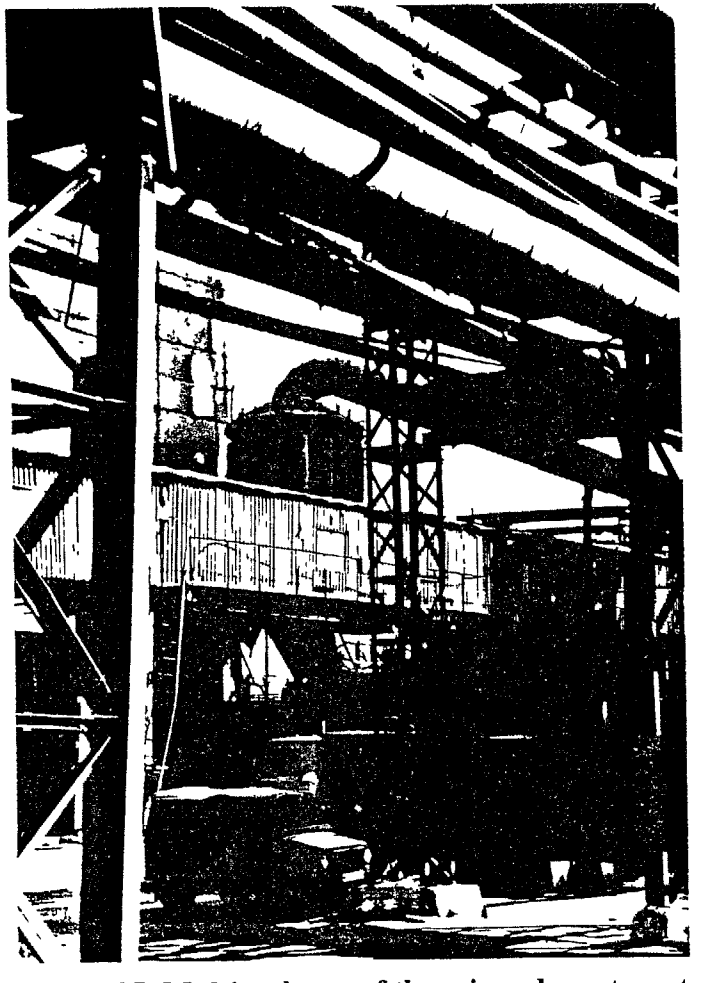

Figure 35. Multicyclones of the mixer department

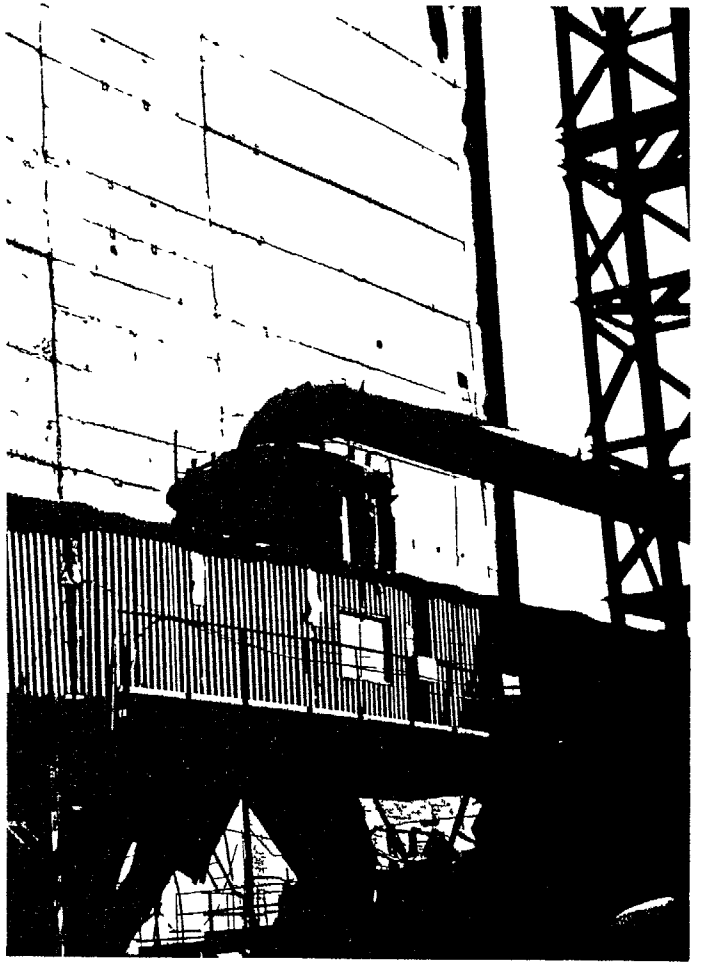

Figure 36. Multicyclones of the mixer department

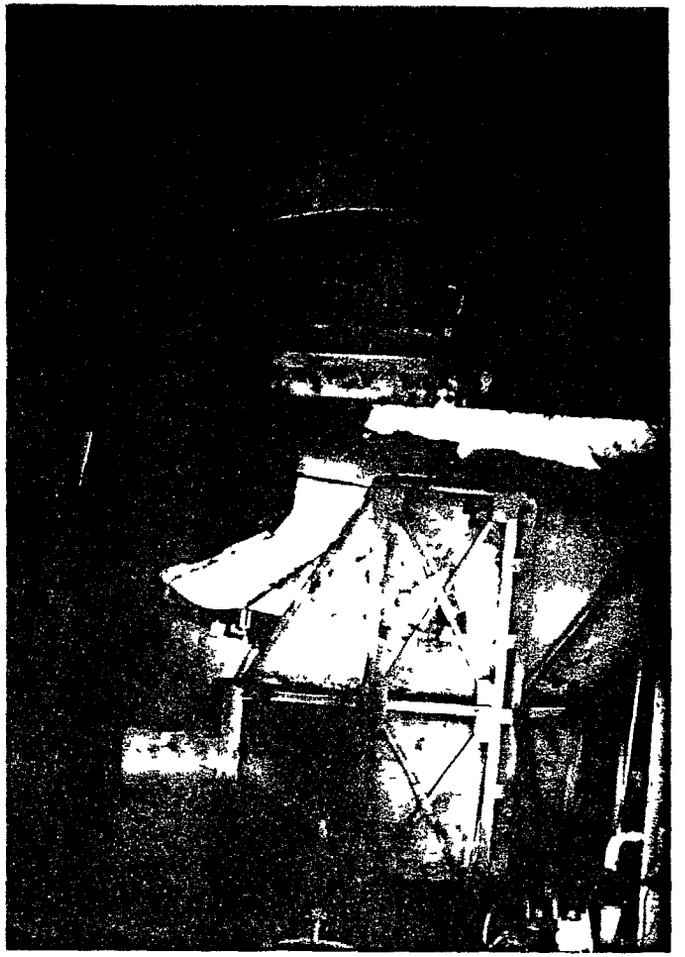

Figure 37. Converter in operation

Figure 38. Converter in operation

