

## WATER MANAGEMENT AND WATER PURIFICATION IN IRON AND STEEL WORKS

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**Abstract**—Iron and steel works, from the viewpoint of water management, can still roughly be classified into “wet” and “dry” works. In the first category, usable water is available in unlimited quantities, which means that, dependent upon the quality of the water, the consumption may approach the usage, the latter amounting to 150–200 m<sup>3</sup>/t of ingot steel, excluding power generation, for a modern integrated works. “Wet” works can only be found alongside rivers and freshwater lakes, being the only situations affording a “once-through” waterhousehold. “Dry” works have to re-use their water to a very high degree, resulting in a water consumption of only 2.5–3 m<sup>3</sup>/t of ingot steel, being roughly 2% of the usage needed. In extreme cases, these figures may be even lower. Many intermediate situations occur. Coastal works, for instance, still often apply seawater or brackish water for once-through cooling or gaswashing in cases where the resulting corrosion problems can be mastered at acceptable costs.

There is, however, a clearly recognizable trend towards re-use of cooling water and process water in the steel industry. The main reason for this development arises from the need for environmental care. As in all process industries, decrease of water usage and water consumption improves the technical and economical possibilities for cleanup of the water and favours reduction of the thermal load.

Under the pressure of national and international regulations against water pollution, an economical balance has to be struck. It seems logical that the outcome tends to decreasing differences in methods of water management between “wet” and “dry” works. Neither river basins and lakes, nor even sea basins and coastal waters offer the possibility of accepting the contamination caused by human activities unlimited. Although the iron and steel industry does not belong to the biggest water-polluters among the process industries, there are some typical contaminants needing attention; cyanides, oil and some non ferrous metals being the most important. Zero pollution of surface water is technically not feasible in the iron and steel industry. It can, however, be approached to an extent that does not seriously impede with ecological conditions in the receiving water. Waste technology has to be further developed to treat the various sludges resulting from wastewater purification in order to create economic feasibility as well.

### INTRODUCTION

Iron and steelmaking requires high temperatures. Iron is cast at temperatures over 1200°C; steel at about 1600°C. During many of the additional processes like coke making, sintering, pelletizing and hot rolling, temperatures of 1000°C are common, 1200°C and higher not exceptional.

These temperatures imply the widespread use of refractories and other heat resisting materials in combination with intricate and extensive cooling techniques. The resulting construction problems tend to direct the technological development of iron and steelmaking to scaling up, mechanization and automation of existing unit processes rather than to new, continuous processes. A flow diagram of a modern integrated steelworks is shown in Fig. 1. This splitting up into separate units results in the necessity of destroying huge amounts of heat during and between the several processes. Where possible and economical this is done by air cooling; however, in most cases water has to be used. The cheapest and easiest way to do this is direct cooling. Pig-iron ingots, coke, blooms, hot steel strip during and after rolling and in some cases blast furnace slag are cooled this way, generating big clouds of condensing water vapour. Also the hot gases generated by blast furnaces, coke ovens and steel converters are cooled by direct water injection.

This means that in iron and steelmaking distinguishing between cooling water and process water is often impossible. Direct cooling is, in many cases, carried out simultaneously with some processing stage. Some examples may be mentioned. Slag granulation is carried out by pouring the molten slag into a pressurized water jet,

resulting in a cooled granulate, ready for transportation. Cooling of hot steel strip during the rolling process also has a descaling function and between rolling and coiling, the mechanical properties of the steel are influenced. Direct cooling of hot gases mostly implies a first washing stage and, in the case of the coke-ovens, the first separation of tar takes place in the main, i.e. the pipe connecting the gas outlet of the ovens of a battery.

Even in the case of indirect cooling the combination with a process, namely steam generation, occurs. Well-known examples are the door-frames of open hearth furnaces and the hoods of steel-converters of the free combustion type. Of course boiler feed water of good quality has to be used in these cases. But mostly indirect cooling is carried out the usual way, i.e. with only a slight temperature difference between the cooling-water inlet and outlet, by which the optimum between investment and operating costs can be reached.

Process water with no cooling is also used within the iron and steel industry. Purifying coke-oven gas, lubrication (in form of an oil emulsion) during cold rolling and rinsing after pickling and coating processes offer some interesting examples from the viewpoint of wastewater cleaning.

### WATER USAGE AND CONSUMPTION

The usage of water for all purposes mentioned amounts to 150–200 m<sup>3</sup>/t of ingot steel (or 500 m<sup>3</sup>/t of paper in the paper industry). For a modern integrated works producing 3–10 million tons of steel per year this would mean a water consumption of 0.5–2.10<sup>9</sup> t/a. This means that overall once-through operation would nowadays only be possible if the works are situated alongside big rivers or large freshwater lakes. But long before iron and steelworks

