MEASURES AGAINST WATER POLLUTION IN THE IRON AND STEEL INDUSTRY

P. GENY and E. DOHEN

Association Technique de la Sidérurgie Française, Wendel-Sidelor, 54-Homecourt, France

ABSTRACT

During the last ten years or so, a number of statutory provisions have been enacted with the eventual object of controlling and restricting the amount of pollution which can be permitted or tolerated in the water systems of the European Continent. Against this background the authors examine the iron and steel industry as it exists in France, tabulating the principal processes likely to be encountered in plants producing coke, coke-oven gas, ores, sinters, pig iron, cast iron, various slags and finished steel in a wide variety of forms. Estimates are given of probable amounts of pollutants which would be produced in the absence of purification treatment, and of water requirements in different kinds of plants. The cost of purification is high and it is emphasized that plants must be sited to give an acceptable compromise between cost of raw materials and water, and the benefits which may be derived either by way of end products or by reduction of need for water through adoption of recirculating systems wherever possible or through reduction of pollution by purification. The financial penalties incurred if pollution is caused are briefly discussed and it is emphasized that new more stringent administrative powers will be necessary to achieve a pollution-free environment. It is noted that biological treatments have to be used with care, it being too easy to allow 'poisonous' material to enter a purification circuit and render it useless, the special nature of coke plant effluents being a case in point. The work of Water and Atmospheric Pollution Committees is particularly noteworthy. It is stated that the latest iron and steel plant built in France has practically no discharge and does not pay any pollution tax, while old establishments can be charged considerable amounts.

1. NATURE OF THE INDUSTRY

The iron and steel industry aims to put at the users' or manufacturers' disposal products composed mostly of iron, bonded or combined with a certain amount of elements, mainly carbon, which determine their properties.

Starting with the ore—a more or less complex iron oxide compound—a complete series of operations is required to obtain the finished products (sheets, beams, rails, concrete rods, wire rod, various structural steel shapes).

The works where all the operations of this series are accomplished are called integrated plants. However, in some plants, this series is incomplete, at least in part, and the best method is to break down the basic line into various elements and to describe each of them.

Table 1.

Plants		Raw materials used	Nature of finished products	Manufacturing process	Nature of waste materials introduced into the water
Coke oven plant		Coal	Coke, coke oven gas, by-products	Coal heating in closed cells and at controlled rates	Phenols, cyanides, various tars, ammonia
Burden preparation:	Crushing, screening	Ore	Screened ore	Crushing, screening	Suspended solids
	Pelletizing	Ore breeze	Pellets	Mixing with bonding agent and fuel, then baking	Suspended solids, dissolved salts
	Sintering	Ore breeze	Sinter	Mixing with a fuel, then baking	Suspended solids
Cast iron manufacture		Ore or sinter or pellets Scrap Coke {fuel / natural gas}	Pig iron for steel making or cast iron, blast furnace gas slag	Iron oxide reduction by carbon at high temperatures	Suspended solids, cyanides, phenols, ammonia (in certain cases) granulated slag, lime
Steel manufacture		Pig iron, scrap (oxygen)	Steel, slag	Combustion of impurities contained in pig iron (Si, C, P...), grades obtained by additions	Suspended solids, lime
Hot rolling:	Manufacture of semi-finished products	Liquid steel or ingots	Blooms, billets, slabs	Continuous casting or rolling of ingots obtained from castings in moulds (ingot moulds)	Lime, suspended solids, oils
	Final rolling	Billets, slabs	Beams, merchant bars, rounds, wire, rod, rail, etc ..., sheet	Hot rolling	Lime, suspended solids, oils
Cold rolling		Sheets	thin sheets	Cold rolling	Oils, suspended solids

One given plant will then be defined by the links in its production chain, the complete chain being: preparation of blast furnace burden; production of cast iron; steel manufacture; hot rolling (manufacture of semi-finished products, and final rolling); cold rolling.

Certain operations sometimes actually performed in the iron and steel works may be added: lime preparation, treatment of phosphorus slag, of blast furnace slag, etc., which are considered by the Basin Financial Agencies as integral parts of the iron and steel operations in the outright calculation of pollution.

