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Water Treatment Engineering for Overseas Plant

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1 Introduction

The steel industry uses large quantities of various kinds of service water. For many years, Kawasaki Steel has constructed, operated, and maintained water treatment facilities in steel mills locally. On the basis of the techniques thus developed, the company constructed its first overseas water treatment facilities at Tubarão Works in Brazil in the 1980s and has since carried out many water treatment projects abroad.

Kawasaki Steel's Engineering and Construction Divisional Group can supply water treatment engineering capable of meeting severe effluent standards, assuring the water quality level required to produce high-quality steels, and minimizing the construction cost, operation cost and maintenance cost of water treatment facilities to maintain the competitiveness of steel products. In this engineering, these apparently conflicting requirements are met in a well-balanced manner.

This paper describes Kawasaki Steel's water treatment techniques related to steel mills and its basic concept of water treatment engineering and presents actual results of four recent projects.

2 Kawasaki Steel's Water Treatment Techniques

Table 1 shows the water supply and treatment facilities in each production process of a steelworks and related business and the main water treatment processes that compose these facilities.

These facilities have been improved through operation, maintenance, control, and periodical analyses of water quality to meet the requirements of production lines, modifications of production lines, and tightened effluent standards. Especially, the water recovery rate has been raised to the maximum degree by enhancing water recovery because large quantities of water are used. At the same time, technical know-how has been accumulated by making various improvements aimed at creating closed systems which discharge as little water as possible to the outside.

The individual water treatment processes used in these facilities cover almost all the water treatment processes generally applied in other industries. Conversely, almost all water treatment systems can be formed by efficiently combining the techniques in these individual processes.

Thus, Kawasaki Steel's water treatment techniques can meet various water treatment requirements, including those unrelated to steel mills.

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Table 1 Water treatment process in steelmaking plant

Water treatment system	Parameter	Coagulation sedimentation	Filtration	Ultra-high rate filter	Dissolved air flotation	Activated carbon adsorption	Neutralization	Ion exchange	Membrane filter separation	Oxidation & reduction	Activated sludge	Contact aeration	Dehydration	Composting	Disinfection (ozone, chlorine)	Others
Industrial water treatment system	SS	○	○										○		○	
Potable water treatment system	SS	○	○										○	○	○	
Softened water treatment system	Hardness (cation)							○								
Demineralized (ultra-pure) water treatment system	EC, Cation, Anion					○		○	○							
Coke gas liquor treatment system	COD, NH_3, Phenol	○				○					○		○			○
Blast furnace gas cleaning water treatment system	SS, Zn	○											○			
Converter gas cleaning water treatment system	SS	○	○										○			○
Continuous casting water treatment system	SS, Oil	○		○									○			
Hot strip mill water treatment system	SS, Oil	○		○									○			
Cold strip mill oily water treatment system	Oil, COD	○	○		○	○							○			
Cold strip mill pickling waste water treatment system	pH, SS, Fe	○	○				○			○			○			
Cold strip mill cleaning waste water treatment system	pH,Oil,COD		○		○	○	○				○	○	○			
Plating waste water treatment system	Heavy metal, COD	○	○			○	○			○			○			
Oil regeneration system	Oil						○						○			○

3 Features of Kawasaki Steel's Water Treatment Engineering

The features of Kawasaki Steel's water treatment engineering are enumerated below.

(1) Before customer's design conditions such as water volume and water quality are determined, they can be estimated from the company's database, and designs can be made at this point of time.

(2) When design conditions are presented, designs can be made by considering points to be noted, such as variations, referring to actual values.

(3) Local procurement is conducted as far as possible in consideration of the ease of maintenance and control. In this connection, it is possible to refer to data on various types of machines operated at steelworks.

(4) The dispatch of supervisors with abundant experience of construction and operation ensures good quality assurance and production control and permits the training of operators through construction supervision.

(5) As required, training in operation can be conducted using actual facilities at the company's steelworks.

(6) It is possible to dispatch supervisors capable of managing the whole construction process in place of the customer.