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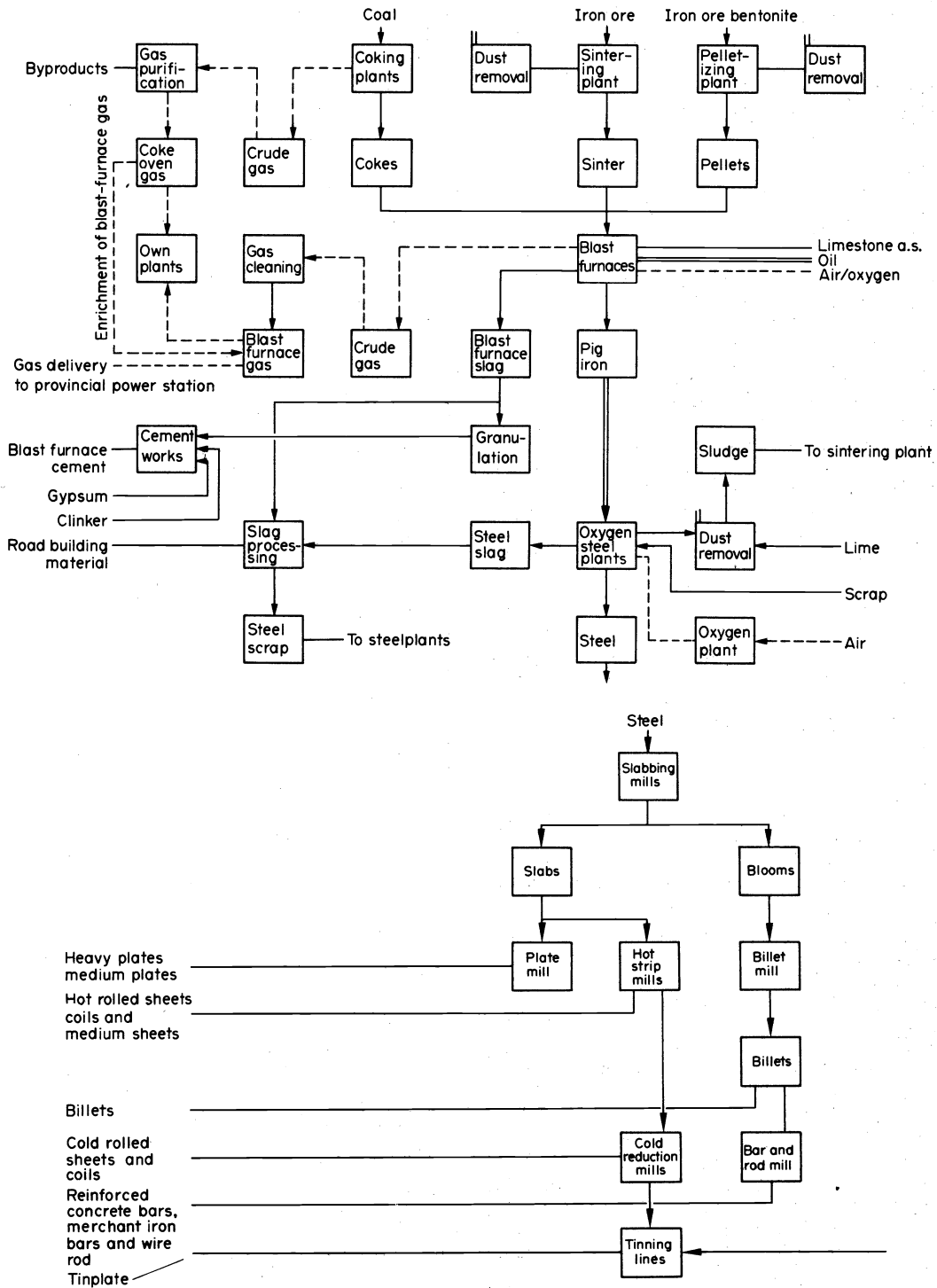


Fig. 1.

reached the sizes and capacities of to-day, recirculation practices had been introduced, in particular in those cases where conditioning or purification of the water became necessary. Nevertheless there still exist big differences between so called "wet" and "dry" works as to their water household. "Wet" works can dispose of unlimited

quantities of usable water and recirculate only by force of purification requirements. "Dry" works have to recirculate almost completely, their water input corresponding to by far the greater part with the evaporation losses (Fig. 2). Another interesting example of "dry" practice gives the ARBED-works in Luxemburg. The ARBED-Esch-Belval† works, an integrated works with an ingot steel production of about 1.5 million t/a has to manage its water household with only 650,000 m<sup>3</sup>/a of effluent from a

†Data given by kind permission of G. W. Cook, B.S.C. (Fig. 2), A. Wagner and Fr. Schroeder, ARBED.

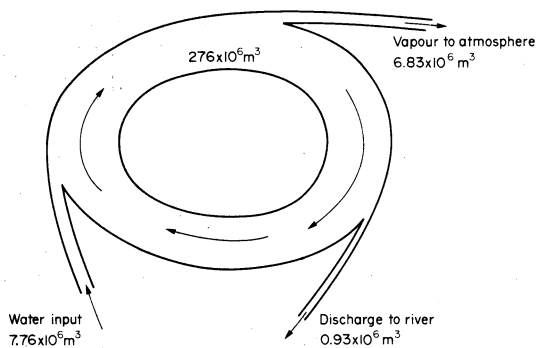


Fig. 2.