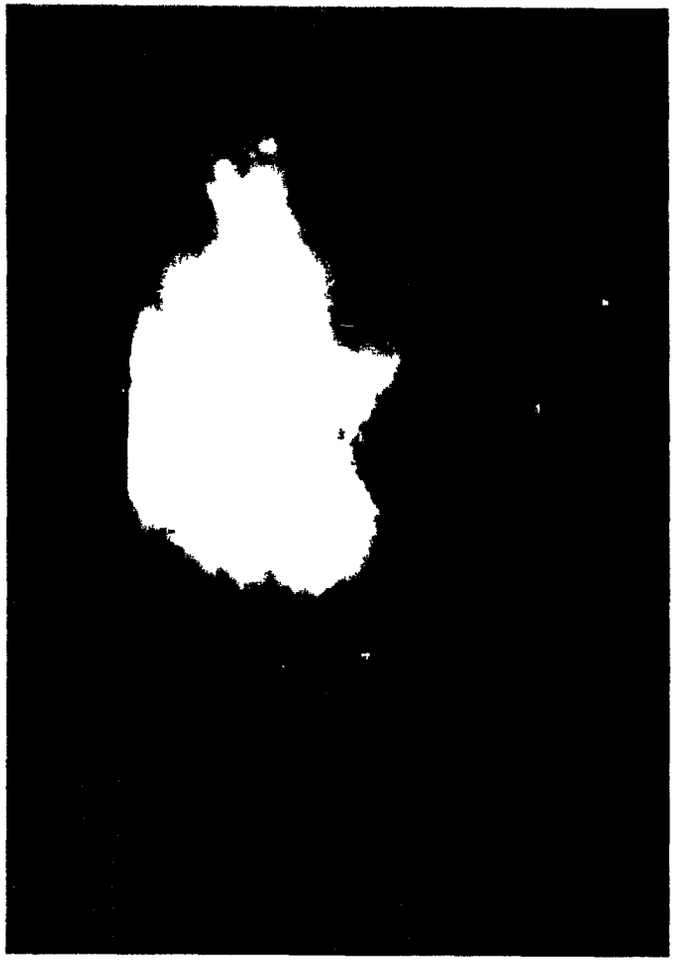

Figure 39. Converter in operation

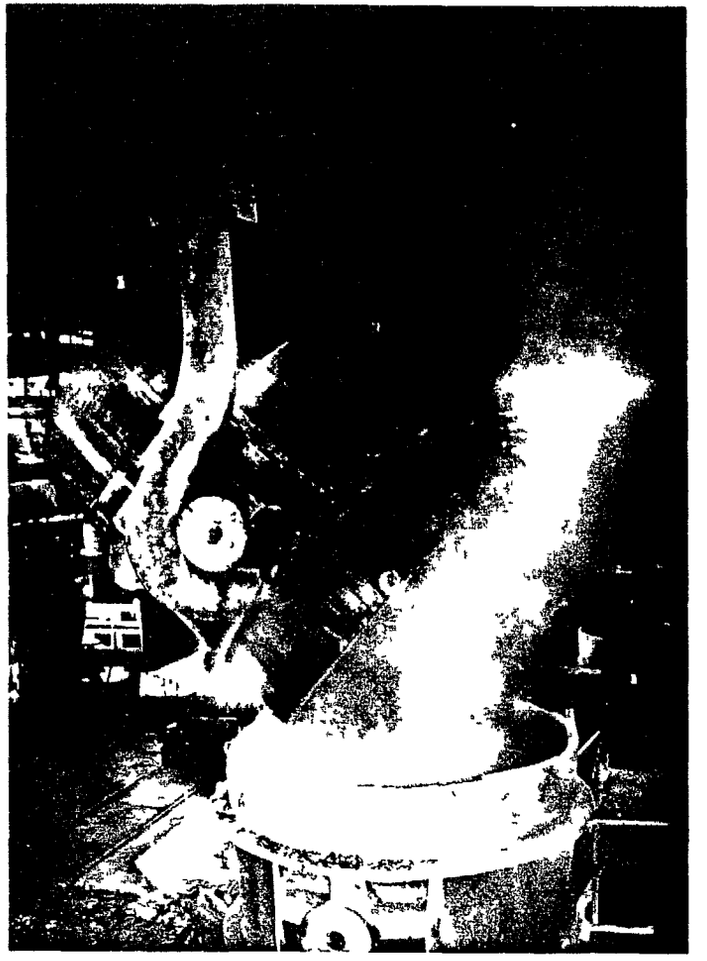

Figure 40. Preparation for pouring into converter

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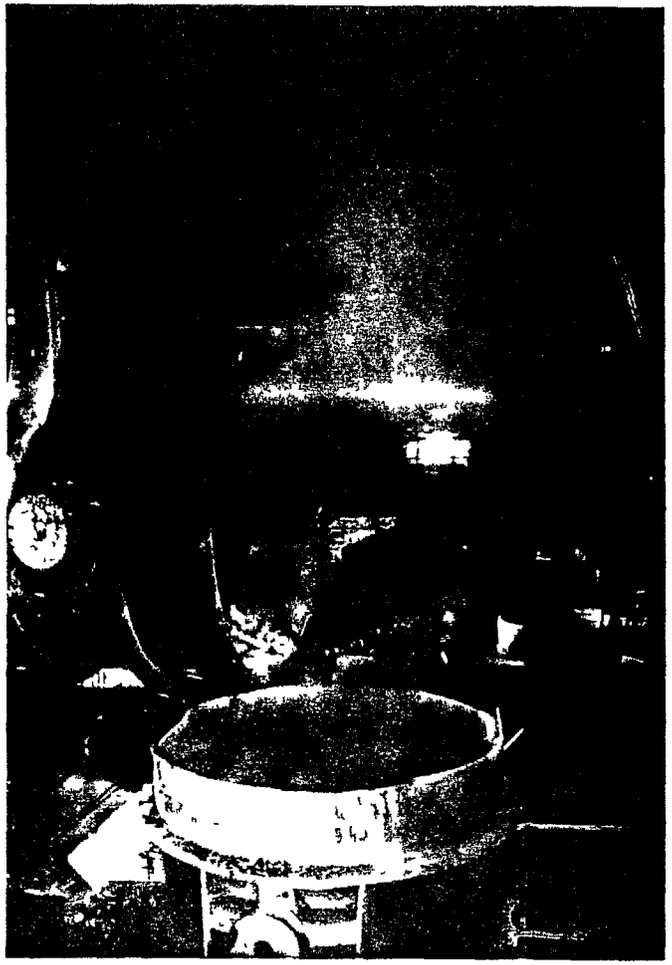