4 Examples of Construction of Water Treatment Facilities

4.1 Water Treatment Facilities for Hot Strip Mill in Taiwan

4.1.1 Outline of project

The hot strip mill at An Feng Steel Co., Ltd. is a mill for rolling slabs into coils. The required water treatment facilities are a direct cooling water treatment facility for removing the iron scale generated during rolling and cooling and an indirect cooling water treatment facility for cooling the reheating furnace and hydraulic equipment.

In this project, Kawasaki Steel furnished only the water treatment facilities, and European and American manufacturers furnished the rolling mill and reheating furnace.

Kawasaki Steel's scope of engineering, in addition to the basic design, detail design, supply of equipment, dispatch of supervisors and training, covered various kinds of management for a general performance guarantee.

This project was the first full-scale water treatment engineering in Taiwan for Kawasaki Steel. The company's basic policy of "engineering from the customer's viewpoint" was highly evaluated and this contributed to its successful bid for the subsequent Tung Ho project.

4.1.2 Features of water treatment facilities

The flow sheet of the water treatment facilities is shown in **Fig. 1**. The efficiency of water use was increased by raising the recirculation ratio (water recovery ratio) because this rolling mill consumes large amounts of water: 3 600 m^3/h in the indirect cooling system and 9 100 m^3/h in the direct cooling system.

The direct cooling system is composed of a scale pit, PPI(parallel-plate interceptor) sedimentation basin, ultra high-rate filter, cooling tower, pumps, sludge dehydrator, and other ancillary equipment. This water treatment facility was installed to remove mainly fine iron scales. Combining the PPI sedimentation basin with the ultra high-rate filter resulted in a compact design and small installation area.

In the indirect cooling system, softened water is used as make-up water because the hardness of industrial water is high. The utmost attention was paid to safety by installing a backup system comprising a diesel pump, an emergency power source and an elevated water tank in the water supply system for the reheating furnace.

Because a large amount of water is circulated in these facilities, Kawasaki Steel's operational know-how was best applied in the method for operating the water-sup-