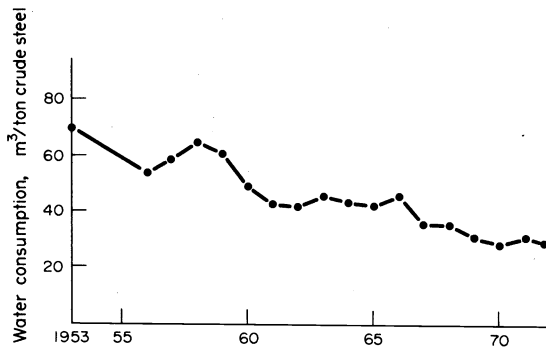


Fig. 4.

nearby domestic water purification plant, 2,150,000 m<sup>3</sup>/a of drinking water and an uncertain amount of rainwater, averaging to 700,000 m<sup>3</sup>/a. So, its water consumption is one of the lowest in the world: 1.9 m<sup>3</sup>/t of ingot steel excluding rainwater. About 0.7 m<sup>3</sup>/t is discharged as purified effluent, so only 1.2 m<sup>3</sup>/t of ingot steel represents the net consumption of the works, being only 0.5% of its water usage. This performance can only be reached by reduction of evaporation, by utilization of sealed cooling circuits, cascade arrangements (Fig. 3), high recycling rates and careful attention to prevention of losses.

It must however be pointed out, that these performances can only be the result of considerable investments.

In comparison a works of the "wet" type may be characterized. The Mannesmann A. G. Hüttenwerke at Duisburg, W. Germany,† is situated along the River Rhine. In 1951 no circulating water system existed, except for the circulation pumps of blast furnaces 1-4. The water consumption was very high and amounted to 70 m<sup>3</sup>/t of ingot steel, i.e. roughly 40% of the total usage. In 1972 due to purification requirements, the water consumption had been reduced to 28 m<sup>3</sup>/t (Fig. 4). This means that "once-through" operation has been practically abandoned. Nevertheless the works has to its disposal 2-3 million t/a underground water of fair quality and is licensed to take in 8 million t/a of drinking water. Added to these quantities a pumping capacity for Rhine water of 14,000 m<sup>3</sup>/hr or 120 million t/a is present. It may be clear from these data that

recirculation practice can go together with a wide range in water consumption.

Coastal works present, however, another picture. Until the beginning of the sixties discharge of contaminants in tidal waters or large estuaries seldom encountered objections. Suspended matter either settles rather quickly or disappears by dilution. Phenols, cyanides and even ammonia are broken down by bacterial action at a sufficient rate in relation to the immense volume of the receiving water and the refreshing effect of the tidal streams. Acids are neutralized quickly by the natural hardness and even iron salts do no other harm than the optical effect, caused by their hydrolysis into ferric hydroxide which slowly settles down. So until the beginning of the last one or two decades there existed no purification problems whatsoever, except prevention of oil spills. Even coastal works have always been obliged to skim their rolling mill waste water!

This picture has changed dramatically during the last ten or twenty years. The main reason for this change is the serious pollution of inland seas and many coastal waters. Special attention is recently directed to discharges of non-ferrous metals in certain effluents of the iron and steel industry, especially zinc, but also some others, dependent upon the ecological vulnerability of the receiving water. The reasons are not only their poisoning effects but also their tendency to accumulate in food chains. For some coastal works this means that requirements concerning purification of discharges are now hardly less stringent than in freshwater situations and nearly all have to take purification measures of some sort. On the intake side there is a tendency to change over from

†Data given with kind permission of Dr. R. Roth, Mannesmann A. G. Hüttenwerke, Laboratorien.

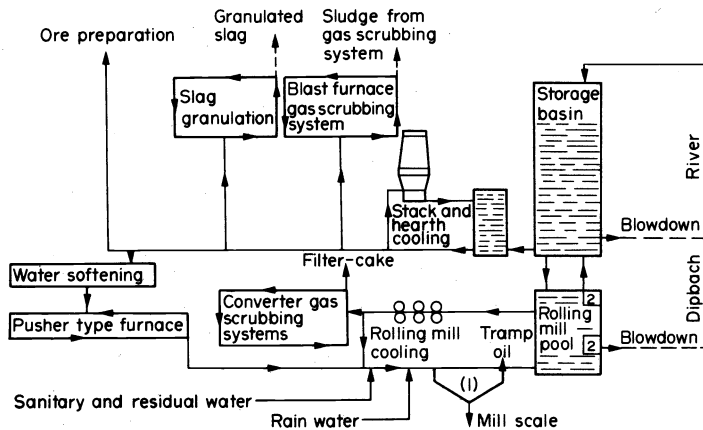


Fig. 3.

seawater to freshwater for those applications where the extra investments for corrosion abatement were outweighed by the lower cost of once-through seawater operation. One of the classic examples is the blast furnace, where a change-over from once-through seawater practice to freshwater recirculation is clearly recognizable, both for wall-cooling and gaswashing. For wall-cooling the main reasons for this change are the dependability of the cooling system and, thanks to the development of more refined cooling techniques, lower operation costs. As to the recirculation the sole reason is prevention of waterpollution, as mentioned before.

