1910

The design and installation of an apparatus for dehydrating the air which is used in the blast furnaces of the Hanyang Iron and Steel Works and other suggested improvements, Hanyang, Hupei, China

Andrew Jackson Seltzer

T H E S I S

for the

D E G R E E

of

M E T A L L U R G I C A L   E N G I N E E R

-SUBJECT-

THE DESIGN AND INSTALLATION OF AN APPARATUS FOR DEHYDRATING THE AIR WHICH IS USED IN THE BLAST FURNACES OF THE HANYANG IRON AND STEEL WORKS AND OTHER SUGGESTED IMPROVEMENTS, HANYANG, HUPEI, CHINA.

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LOCATION AND HISTORY OF WORKS--The Hanyang Iron and Steel Works is located in the city of Hanyang, Hupei Province, inland on the mighty Yangste Kiang, a distance of one thousand seventy-five kilometers from Shanghai. The Works is at the junction of the Yangste and Han Rivers and covers several acres. The Works was established by the Viceroy Tchan and was to have been located at Shanghai, but His Excellency, the Viceroy, was transferred to Wuchang, so he decided to locate the Works in Hanyang--just on the opposite bank of the Yangste, from Wuchang.

At first the Works was owned and operated by the Government and only pig iron was manufactured, until the year 1893. They then attempted to make steel, but finding the pig to contain too much phosphorus for the Bessemer process (only about 0.2%), and other executive complications arising, they were unable to maintain the Works on a paying basis and it was purchased by Chinese capitalists. These Chinese capitalists engaged engineers and metallurgists from France and Belgium, who remodelled, improved, and enlarged the Works and in the latter part of 1894, they began to produce excellent steel.

The Works originally consisted of two blast furnaces and in 1893, two five-ton Bessemer converters were installed. The new engineers remodelled these two blast furnaces--increasing the capacity from sixty tons each to one hundred twenty tons each; they also put in one ten-ton Siemens Martins open-hearth furnace, put down a rail mill, a one-hundred-centimeter blooming mill, a ninety-centimeter reversing plate mill, and built a foundry.

PRESENT EQUIPMENT--The Works at present consists of two original blast furnaces, capacity increased to one hundred twenty tons each, four thirty-ton basic open-hearth steel furnaces, one ten-ton furnace for melting scrap, one Wellman pig-mixer, one one-hundred-centimeter reversing blooming mill, a ninety-centimeter reversing plate mill, a seventy-five centimeter reversing rail mill, an eighty-five centimeter beam mill, a fine modern twenty-five centimeter, three high mills for rolling small bars and shapes, and all of the accessory apparatus for straightening, truing, and punching rails and all necessary testing appliances.

SOURCE OF RAW MATERIALS--The company have their own iron mines and also their own coal mines and coke ovens, The iron mines are located at Tayeh--one hundred forty-five kilometers down the Yangste Kiang, from Hanyang, and twenty-six kilometers back from the river. Here there is really a mountain range of iron ore. The entire range, however, is not iron ore, the main ore body appearing in three hills, each two hundred fifty meters high, about fifty meters diameter at the top, and between one hundred seventy-five and two hundred meters diameter at the base.

Two of the hills are quite near to each other, being separated by a narrow valley; the third is at a distance of six kilometers from these two and the vein is barren for the entire distance.

This iron range is a contact deposit, the contact on the north wall being a compact, close-grained diorite; the south contact being a very pure, almost white, marbly limestone. The diorite is very hard and not seriously affected by weathering, has not been eroded to any great extent, and lays snugly against the iron ore to its maximum height. The limestone has been seriously eroded and in many places has left the hematite very near the surface. The richest part of the vein has a south-east, north-west trend, but beyond this rich part, the vein is almost barren and runs practically due east and west. The ore is a good hard hematite and it is necessary to blast most of it. The drilling is all done by hand and a poor driller is Mr. Chinaman. He is not only distressingly slow, but it is practically impossible to convince him that the Western method of pointing holes is far superior to his own ideas on the matter, and even after the holes have been marked for him, he will often ignore the marks and place them, according to his own views. The German engineer, in charge of the mines, informed me that one German driller would break as much ground as eight or ten Chinese. The work in these hills is all open-cut, and as the ore is blasted, it is sent down inclined planes in one-ton cars and loaded into the company's lighters and towed up to Hanyang by the company's steam launches. Each lighter holds three hundred fifty tons and one launch tows two lighters, one roped along side and the other astern.