It is not the same with the manufacture of metallurgical coke.

Considering its importance and the treatment difficulties, the pollution caused by a coke oven plant linked with an iron and steel plant is added to that of the iron and steel plant.

Therefore, metallurgical coke manufacture has been incorporated in the

Table 2. Outright estimate of amounts of pollutants introduced without any purification treatment

Processes involved	Characteristic value	Specific pollution per unit of characteristic value		
		METS kg/t	M.Ox kg/t	Conductivity $\frac{\text{mho}}{\text{an}}$ m^3
Blast furnaces	Ton produced:			
	pig iron for steel making,	4.3	0.55	—
	other cast iron	6.3	0.55	—
Coke oven plant proceeding to coke quenching:	Ton of coke produced			
with crude ammonia liquor		0.30	0.49	—
by the wet process		0.30	2.00	—
by the dry process		0.20	2.00	—
Iron ore treatment	Ton produced			
Iron ore crushing, beneficiation and sintering plants:				
with dust removal by the dry process		0.17	0.016	—
with dust removal by the wet process		1.55	0.10	—
Steel plants:	Ton produced			
without gas cleaning		0.32	0.032	—
with gas cleaning		1.70	0.09	—
Hot rolling including tube drawing:				
1st heat	Ton ingots charged	0.2	0.02	
2nd heat	Ton of semi-finished products charged	3.00	0.30	—
Cold rolling:				
operating with soluble oil	Ton of steel submitted to treatment	0.20	0.10	—
operating with vegetable oil	To be determined for each case per measure	—	—	

production line shown in the accompanying table (*Table 1*) which also indicates the possible consequences for the water used in the course of these operations.

Table 1 calls for a few comments. In the iron and steel industry, manufacturing principles have not varied for several decades, but the implementation of these principles has strongly developed and is still developing.

Owing to the importance of investments in the iron and steel industry, the various plants are not all at the same development level, and it becomes very difficult accurately to determine the amounts of the various pollutants introduced into the water. As regards the concentration of pollutants in waters

Table 3. Blast furnace gas washing water

METS	500–3 000 mg/l
Total iron	100–1 000 mg/l
CN	0.2–1.5 mg/l
Sulphates, phenols, naphthalene	Mentioned as a reminder

Table 4. Coke plant water

Ammonia, free or not	up to 2 g/l
Suspended matters	up to 3 g/l
Volatile phenols	50–1 500 mg/l
Total sulphur	about 500 mg/l
Organic nitrogen	about 100 mg/l
CN	up to 1 g/l
Pyridine	As a reminder

Table 5. Rolling mills water

Suspended matter	0–a few g/l
Oils:	
hot rolling	0–50 mg/l
cold rolling	a few g/l

flowing out of the plants, there is an additional complication owing to the various ways of utilizing water in plants that are similar from the iron and steel point of view.

The best overall estimate of the pollution from iron and steel manufacture can be found in the following extract from the table of outright estimate of pollutants introduced, (*Table 2*) which is used by the Basin Financial Agencies† to calculate the outright pollution taxes, namely at the outlet of the plant before any water treatment. These values have been set up in agreement with officials in the profession.

To these may be added the measurements performed in different plants and gathered together in the following tables (*Tables 3–5*).

† See in the Appendix a summary on the Basin Financial Agencies.

For a given pollution and the same plant the deviations are very important. Again this refers to crude pollution. This crude sewage is then generally treated, recirculated to a greater or lesser extent with varying results, and this scatters the final results even more.

In order to take into account each particular situation, the Basin Financial Agencies correct the outright pollutions calculated according to the schedule by multiplying them by an individual reducing coefficient which makes allowances for these treatments. These reducing coefficients vary from 0 to 1, both extreme values included.

WATER FLOW ACROSS THE PLANT

Water uses

Quantitatively

The iron and steel industry consumes much water. In order to produce one ton of steel it effectively pumps in from 100 to 200 m^3, viz. 150 m^3 on average, of which approximately 2 to 4 m^3 have disappeared at the end of the cycle, either by evaporation, or consumption in the course of manufacture or incorporation in the wastes.