As a consequence, some modern seaside works hardly differ from "dry" works as to their water management. One example: the USINOR Dunkirk works show a specific water consumption comparable with those of the ARBED Esch-Belval works. An example of an intermediate practice may bring this paragraph to a close. The Hoogovens-Estel works in IJmuiden would find itself in a situation comparable with the USINOR Dunkirk works and many others in, for instance, Japan and Italy, but for the possibility of drawing freshwater from the River Rhine. When about the middle of the fifties the extraction of groundwater was severely restricted an almost complete switch from good groundwater to surface water of doubtful quality had to take place. After a short period in which surface water from the nearby polders was taken in a joint venture was made with the local drinking-water companies to transport water from the nearest Rhine branch (the Lek) to the coastal dunes to infiltrate it, thus taking advantage of the purifying capacity of the sand soil. This transportation was realized by laying a reinforced concrete pipeline of a special construction with an inner diameter of 1400 mm and a length of about 70 km. Near the intake a rapid sand filtration (for some time past also a flocculation) is carried out and subsequently the water is lightly chlorinated to prevent microbiological growth. Hoogovens was enabled to take off sufficient water for its needs from a sidebranch of the pipeline. In later years the system was extended with two pipelines of 1200 mm diameter each. The total transporting capacity now totals up to 150 million m<sup>3</sup>/a of which Hoogovens can draw off 37 million m<sup>3</sup> yearly at a low price, compared with drinking water. This means that Hoogovens at a production level of 5.2 million t/a of ingot steel can afford itself a water consumption of about 6.5 m<sup>3</sup>/t of ingot steel. In fact this figure is higher, because of the fact that 225 million m<sup>3</sup>/a of seawater and 1.5 million t/a of brackish water are still used for once-through blast furnace cooling, washing of blast furnace gas, washing of waste gases from the pelletizing unit and slag granulation. Moreover 25 million t/a of salt deep-well water with a constant temperature of 12°C is used for cooling of the air in the electric motor rooms of the rolling mills. Thus Hoogovens-IJmuiden can still be considered as a "wet" works and efforts are made to keep up this practice in future extensions.

A summary of the data given in this chapter is shown in Table 1.

#### WATER CONDITIONING

From the foregoing chapter it may have become clear that the ratio water consumption/water usage mainly depends upon the availability and the costs of the water needed. Of course the costs also show a relation with the water-quality. Conditioning of the used water is nearly

Table 1. Specific water consumption in four European steelworks (1973) (excluding power generation) in m<sup>3</sup>/t of ingot steel

	B.S.C.			
	Applby- Frodingham	Arbed Belval	Mannesmann Duisburg†	Hoogovens IJmuiden
	Freshwater			
Surface water, including				
sewage effluent	3.8	0.4	~25	6.5
Groundwater	0.1		0.5-1	
Plant drainage	1.2	0.5		
Drinking water	0.5	1.4	1.5-2.5	0.2
	Seawater			
Surface water				45‡
Deep-well water				5‡

†Only the total consumption of 28 m<sup>3</sup>/t has been authorized by the works; the subdivision is a rough estimate given only for the purpose of illustrating the big differences existing between the four works.

‡Once-through.

always necessary and ranges from simple removal of suspended matter to complete de-ionization, the latter not only for feed water of evaporative cooling units but also for processing some cold rolled and coated sheet, for instance tinplate. Indirect cooling normally takes place, as has been pointed out, with recirculating water. It will be clear that the recycling ratio, which varies widely between "wet" and "dry" works, has a certain influence upon the modalities of the conditioning. Because of the fact that many cooling operations can be carried out at elevated temperatures, the application of sealed circuits with back-cooling by air becomes gradually more frequent. In this extreme case conditioning costs are practically zero. Scaling and corrosion problems in cooling-tower circuits arise because of both the constant taking up of oxygen and carbon dioxide, and the high temperatures of many of the supposedly cooled surfaces. High wall-temperatures also many give rise to cavitation problems by forming of vapour-bubbles. To prevent this, high water-velocities and careful shaping of the cooling units to prevent dead corners are required. Application of anti-corrosion treatments by addition of chromates and zinc compounds in combination with pH control has been, also in the iron and steel industry, a big step towards the solution of many corrosion problems in cooling-circuits, but in its turn involves a purification problem. Therefore developments proceed in the direction of non-pollution additives. Water for direct cooling of solids and gases seldom requires pretreatment because, as has already been pointed out, this water either is used once-through or circulates through a purification circuit in which the processing can be easily adapted to the quality of the water used.

Other water systems in the iron and steel industry can be pre-treated solely by sand-filtration and softening. The special applications, mentioned previously, require de-ionising. One of the reasons for this is, that in an iron and steel works there are several possibilities for cascade connections between circulation systems. A well known example is the use of the overflow of hot rolling mill cooling systems into the gas cooling and gaswashing circuits of LD-steelplants. Many other combinations are applied, especially in "dry" works, as has already been shown in the case of ARBED (Fig. 3). In

cascade connections, the make-up water is fed into the system requiring the best water quality, thus giving possibilities to reduce the overall purifying costs considerably.