Figure 41. Preparation for pouring into converter

Figure 42. Loading of scrap metal into the converter

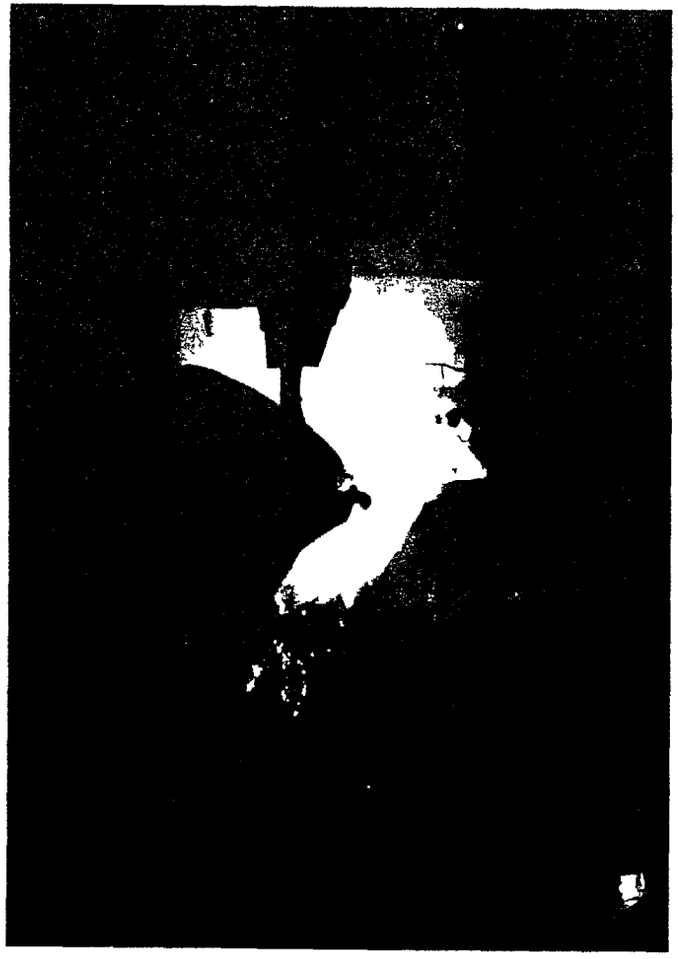

Figure 43. Pouring of cast iron into the converter

Figure 44. Pouring of cast iron into the converter

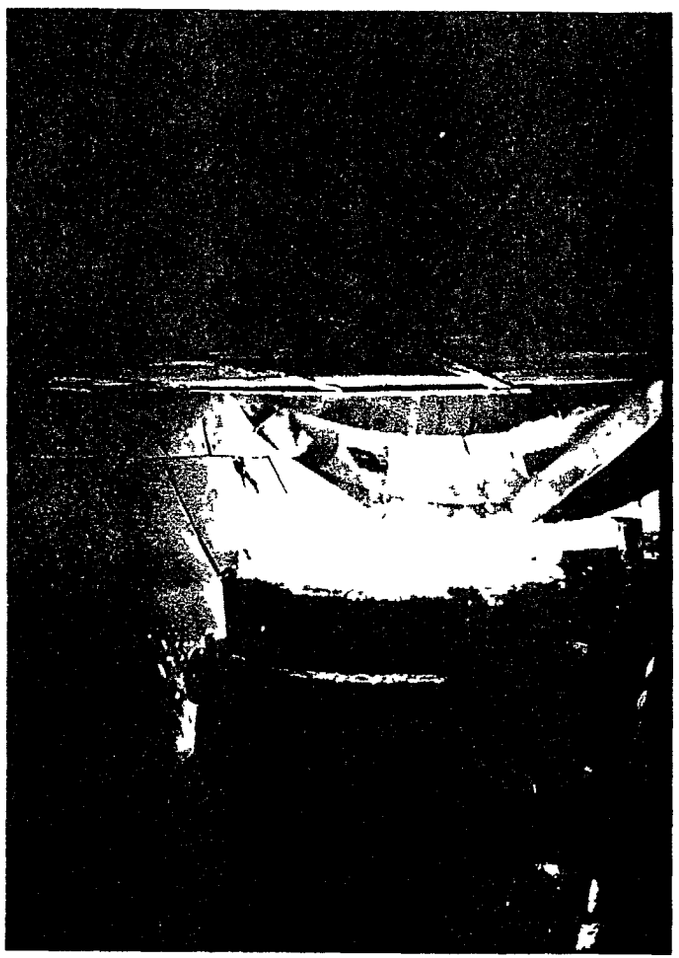

Figure 45. Pouring of steel out of the converter

Figure 46. Blowing in of metal with nitrogen