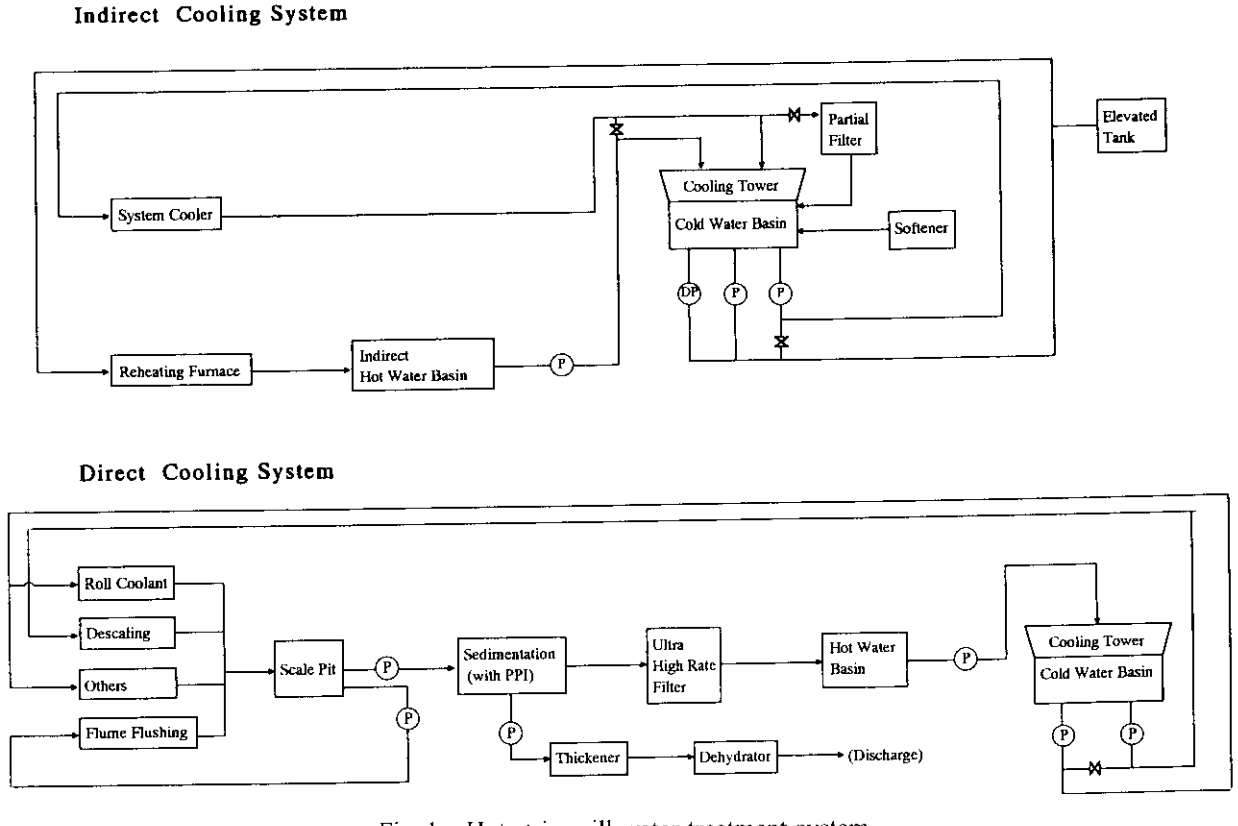

Fig. 1 Hot strip mill water treatment system

ply pumps.

4.2 Water Treatment Facilities for Electric Furnace and H-Beam Rolling Mill in Taiwan

4.2.1 Outline of project

The electric furnace and H-beam rolling mill of Tung Ho Steel Enterprise Corp. are composed of an electric furnace and continuous casting mill that produces steel by melting iron scrap and casts blooms, and a rolling mill that reheats the blooms and rolls them into H-beams. The required water treatment facilities are composed of (1) an indirect cooling water treatment facility for cooling the electric furnace, continuous casting molds, reheating furnace, and machines and (2) a direct cooling water treatment facility for the roll coolant, descaler, and continuous casting machine.

In this project, Kawasaki Steel furnished the water treatment facilities on a full-turnkey basis. In other words, the company carried out all the tasks from design to material procurement, dispatch of supervisors, field work (civil and building, and installation), commissioning, and training.

This full-turnkey basis permitted smooth interface coordination among civil and architectural design, design of machine piping, and design of electrical work and made it possible to shorten the construction period by the parallel execution of civil and building work and installation work.

Overseas projects usually involve some uncertainty as to the product quality of local manufacturers and the capability of contractors. On the basis of its experience with past projects, Kawasaki Steel employed reliable manufacturers and contractors and achieved the required quality within the delivery deadline.

4.2.2 Features of facilities

The flow sheet of these facilities is shown in **Fig. 2**, and a general view is shown in **Photo 1**. The makeup of these facilities is basically the same as the water treatment facilities for the hot strip mill earlier described, except that the water supply and drainage equipment for the electric furnace and continuous caster is added.

The water supply systems of the cooling water for the electric furnace and reheating furnace are provided with a backup system for emergencies, as with the water treatment facilities for An Feng Steel Co., Ltd.

In the direct cooling system, a common scale pit is shared by the continuous caster and the rolling mill by adjusting the plant layout, and the system is divided into two parts behind the scale pit. This is the result of Kawasaki Steel's advice on means of reducing construction costs, which was made possible by engineering based on the basic design of the whole plant.