#### WATER PURIFICATION

It is beyond the scope of this introductory lecture to go into the many water purification processes being in use or in course of development in the iron and steel industry. Some interesting developments will be described during this section.

On the other hand it is useless to look for guiding principles. Each section of the complex structure called an iron and steelworks has to cope with specific problems in water purification and shows up its own history and developments. The best compromise seems to be to try and draw a rough sketch of the principal developments taking place due to the pressure of water-pollution laws and regulations all over the industrialized world, and to give special attention to problems specific to the iron and steel industry. Another point of interest may be the many interactions which develop between air pollution, water pollution and waste disposal leading to a waste technology, the problems of which have often to be solved simultaneously with the introduction of water purification.

#### Blast furnaces

The cleaning of the blast furnace gas is carried out by means of a gaswashing system. The gas leaves the top of the blast furnace at a similar rate to the "hot wind" blown into the hearth of the furnace. The only purpose is removal of the blast furnace dust entrained with the gas, to make it fit for fueling. The resulting washing water, however, does not only contain this non-toxic ore, coke and lime dust, but also other contaminants, partly in solution, partly in very fine suspension: lead, zinc, cyanides and some fluorides. To-day's regulations ask for removal of these substances. To give an impression of the consequences of this obligation a simplified picture of one of the technical possibilities to reach this end is given in Fig. 5. It is the system adopted by the B.S.C.-Appleby-Frodingham works.†

†By kind permission of G. W. Cook, B.S.C.

‡Extraction processes for the recovery of phenolics are in use or are installed mainly in Western Germany.

Lime is added to the incoming liquor to raise the pH value to a level between 11.9 and 12.2 in order to establish suitable conditions for alkaline oxidation of the cyanide and precipitation of the zinc, lead and a major part of the fluoride. Chlorine is injected as the liquor enters a "circulator" reaction/sedimentation tank which is designed to give intimate mixing of the chemicals with the liquor and allow adequate time for subsequent settling of the precipitates. The precipitated solids are withdrawn as a sludge. The clarified water from the circulator is fed through pressure and sand filters to a neutralisation tank where sulphuric acid is added to restore the pH value to a level between 5 and 9. The plant is automatic in its operation. Variations upon this theme exist or are developed. However, a sludge always results containing zinc, lead and complex cyanides (the free cyanides may be removed by filtration of the sludge and recirculation of the effluent). The treatment of this sludge constitutes one of the major waste problems of the iron and steel industry to-day.

#### Coke-ovens

For a long time the distillation products from the coke-ovens have been a source for financial benefit. Tar, naphthalene, benzole and related compounds, phenols, sulphur and in earlier days even ammonia could be sold as such or after conversion into other products. This circumstance has led to a well-developed by-product technology, including recirculation of the process-water needed. But when, after the second world war, the petrochemicals surged upward, the economic possibilities for coke-oven by-products disappeared one after the other, tar being the the only substance which still can be recovered, without a loss. After a period of serious water-pollution by phenols, cyanides, ammonia, sulphur compounds, etc., the old by-product technology has returned in a modernized form as a gas-purification plant. The main differences are:

Ammonia and cyanides are burnt for the greater part.

Phenols are broken down in biological treatment plants together with the remainder of the cyanides. Up till now, these plants have been similar to normal sewage-treatment plants.

Hydrogen sulphide is converted to sulphuric acid.

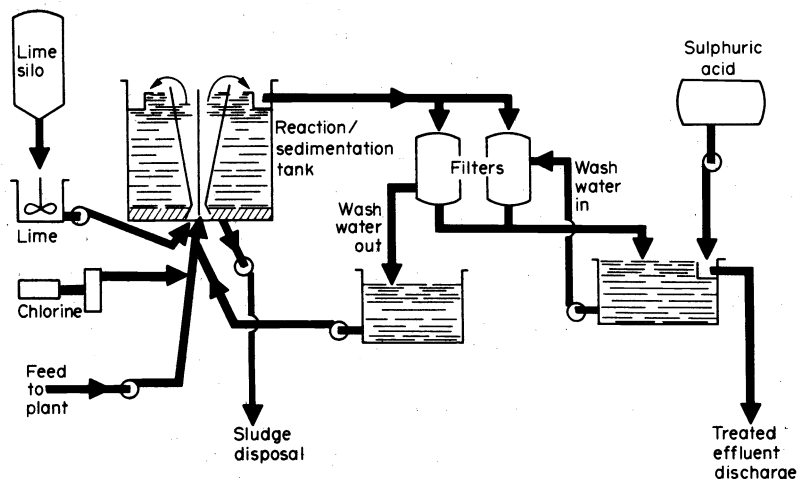


Fig. 5.

Benzole and related compounds remain in the coke-oven gas; naphthalene is usually mixed with the tar.

Along these lines coke-oven waste water can be purified to satisfy the severe regulations.