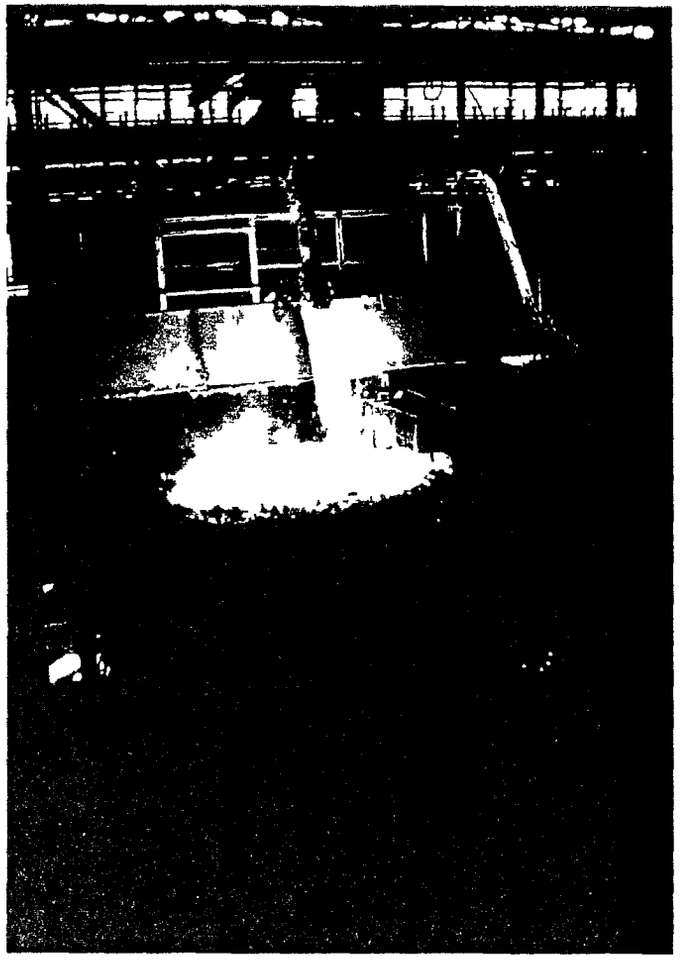

Figure 47. Blowing in of metal with nitrogen

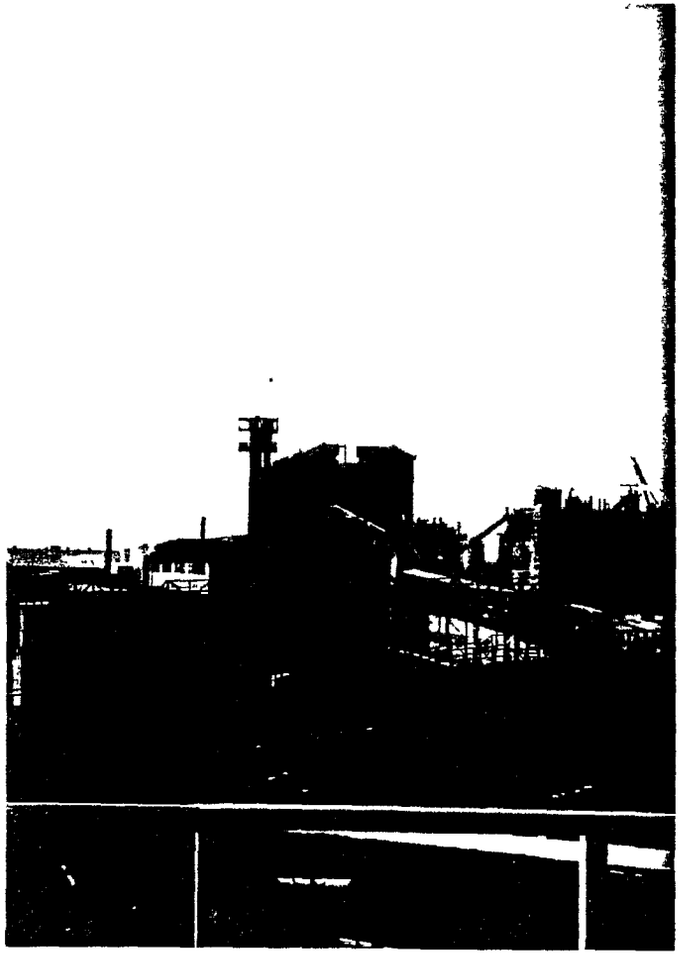

Figure 48. Emissions into atmosphere through an aeration lantern

Figure 49. Smoke stack of the converter shop

Figure 50. Radial settler of gas cleaning units of the converter shop

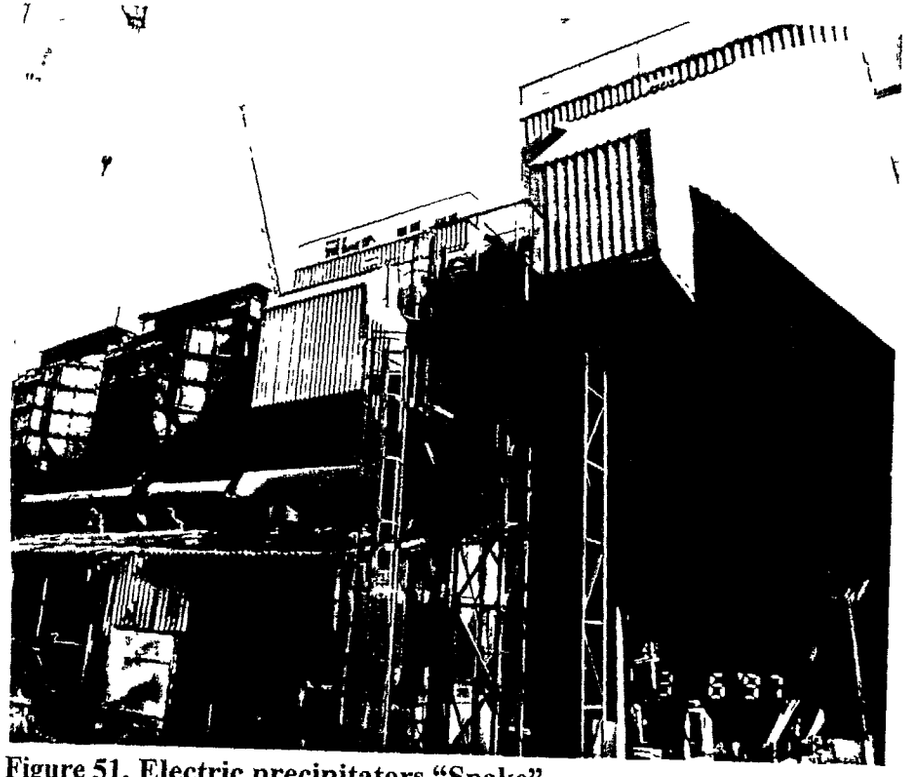

Figure 51. Electric precipitators "Spake"