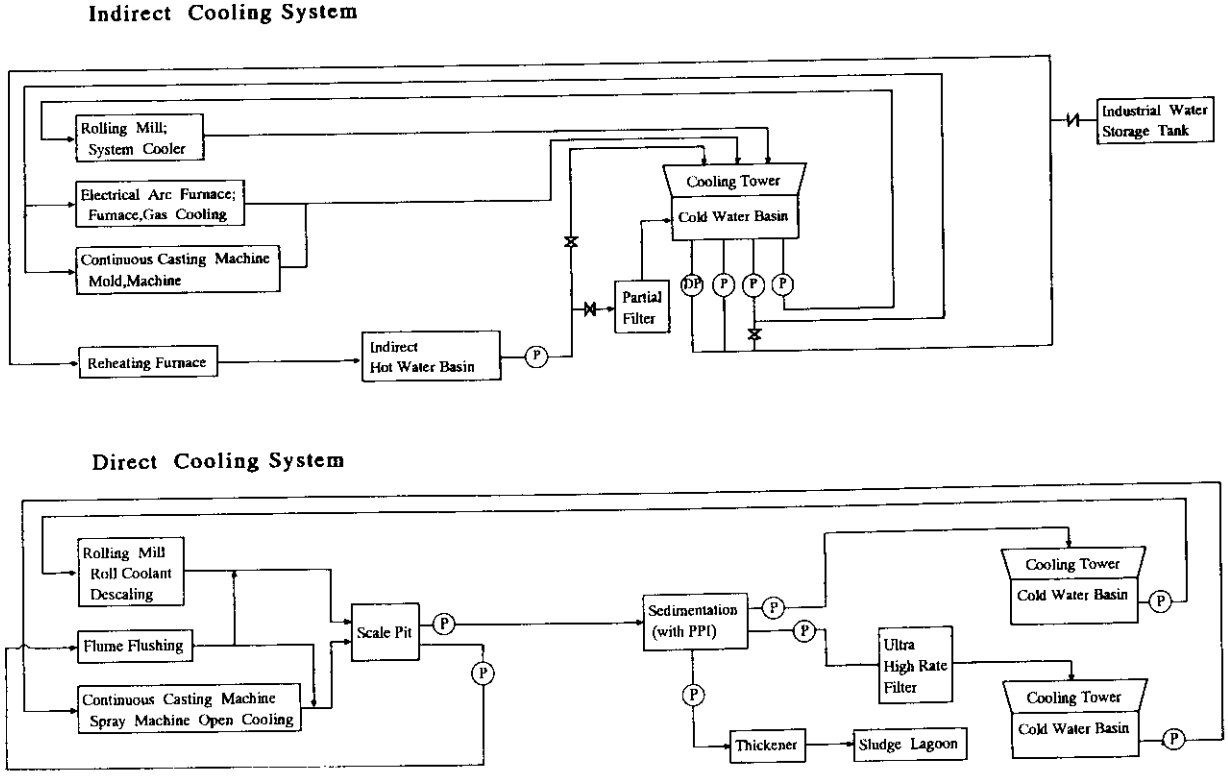

Fig. 2 Steelmaking and rolling mill water treatment system

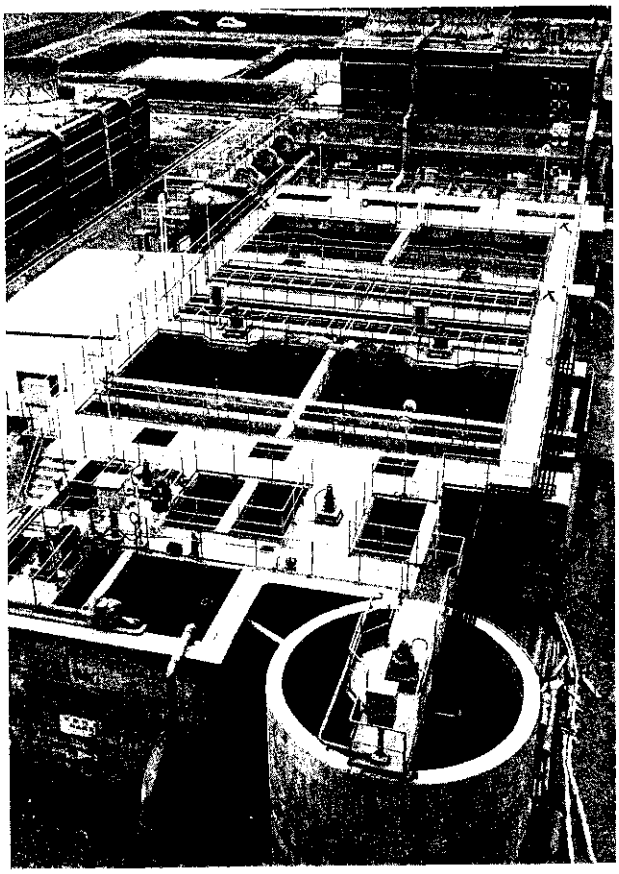

Photo 1 General view of water treatment plant for steelmaking and rolling mill

4.3 Water Treatment Facilities for Cold Strip Mill in Taiwan

4.3.1 Outline of project

The cold strip mill of Ton Yi Industrial Corporation is a mill for rolling steel sheets (loam plates as tin-mill black plate). This mill requires water supply and drainage equipment for the principal mill equipment, such as pickling, rolling, electrolytic cleaning, annealing, skinpassing, and roll-grinding equipment, and water supply and drainage equipment for accessory equipment, such as boilers and the acid recovery plant. The water supply and drainage equipment covers a wide range of water supply plants for various kinds of water —industrial water, potable water, demineralized water, and softened water—indirect and direct cooling water treatment facilities, oily waste water treatment facility, acid and alkali waste water treatment facility, and palm oil regeneration plant.

In addition to performing the feasibility study and providing engineering and construction management (engineering such as basic design, dispatch of supervisors, and training) for all these water supply and drainage facilities, Kawasaki Steel also furnished the detail design and equipment supply of the direct cooling water treatment facility, waste water treatment facility, and palm oil regeneration plant.

The following describes the features of the direct cooling water treatment facility and palm oil regeneration plant, in which Kawasaki Steel's many unique techniques are incorporated.

4.3.2 Features of direct cooling water treatment facility

The flow sheet of this facility is shown in **Fig. 3**. Larger quantities of water and oil than in the usual rolling oil circulation system are required by this rolling equipment, because the cooling and lubrication method adopted for the rolls of the cold strip mill is a direct system in which the cooling water and rolling oil (palm oil) are separately injected. Kawasaki Steel has accumulated various kinds of know-how related to this direct cooling water treatment facility based on about 30 years of operation at its Chiba Works.