### *Steelplants*

Although for dust removal from the waste gases of steel converters and electric steel furnaces, dry methods such as electrostatic precipitators and bag filters have found widespread use. It can be said that nowadays the wet systems, like high energy venturi scrubbers prevail, at least in LD steelmaking. Nevertheless there hardly exist any water pollution problem in steelmaking because of the fact that, from the very beginning, these wet systems have been a part of closed circulation—settling systems, differing only in the way of treatment of the sludge. There are however, some difficult conditions to fulfil. The high pH value of the circulating water, which is due to the alkaline slag conditions, causes scaling in the scrubbing units which has to be kept under control by special construction details and careful pH control. The latter is carried out by addition of acids or acid solutions, such as waste pickling solution. Too low pH values in the settling basins or thickeners may cause not only corrosion but also dissolving of polluting metals, zinc being the principal one.

Another difficulty is formed by the processing of the sludge. The chemical and physical properties of the dust which are different depending upon the degree of combustion of the converter gases, ranging from free combustion at the mouth of the converter to complete suppression of combustion in the OG-system, influences the process variables in settling and filtering and may give different results in the sintering process, the latter being the usual destination for the dust. As has already been mentioned in one of the foregoing chapters, a very interesting possibility arises from the necessary large dimensions of the thickeners. Their capacity allows taking up wastewater streams from the hot rolling mills, which, for this reason, may contain certain amounts of suspended solids and even oil, thus simplifying some treatment problems in the mills themselves.

As a final remark we may recall our mentioning of the possibility of using spent pickle liquor for pH regulation, which, under circumstances, also helps in solving a water pollution problem.

### *Hot rolling mills*

The problems of the cooling of the rolls and of the rolled strip itself arise principally from the immense quantities of water in circulation. Depending upon the type and the quality of the steel being rolled, the water usage may vary between 40 and 60 m<sup>3</sup>/t of rolled steel. This does not require revolutionary treatment methods, merely a refinement of existing apparatus to reduce investment and operating costs. Thus, separating the water flow into different circuits, depending upon the degree of contamination by mill scale, fine suspended particles, oil and heat is one of the characteristics. However, these multi-stage treatment plants are very susceptible to bad maintenance. Perhaps therefore, this is the best spot in this lecture to draw attention to the fact that good maintenance of purifying units requires a high level of maintenance discipline and organization. Good maintenance is in fact far

more important for reaching good purifying results than choosing the best types of gravity separators, filters and hydrocyclones. As the best maintenance planning cannot prevent unexpected setbacks perhaps the mental attitude of the works management towards clean air and water may be even more important than the level of maintenance discipline and organization mentioned before. The mill scale recovered is mostly added to the sinter mix. The oil content of the scale gives rise to problems in the electrostatic precipitators for dust removal from the waste gas of the sintering plants. These problems, consisting of glowing surface combustion upon the filter plates, have only been partially resolved until now.

### *Cold rolling and finishing*

Cold rolling of steel requires the use of oil emulsions. Of course these emulsions are recirculated and regenerated as far as possible, but, especially during the periodical standstills these emulsions have to be refreshed. Splitting-up of these emulsions is hampered by not only their stability but also by the fact that addition of de-emulgating agents may in itself give rise to contamination of the effluent. Therefore, an interesting development is based upon the principle of ultrafiltration. Figure 6 shows a sketch of the pilot installation at Hoogovens by which the ultrafiltration trials are carried out. The UF membranes can have several shapes such as hollow fibres, spiral wound sheets, tubes, etc. The principal materials the membranes are made from are cellulose acetate and polyamide. The results are promising; the oil content of the effluent being lower than 10 ppm. The separated oil can, like nearly all other oily residues originating from an iron and steel works, be used for injection into the blast furnaces.

A well known wastewater problem is constituted by acid pickling. Because of the fact that this problem can be solved by regeneration of iron oxide or iron salts and recirculation of the acid, we shall confine ourselves to the remark that in a pickling-regeneration system with cascade rinsing, care has to be taken that the water consumption of the regeneration exceeds that of the rinsing section. In this way, draining of acid rinsing solutions can be avoided.

From the many finishing operations applied in the iron and steel industry, electrolytic tinning may be chosen as an example because of the fact that several types of substances have to be removed from the effluents, i.e. acids, fatty substances and non-ferrous metals. Because of the need to reduce the concentrations of these metals to extremely low concentrations, this subject merits particular attention. Electrolytic tinning is carried out by cathodic precipitation of tin-ions from a strongly acid solution upon the steel surface to be tinned. Before tinning the strip has to be pretreated by cleaning and pickling, after tinning, finishing treatments by bichromate and a suitable acid, for instance citric acid are necessary. To these ends the strip is passed through tanks, consisting each of a treating (C) and a rinsing (R) part (Fig. 7).