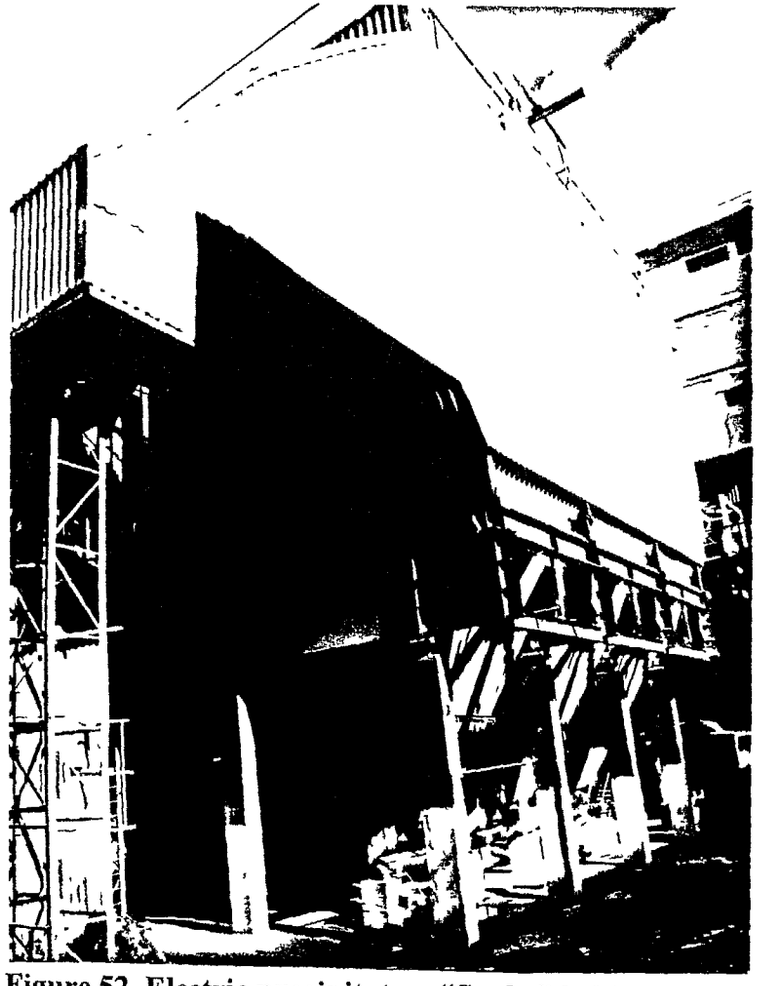

Figure 52. Electric precipitators "Spake" behind furnaces #3 and 4

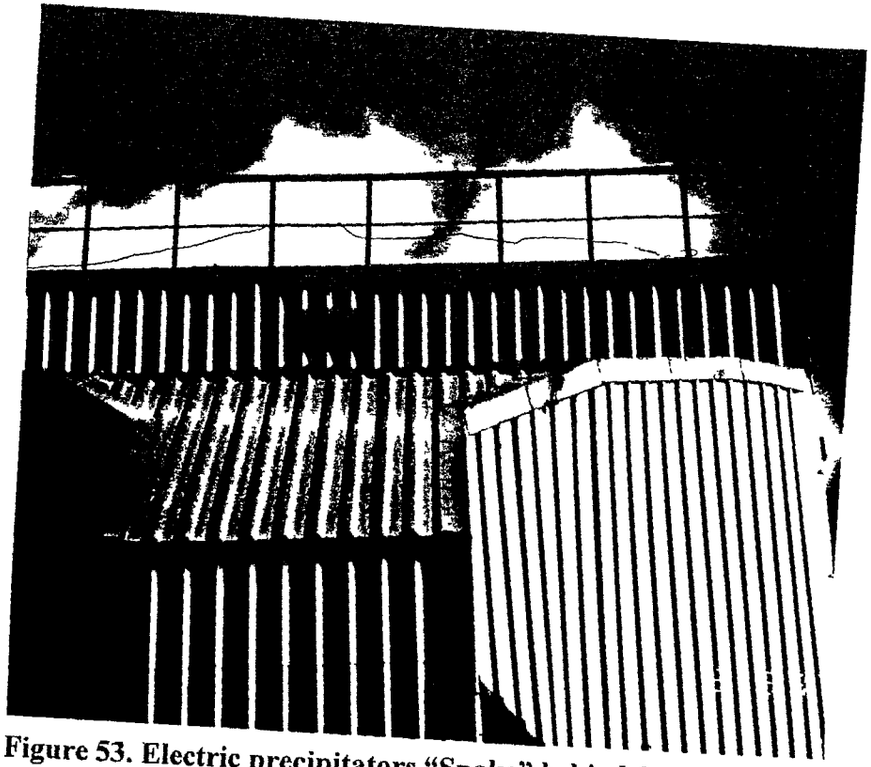

Figure 53. Electric precipitators "Spake" behind furnaces #3 and 4

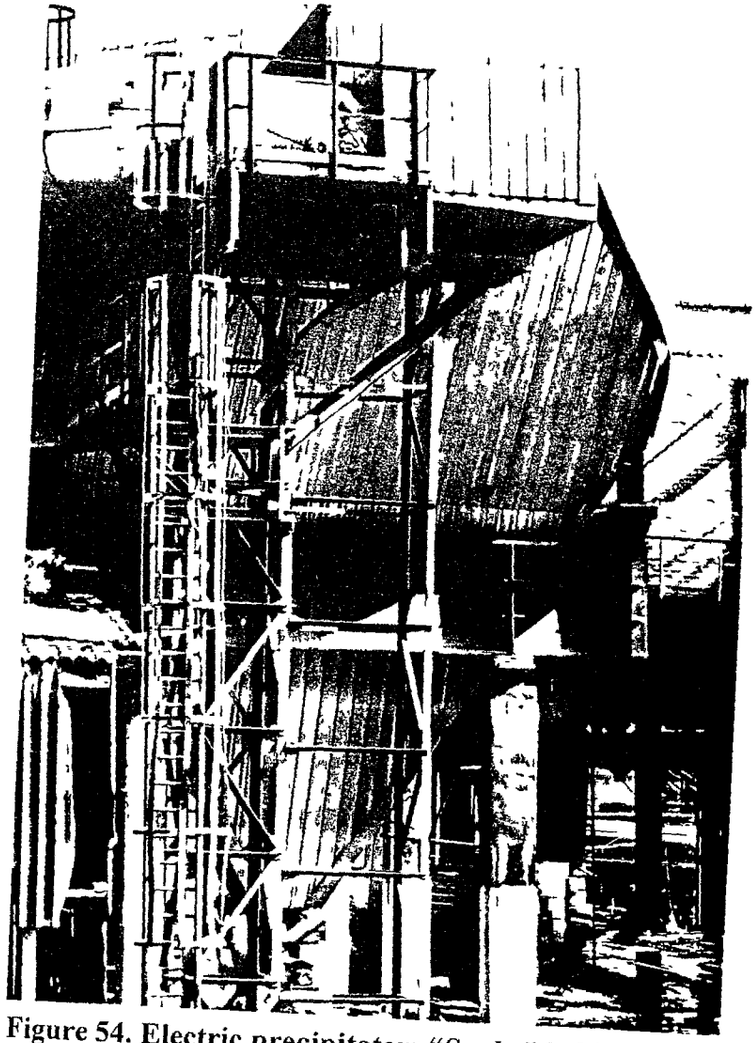