For the manufacture of one million tons of ingot steel a year, this corresponds to:

Pumped water	100–200 × 10^6 m^3/year or 12500–25000 m^3/h
Waste water	2–4 × 10^6 m^3/year or 250–500 m^3/h

Per plant, the breakdown of the quantities pumped in is approximately as follows:

Sintering	0–20 m^3/t sinter
Blast furnace	50–80 m^3/t pig iron
Steel plant	2–20 m^3/t steel
Rolling mills	2–80 m^3/t rolled
Coke plant	2–5 m^3/t coke
Blast furnace gas cleaning	3–7 m^3/1000 m^3 gas.

Qualitatively

Water has many varied uses in the iron and steel industry—cooling (the most important use), power transfer, gas cleaning, matter removal—to mention only the main ones.

The types of use are varied since one may find cooling circuits open, closed, with atmospheric coolant, with air convector and totally closed, with low pressure steam, with medium or high steam pressure, wasted or recovered, with natural or forced circulation.

The water qualities vary according to the requirements of each circuit, and extend from raw water to treated water, from removal of carbon to a complete demineralization and conditioning.

Origin of the water

As problems relating to quantity and quality have to be solved, and the layouts of plants have to be selected according to economical requirements in which water is one of the secondary factors, the iron and steel industry obtains its water wherever it can best be found with regard to quantity and quality: surface water, mine water, artesian water, public tap water, and even sea water. The proportions vary greatly from one plant to another.

Circuit diagram

In order to facilitate the representation and reading of the water circuit diagrams to ensure complete understanding between those in charge of the water, the Association Technique de la Sidérurgie has standardized the symbols used in the diagrams and defined a few words such as: draught, net consumption, discharge, cycle, closed cycle, etc.

A flow-chart model is being submitted to the international authorities in order accurately to define the terminology used and thereby contribute to mutual understanding.

Importance of waste water

Considering the small quantity of water consumed, the waste water from each plant has the same measured volume as the water which flows into the plant. Because of partial and general recirculations, it is not possible to effect a summation for the whole plant, and the recirculation rate defined by:

$$R = \frac{\text{Sum of the circulation water flow of network} - \text{draught flow}}{\text{Sum of the circulation water flow of network}}$$

varies from 0.99 (no discharge) to less than 0.1 (practically no recirculation).

WASTE WATER TREATMENT

Nature of products extracted during treatment

(A) First, the suspended matter: sinter plant dust, flue dust, steel plant dust and mill scale. This is of variable grain size, but generally small—from 0 to 100 μm—settling well down to 10 μm and containing much iron (30 to 60 per cent). This dust is collected, treated and returned to the fabrication line, except that from blast furnace gas when it contains elements which are harmful to the blast furnace, particularly zinc. Granulated slag, soaked silicate, occurs in the form of grains a few millimetres in size, the bulk density of which may be less than one.

(B) Oils are found in the water flowing out of rolling mills particularly and originate from lubrication of mechanical elements. The oils should be separated, especially vegetable or animal oils used in cold rolling mills which present very difficult problems for their removal.

(C) In some particular manufactures (special cast irons, spiegel cast iron, etc.), cyanides occur in the flue dust waste, up to 100 mg/l and above. Cyanides are always present anyway, but during normal operation the quantities are very low and oxidation is fast.

(D) In coke plant waste water phenols, cyanides, ammonia, etc. are found.

Treatment for each separate effluent

Effluent containing suspended matter (sinter plant, blast furnaces, steel plants, hot rolling mills)

A conventional settling process in rectangular or circular tanks is used. Considering the outputs, flocculation is only seldom used; withdrawal of sludge is performed by means of pumps or, in the case of mill scale, by clamshells.

The settled sludge is either thickened or dried in vacuum filters, according to its final use.

Effluent containing oils

To collect current oils, the conventional processes of natural flotation and collection by mobile troughs are implemented. The reclaimed oils are generally incinerated.