At Hoogovens, until now all effluents are drained off to the outer harbour via the waste acid sewer and to the inner harbour by the normal sewers. The treatment foreseen is shown in Fig. 8 showing a complete treatment of the various effluents by means of a cation-anion exchange system; the regeneration wastes are reduced by ferrous iron from the pickling rinse section. The system is closed by a settling tank; the overflow contains only minor traces of metal salts. Sufficient storage tanks are installed

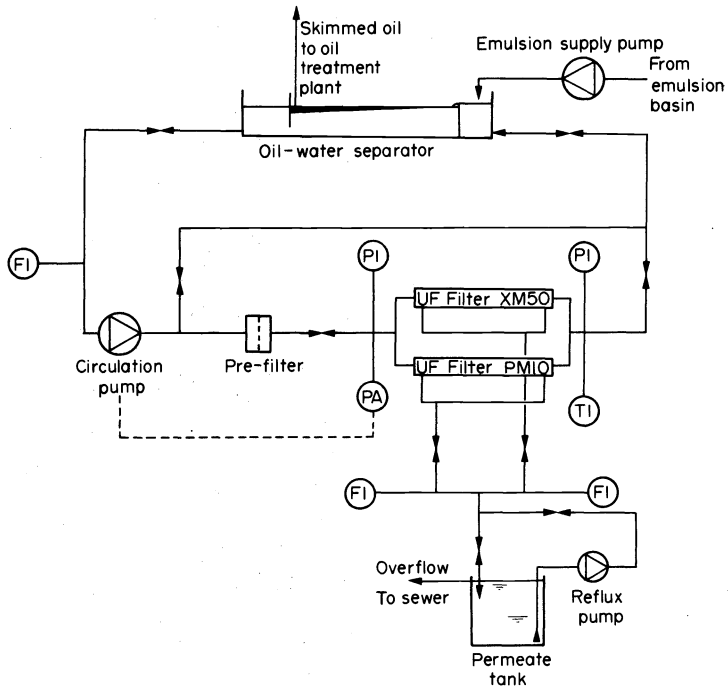


Fig. 6.

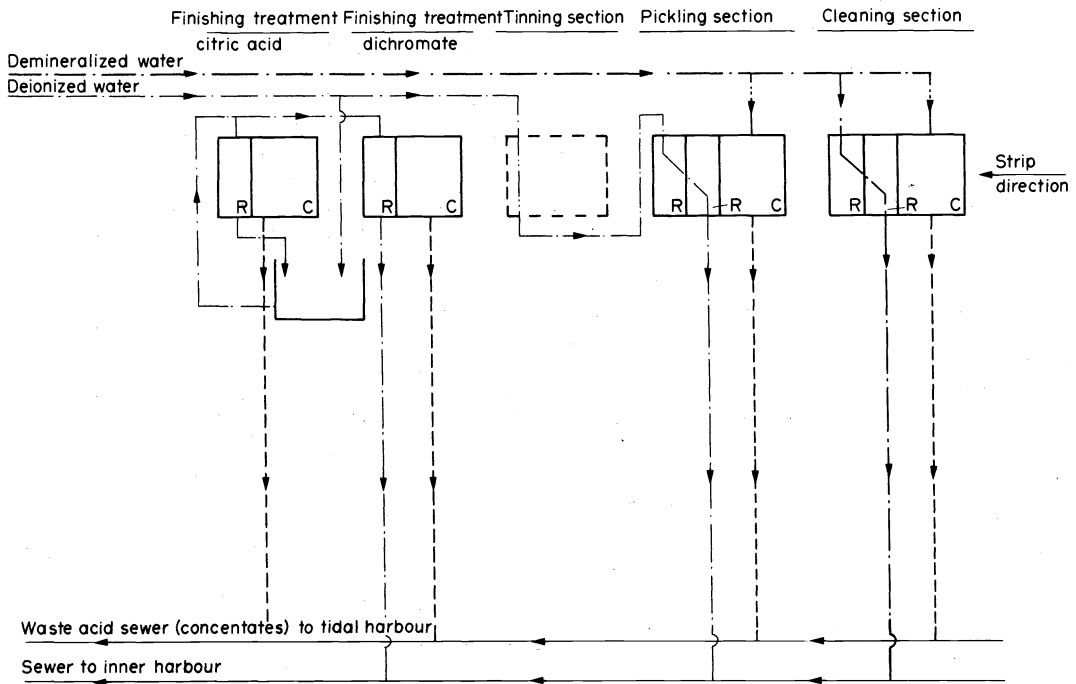


Fig. 7.

to make possible cleaning and maintenance operations without discharging the contents of the system into the sewers.

**Others**

As it will be clear to everyone acquainted with iron and steelmaking, the foregoing summing-up of water purification problems is far from complete. Sintering and

pelletizing, coke quenching, maintenance shops and many minor items have not been discussed. However, these do not show up problems given in this picture.