Figure 54. Electric precipitators "Spake" behind furnaces #3 and 4

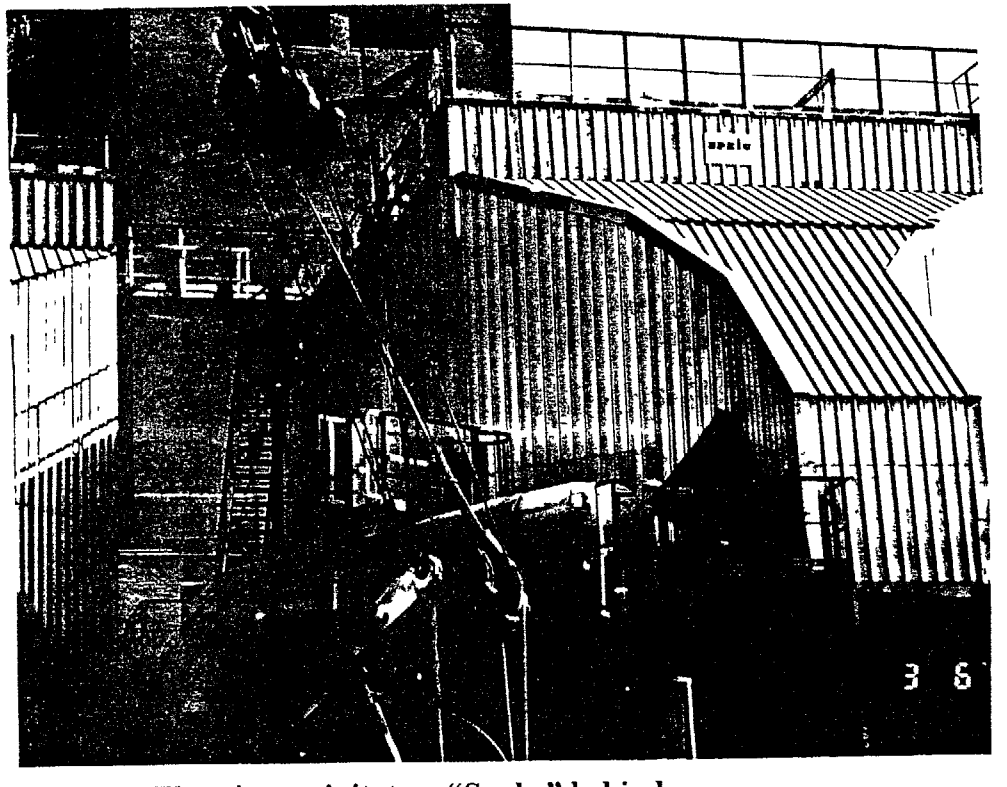

Figure 55. Electric precipitators "Spake" behind furnaces #3 and 4

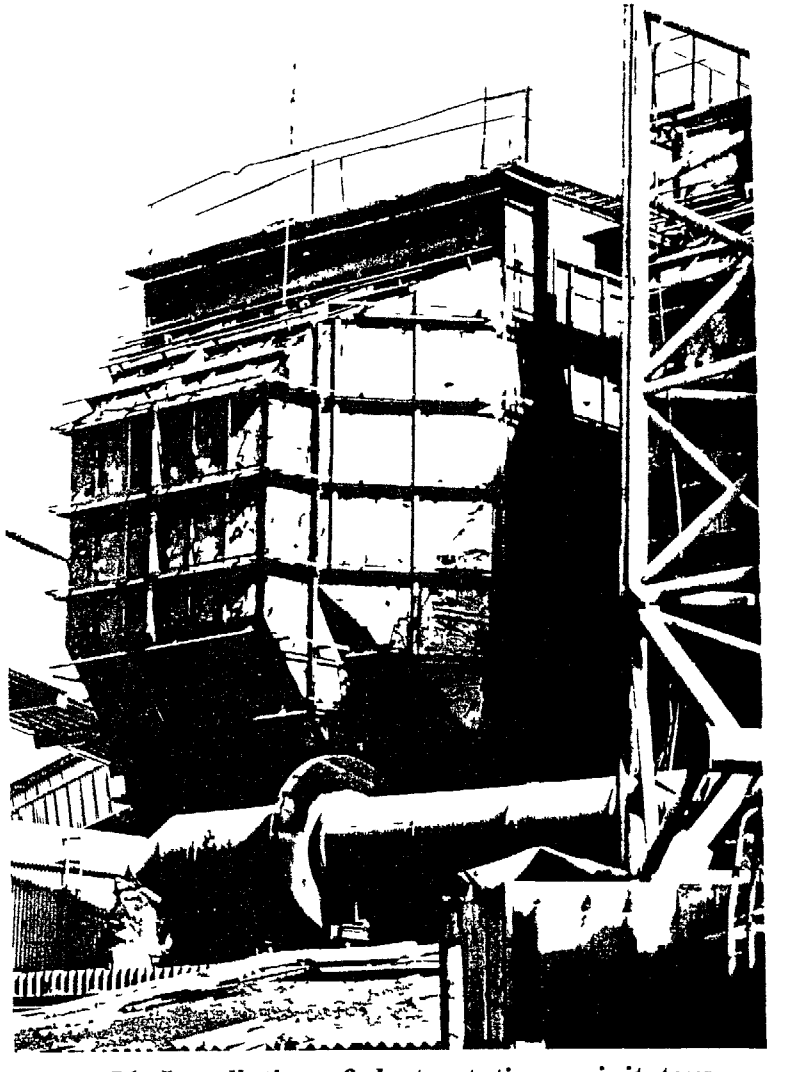

Figure 56. Installation of electrostatic precipitators "Spake" behind furnaces #1 and 2