This direct cooling water treatment facility is composed of two-stage dissolved air flotation tanks, and a cooling tower, strainer, and ozone disinfection facility. The waste oil separated in the rolling mill and dissolved air flotation tanks is regenerated by the palm oil regeneration plant described below.

The accumulation of salinity and mixing of solids in the direct cooling water for the tandem cold mill may result in the rusting of products (sheets) and occurrence of roll marks. Disinfection by ozone was adopted because chlorine-base disinfectants cannot be used. An auto-strainer was adopted, because residual oil adheres and mud balls of slime form in the sand filters usually adopted in water treatment facilities to remove solids, resulting in insufficient filtering.

Ozone is injected in two places: the zone before the cooling tower, by a continuous ozonizer, and the water supply piping, by an intermittent ozonizer. This technique, which was jointly developed[1-10] by Kawasaki Steel and Mitsubishi Electric Corporation, has been used for ten years at Chiba Works. The purpose of intermittent ozone injection is to prevent the formation of slime on the internal walls of the water supply piping and roll spray nozzles and not to disinfect the feed water itself. During intermittent ozone injection, therefore, the direct cooling water in the piping is replaced with filtered industrial water to decrease the amount of ozone which is chemically reduced by the organic matter in the water. The volume of intermittently injected ozone is determined by the pressure, pH, concentration of organic matter, and retention time of the water to be treated. Because water is supplied from a new facility in this project, the design injection volume of ozone was calculated by estimating the quality of the water.