In the case of cold rolling mill oils, there is not yet any satisfactory process. A flotation technique by hydrogen micro-bubbles originating from electrolysis is being developed, and a plant is in operation on an industrial scale.

Slag granulation effluent

An efficient and commonly used means consists in directing the granulation waste waters into a filtering-bottom tank which removes the granulated slag grains whose bulk density is lower or higher than that of water.

Blast furnace flue dust effluent containing cyanides

It is difficult to apply the conventional cyanide treatments as the outflows are large (400 to 1300 m^3/h per blast furnace, depending on its size) and the water contains much carbonate. If recycling is important with a passage across an atmospheric cooling agent, one benefits by a natural elimination which is accelerated by the polyphosphates, according to a process as yet unknown.

Coke plant effluent

Biological treatment coupled with the conventional settling tank seems to be the only efficient process for coke plant wastes, but the investment and operating costs make even those with the best intentions shrink from it. In several coke plants, these waters were used for coke quenching by the wet method. Many drawbacks have contributed to the abandonment of this way of operation. In conjunction with the Basin Agencies, the iron and steel industry has resumed the study of biological processes, trying to find an economically valid compromise.

SPECIAL DIFFICULTIES

Technical considerations

As iron and steel water treatments are mass operations, smooth running and care in the plant are more important than the search for highly technical solutions. Nevertheless, the cost is very important. Thus, a 1 000 000 t/year plant collects from 10 000 to 30 000 t/year blast furnace sludge (dry) which has to be carried over to and piled up on a slag heap, from 10 000 to 20 000 t/year mill scale, and so on.

The iron and steel plant wastes must not be discharged into town sewers as the refuse which the waters contain and which is essentially composed of mineral matters may, even after treatment, disturb the smooth operation of the biological treatment installations.

Analytical aspects

The water analyses made in the iron and steel industry call for conventional methods which do not need any special comment. Also, there are no specific difficulties apart from the coke plant effluents during the BOD_5 estimation (existence of phenols, cyanides).

Economic aspects

Fully aware of the pollution problems, the iron and steel industry works in close cooperation with the pollution control organizations.

Within the Association Technique de la Sidérurgie there is a Committee (Water and Atmospheric Pollution Committee) which is responsible for surveying the pollution problems and for finding solutions to them. As a matter of fact, its members are the engineers who, in each plant or firm, are entrusted with the implementation of this pollution control.

However, in practice it is very difficult to separate 'pollution control' from 'water management' in the plant; undoubtedly, good water management leads to a decrease in pollution and pollution control requires good water management.

The draught and pollution taxes paid to the Basin Agencies vary between 0.20 and 0.25 F/t ingots. This is an average value.

In fact, the old plants are being progressively modernized and their taxes are definitely higher than these figures, according to their degree of modernization.

On the other hand, the new units possess elaborate treatment and recirculation systems right from the start.

Thus, the latest iron and steel plant built in France has practically no discharge and does not pay any pollution tax.

If the pollution taxes paid by the iron and steel industry are compared with the estimate which might be made on the basis of the raw outright estimate used by the Agencies, a ratio close to $\frac{1}{4}$ is found; this amounts to saying that the treatments undergone by the water before being discharged from the iron and steel plants retain approximately 70 per cent of the theoretical pollution. As above, this value is an approximate average, but it shows nevertheless the effort which has been made by the iron and steel industry towards the control of water pollution.

However, it must be admitted that this effort is not sufficient and that it must be maintained and amplified as far as possible.

In this respect, several surveys are under way within the French iron and steel industry in order to find out more accurately the water cost (draught, treatment, circulation, discharge) with a view to determining the impact of this pollution control particularly on the cost of the manufactured items.