**INTERNATIONAL COOPERATION**

The iron and steel industry can be characterized by an intensive and cordial technical exchange of information,

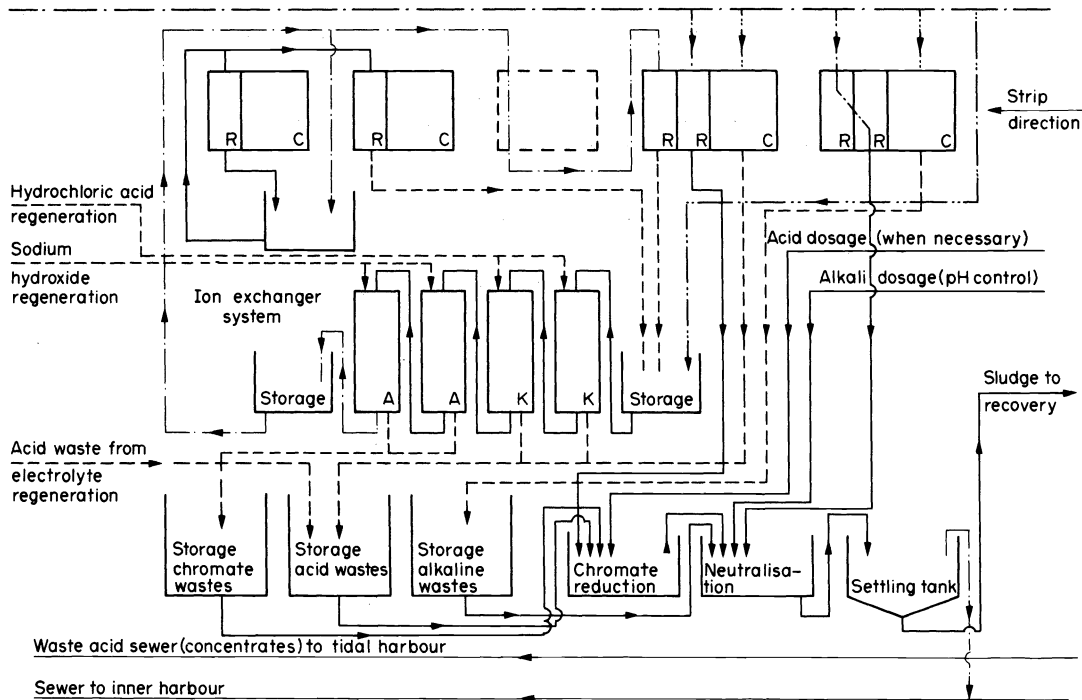


Fig. 8.

hardly hampered by national borders. In this we still recognize the historic evolution of this very old craft and generally speaking, it can be said that competition does not seriously impede this exchange.

From this viewpoint it is not astonishing that the European Common Market has started in the iron and coal trade. Soon after the establishment of the ECSC a research program was started concerning improvement of working conditions in coal mines and in the steel industry. Already during this first program it appeared impossible to keep out projects in the field of dust catching, which in fact concerned environmental hygiene instead of in-plant industrial hygiene.

In the beginning these projects were still earmarked as industrial hygiene projects but the second program which was carried out between 1967 and 1973, was open officially to projects concerning environmental air pollution. During this second program the first water pollution project came forward. Though frowned upon, this project, concerning the cyanide problem in blast furnace gas washing effluent, was at last accepted under the motivation that there exists a direct line with air pollution abatement.

The third research program which was approved of by the European Commission in 1974, includes all environmental aspects including noise. 10,000,000 European Monetary Units are available for financial support of this program that will span, like the first two programs, a period of 5 yr.

In the field of water pollution the following projects have been brought in already:

Improvement of processing of coking effluents (France).

Study of the performance of a biological treatment plant for coking effluent under variable input conditions (United Kingdom).

Analytical control of water pollution in salt water effluents (Italy).

Checking suspended matter in effluents from the iron and steel industry (United Kingdom).

Next to these projects some concerning the treatment of sludges have been brought in.

In accordance with Article 55 of the ECSC—Treaty all member-countries can make use of the results of these research projects. A second activity of the ECSC running more or less parallel with OECD-activities in this field concerns the very complex problem of cost allocation. To this end very detailed questionnaires regarding an inventory of installations for environmental protection with all technical data and the investments done and planned in the years 1972 up to and including 1976 have to be filled out by all works in the Community.

In this questionnaire difference is made between installations for combating air pollution, water pollution, pollution by fatty and solid waste and noise. On the investment side, however, no such differences are made. This may illustrate the fact that it seems to be fairly impossible to get a picture of the costs spent on anti-water-pollution measures alone. In too many cases these measures are part of an integrated effort to reduce or prevent air, water and soil pollution. Thus it will be more fruitful to establish the economics (or otherwise) of pollution control as a whole.

As already has been mentioned, the OECD is also on its way; Sweden and the United States already showing some progress. Maybe within some years a clear picture of the cost of environmental control in the iron and steel industry will result from these efforts and replace the wide variety of investment percentages publicized nowadays.

Finally the International Iron and Steel Institute has to be mentioned as a body, established in 1966, uniting as members the principal steel companies in the free world. Meetings are held all over the world and several Committees have been established. The Committee on



Environment, existing only a few years, has already organized a Symposium on Environmental Control in the Steel Industry, held in Tokyo in 1974 in which two of the seven sessions were dedicated to water problems. In order to be able to discuss the environmental matters openly among the members, some reserve has to be exercised in publication of the proceedings.

The IISI may play a role as a representative body in the world steel industry. In this context it has already become a member of the International Centre for Industry and the Environment, through which link with the United Nations' efforts to improve environmental conditions in the world has been established.