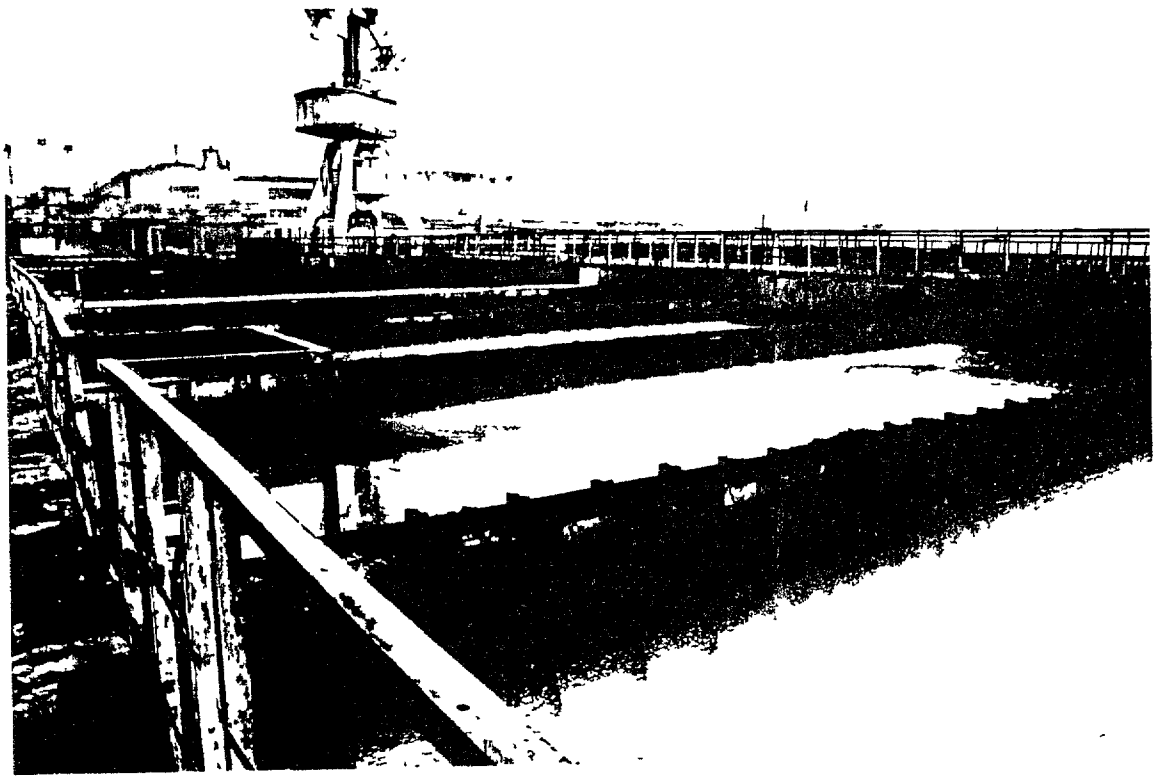

Figure 57. Unit for the dessication of oil products in the horizontal ponds

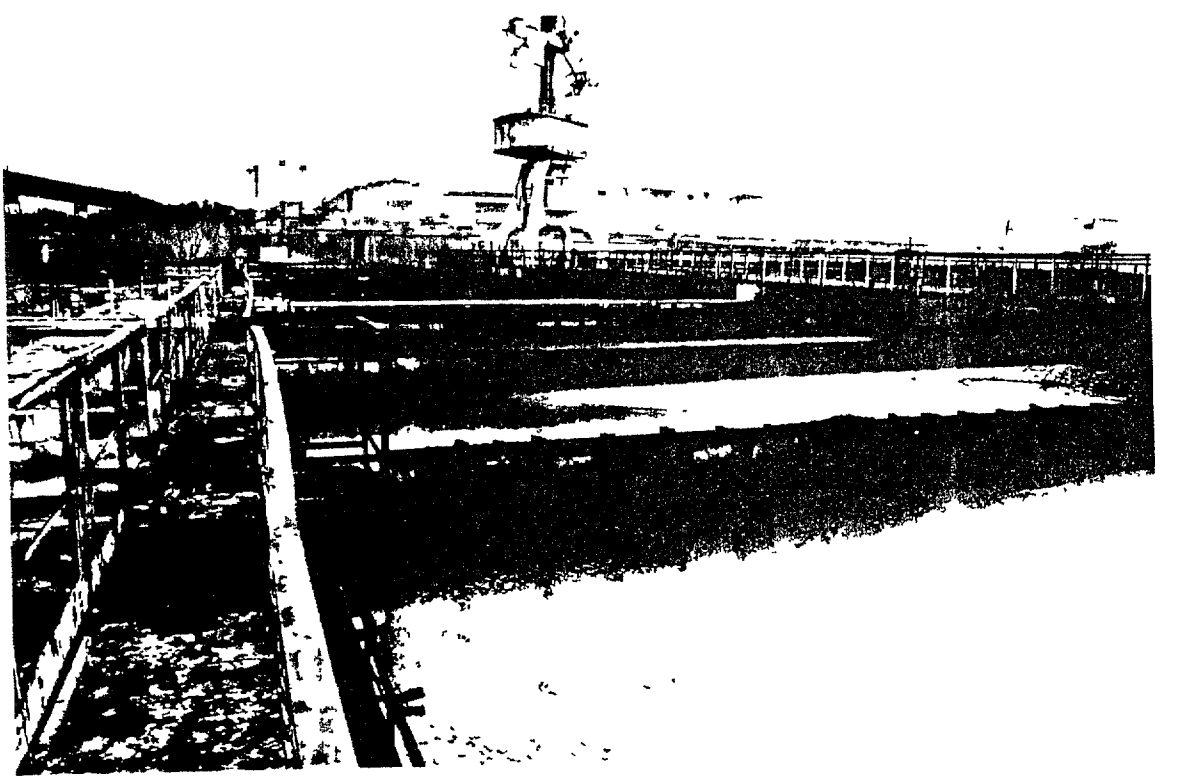

Figure 58. Unit for the dessication of oil products in the horizontal ponds