The auto-strainer is installed downstream of the feed water pump. The internal and external surfaces of this

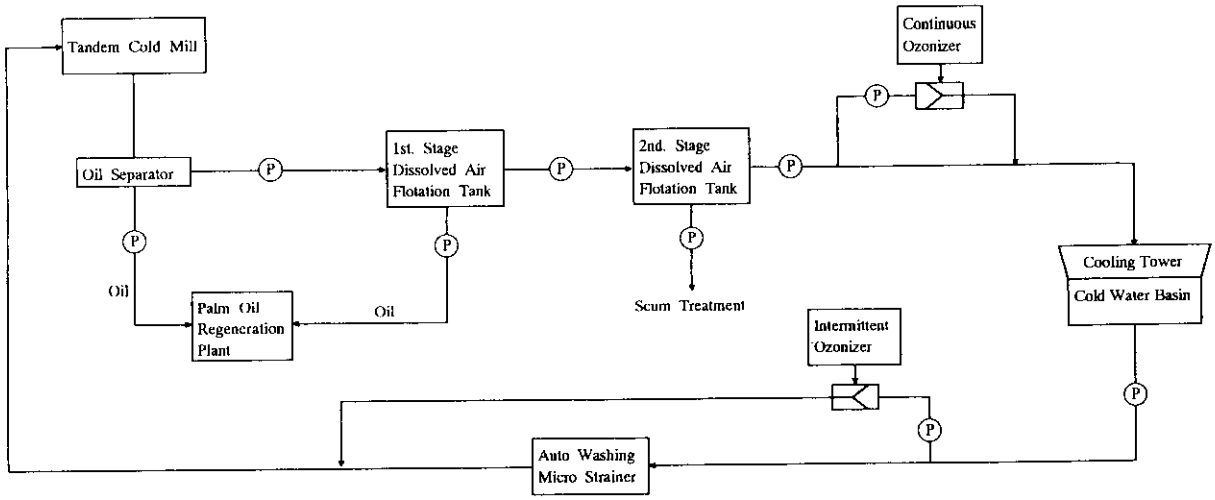

Fig. 3 Tandem cold mill (direct lubrication type) water treatment system

cylindrical strainer are washed with high-pressure water so that the slime formed in the strainer can be efficiently removed.

4.3.3 Outline of palm oil regeneration plant

The flow sheet of this plant is shown in **Fig. 4**. This plant is based on Kawasaki Steel's unique technique for chemically regenerating the palm oil which is used as rolling oil in the cold strip mill. This technique has shown good results through about 30 years of operation at Chiba Works.

Waste palm oil mixed with direct cooling water is separated from the cooling water by an oil skimmer (natural flotation) in the rolling mill and the dissolved air flotation tanks in the water treatment facility. The separated oil in the form of scum enters the regeneration plant.

This scum contains solid matter, such as fine scale that is mixed in during rolling, and disintegrated constituents of palm oil (fatty acid is the principal constituent) in addition to palm oil. If this scum is allowed to stand as it is, iron fatty acid is formed and the scum becomes like rubber of high viscosity, making treatment of the scum difficult. If this scum is dehydrated and incinerated, fatty acid damages the furnace body and clinker is formed from the iron, and the incinerator life becomes very short. This plant is free from these troubles and contributes also to the reduction of running