BIBLIOGRAPHY

Industrie Abwässer Meinck–Stoff–Kohlschütter

R. Chantereau. 'Traitement des eaux résiduaires provenant des laminoirs à froid', A.T.S.-E-PA

R. Groos and A. Denne. 'Operational experiences with a plant for the biological treatment of coke-oven plant wastewaters containing phenols', *Stahl Eisen* No. 6 March (1968)
J. Sobota. 'Décyanuration des eaux d'épuration des gaz de Hauts Fourneaux', Translation C.D.S. I.T. 6 676
R. Chantereau. 'Hydrocyclones', A.T.S.-E-PA
G. V. D. Dunck, Dembeck and Gober. 'Procédé de décyanuration des eaux de lavage du gaz de gueulard au moyen de polyphosphates', Translation C.D.S. I.T. 5 245
R. Levin. 'La granulation du laitier de Haut Fourneau', *CESSID* April (1968)
M. F. Berne. 'Traitement des eaux de laminoirs', *CESSID* April (1968)
P. Durel. 'Lavage de gaz de Haut Fourneau: de fumées de chaînes d'Agglomération, de fumées d'aciérie, de fumées de cubilots à vent chaud, *CESSID* April (1968)
Y. Rouast. 'Les différents usages de l'eau en Sidérurgie', *CESSID* April (1968)
M. Daniel. 'Enquête des Agences Financières de Bassin sur les flux de pollution déversés par les industries', S.H.F., PARIS (1970)

ACT OF PARLIAMENT, DECEMBER 16, 1964

WATER POLLUTION CONTROL BASIN FINANCIAL AGENCIES

I. Repressive and preventive measures

Several acts empower the Administration to penalize, forbid and prevent water pollution.

For example, the Act relating to the classified plants, of August 2, 1961, states that the opening of a polluting plant is liable to a licence or, as the case may be, to a mere preliminary notification, coupled with conditions imposed on the wastes. The Classified Plants Department responsible for the application of that Act is, moreover, charged with the task of ensuring its implementation (police responsibility).

The statutory powers given the Administration did not prevent the situation from growing worse and worse. It was therefore thought advisable to 'update' those measures while reinforcing them. Such is one of the objectives of the December 16, 1964 Act about 'water policy and distribution, and pollution control'. Some of its enforcement decrees are already issued. Others are being prepared.

II. Economical measures

Also, the December 16, 1964 Act opens up new ways of action for pollution control and, more generally, for harnessing the water resources within an adequate geographical frame: the basin's.

The metropolitan territory has been split into six basins (Artois–Picardy, Rhine–Meuse, Seine–Normandy, Loire–Brittany, Adour–Garonne, Rhône–Corsica), in which the persons interested in water conservancy and harnessing, viz. the Administration, the organizations and the users, have at their disposal new economic means to control pollution more particularly.

The Basins Committees (assemblies comprising representatives of the public Authorities, the organizations, and domestic, agricultural and industrial users) are consulted about any problem concerning the basin, and vote for the intervention programmes of the Basin Financial Agencies.

These Agencies—one per basin—are public institutions of an administrative character, whose duty it is to facilitate the realization of works of common interest to the basin by bringing to the main contractors extra means of finance in the form of subsidies or loans. The Agencies also include industrial representatives.

The originality of the 'system' established lies in the origin of the funds placed at the Agencies' disposal: the taxes they are authorized to levy depend on the economic value and quality of the water. They are paid by public or private persons in so far as they use the resources (water draught, consumption or pollution) and make the Agency's action necessary or useful.

So, a manufacturer who pollutes pays the Agency a pollution tax. That tax depends on location or time circumstances which influence the resource quality, and on the pollution waste quantities which are discharged (the parameters taken into consideration to define this pollution and to assess the pollution tax are: suspended matter, oxidizable matter, salinity).

But, on the other hand, the industries may receive from the Agency important financial aid in the form of loans or subsidies, which may amount to 40–50 per cent of the cost of the investments intended for pollution abatement.

These aids add up to those which the public powers also grant: fiscal reductions (exceptional provision for redemption of the premises destined for purification, and fast write-off of equipment) and complementary loans from the Credit National.

The Basin Agencies were installed during the years 1967 and 1968. At present, they are carrying out their multiannual intervention programme.

Finally, it should be emphasized that the Agencies' intervention is superimposed on the statutory action of pollution control without merging into it.

The taxes levied by the Agencies are not fines, though they apply to pollutions which remain forbidden.