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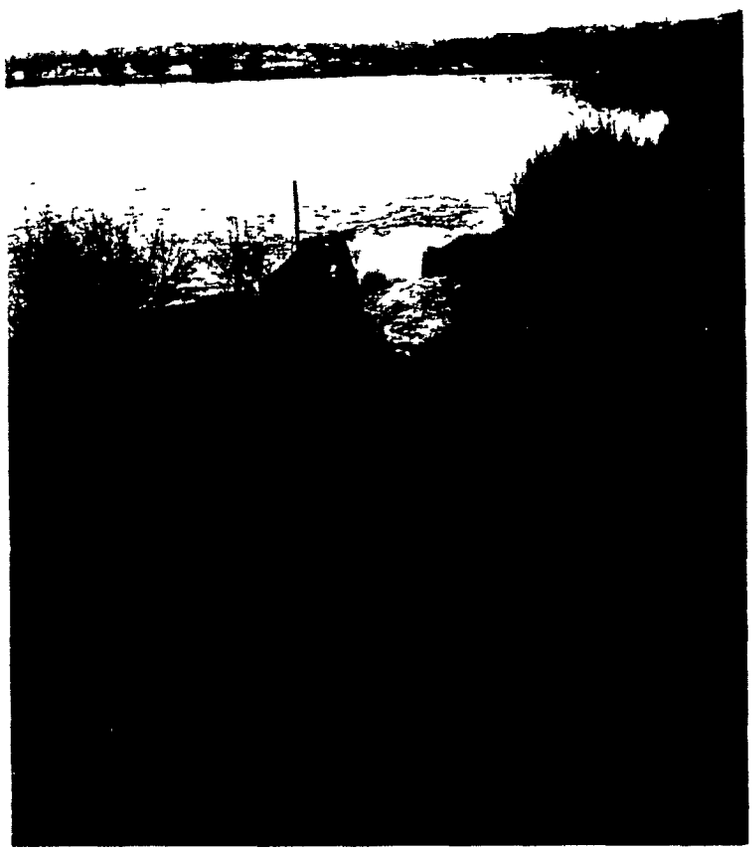

Figure 59. Discharge to the plant cooling pond

Figure 60. Plant cooling pond

Figure 61. Plant cooling pond

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