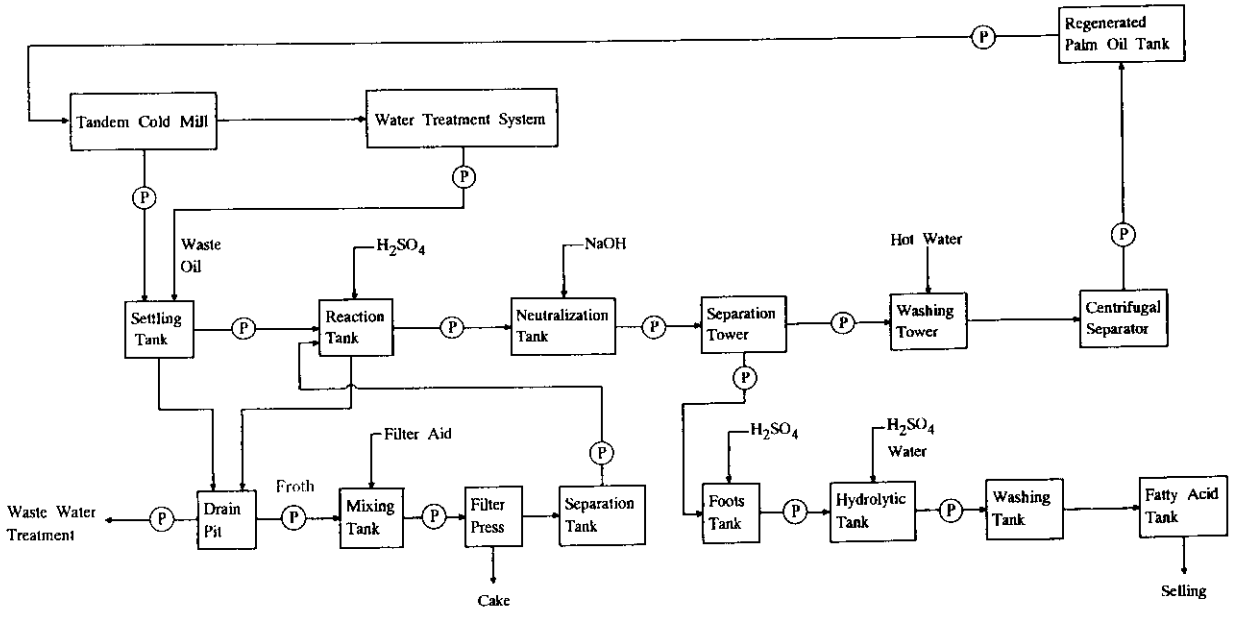

Fig. 4 Palm oil regeneration plant

costs, because the regenerated palm oil is reused.

The entire process of this plant is composed of the palm oil regeneration process, fatty acid recovery process, and waste oil regeneration process. The palm oil regeneration process is composed of oil-water heating separation → sulfuric acid heat reaction → oil-water separation → neutralization → fatty acid settling → washing → centrifugal dehydration. The regenerated oil is adjusted in each process to a quality (acid value, demulsibility, etc.) suitable for rolling.

In the fatty acid recovery process, fatty acid formed by the decomposition of palm oil is recovered and is finally treated to a saleable quality. Fatty acid separated from the palm oil regeneration process as sodium soap is further decomposed to purities of about 95% by hydrolysis (Tricelli's method) under the high-temperature, atmospheric-pressure acid conditions of sulfuric acid.

As is apparent from the above, this palm oil regeneration plant is very effective in environmental protection and resources saving, and Kawasaki Steel's techniques for waste oil treatment including those for oils other than palm oil based on many years of operation will be adopted abroad more frequently than before.

4.4 Effluent Treatment Facilities in Car Painting Booth in the Philippines

4.4.1 Outline of project

Kawasaki Steel furnished on a full-turnkey basis the effluent treatment facilities in a car painting booth of Honda Cars Phils., Inc., located in the Laguna Industrial Park in Manila, the Philippines. Kawasaki Steel participated in the development and carried out the basic planning of the water treatment facilities in the industrial park. The company is therefore well acquainted with the water treatment near this industrial park and has established a good system for local construction work in the Philippines using a local affiliate. These capabilities were highly evaluated by the customer and contributed greatly to the successful bid for this project.

4.4.2 Features of facilities

The flow sheet of the effluent treatment facilities is shown in **Fig. 5**, and a general view is shown in **Photo 2**. The facilities treat and discharge the effluent from the painting equipment of a car factory and can treat

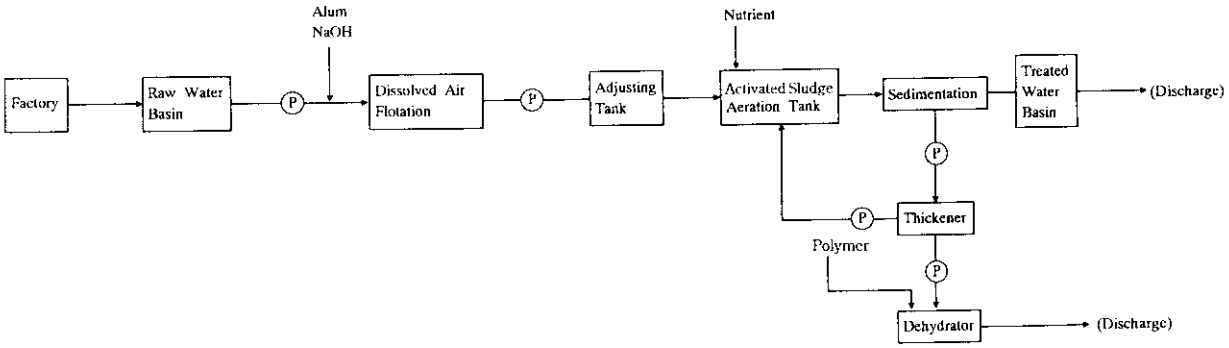

Fig. 5 Car painting waste water treatment

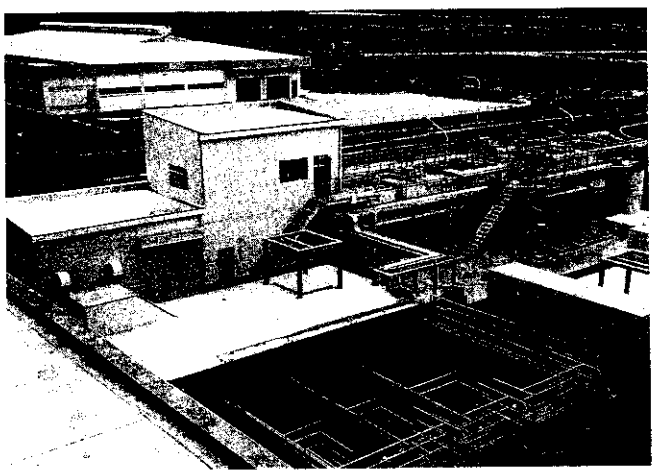

Photo 2 General view of water treatment plant for car painting factory

56 m^3/day of effluent. The whole treatment process of the facilities is composed of dissolved air flotation treatment, activated sludge treatment, sludge dehydration treatment and ancillary equipment. The oil, SS, heavy metals and other inorganics in the effluent are removed by the upstream dissolved air flotation treatment, and the organic matter in the effluent is removed by the downstream activated sludge treatment.

The facilities are equipped with a water quality monitoring system for discharged water and an emergency water reservoir for temporary storage in case of water quality abnormality as positive measures against an environmental problem that was recently discussed in Manila.

Because the treatment of the effluent from the car painting booth is different from that of the waste water in steel mills, treatment experiments on the raw water were conducted in a similar plant in Japan, and the equipment performance of the system was verified beforehand.

5 Conclusions

An outline of Kawasaki Steel's water treatment engineering for overseas plants was given.

(1) Kawasaki Steel has carried out water treatment engineering for overseas plants since 1980 on the basis of its techniques accumulated through the construction and operation of water treatment facilities in steel mills.

(2) The water treatment facilities in steel mills are composed of many processes, and the company has accumulated many water treatment techniques through many years of construction and operation.

(3) Kawasaki Steel has its own steelworks. Therefore, unlike most manufacturers of water treatment facilities, it can engineer water treatment facilities from the customer's standpoint, i.e., in consideration of the production carried out in the customer's plant.

(4) This paper describes the company's recent achievements in water treatment engineering for water treatment facilities in a hot strip mill, electric furnace and H-beam mill, and a cold strip mill in Taiwan and water treatment facilities in a car painting booth in the Philippines.

We intend to conduct engineering by further improving the techniques so as to fully satisfy our customers.

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