Practically no prospecting or exploitation has been done on this wonderful deposit, so in reality very little is known of its contents below the ground level, or its continuity beyond these three hills. At the present time, the Hanyang works is being supplied with three hundred fifty thousand metric tons annually (next year this must be increased to five hundred thousand), and one hundred twenty-five thousand tons goes to Japan each year. The present output from the three hills is about one thousand metric tons per day, but this must soon be increased to sixteen hundred tons. At the present output the ore in sight will last seventy years, but indications lead one to believe that with depth the vein hot only increases in richness, but also grows wider.

The company's coal mines and coke ovens are located at Pinghsiang, which is about three hundred kilometers up the Yangste Kiang from Hanyang and one hundred seventy-five kilometers south of the river. Here are located the second largest coal mines, which are being operated in China. There are two hundred eighty coke ovens and besides supplying coal and coke for the Hanyang works, these mines supply both coal and coke for a large number of steamers, foundries, et cetera. The Hanyang plant receives at present, one hundred sixty thousand tons of coal and one hundred ten thousand tons of coke per year from these mines and this amount is soon to be materially increased.

WAGES AND LABOR CONDITIONS AT BOTH MINES AND WORKS--
About twenty thousand men are employed at the steel works, the iron mines, and the collieries. The following is the schedule of wages at the coal and iron mines per day of ten hours:

Miners . . . . .250 to 300 Cash, equiv. in U.S. currency 8 to 9.5cents
Loaders . . . . 100 to 150 Cash, " " " " 3.25 to 5.0 cents.
Pushers, same as loaders.
Tippling Coolies . 100 to 125 " " " " " 3.25 to 3.75 cents
Small boys and old men who carry ore in bamboo baskets from 80 to 120 Cash ~~gold~~ equivalent to 2.65 to 3.65 cents.
Cost of mining one ton of ore, 270 cash, or 9 cents gold.
Cost of stripping per ton of ore, 30 cash or 1 cent gold.

The schedule of wages at the steel works is higher and is about as follows per day of ten hours:

Rollers on mills . . 350 to 700 Cash, equiv. in U.S. cur. 10.5 to 21.0 ct.
Heaters on furnaces .550 " " " " " 19.0 ct.
Helpers on furnaces 350 to 500 " " " " " 10.5 to 17.0 ct.
Open hearth steel melters, same as heaters.
First helpers . . .350 Cash, equiv. in U.S. cur. 10.5ct.
Blacksmiths . . . 700 to 1000 " " " " 21.0 to 34.00 ct.

Common labor receives about 7.5 cents gold per day and boys and women receive about five cents gold per day. The men at the steel plant work fairly well, but the miners are very shiftless, resembling the Mexican in that they will work just enough days per month to provide sustenance, but no more. The average number of days which they work per month is twenty-one.

The following are the analyses of the ore and limestones at Tayeh, the coal and coke at Pinghsiang, and the raw and finished products at Hanyang

	Tayeh Hematite	Tayeh Brown Iron Ore	Magnetite
Fe	62%	48%	65%
Mn	0.3%	7.0%	0.13%
SiO_2	4.0	6.0	3.0
Al_2O_3	2.0	- -	- -
S	0.02	0.01	0.06
P	0.05	0.03	0.12

Tayeh limestone . . . .96 % $CaCO_3$, 2.5 % SiO_2.

Pingsiang Coal	Ash	10 to 25%
	Volatile Matter	25 to 35 %
	Sulphur	0.02 to 0.06%
Coke	Ash	10.0 to 25.0%
	Sulphur	0.3 to 0.6%
	Phosphorus	0.06 to 0.25%

Analyses at the Steel works:

Blast Furnace Slag		Foundry Pig Iron		Siemens-Martin Pig Iron	
SiO_2	33.0%	C	3.8%	C	3.9%
Al_2O_3	16.0	Si	2.5	Si	0.65
CaO	46.0	Mn	1.0	Mn	1.10
MgO	2.0	S	0.01	S	0.045
Fe	1.0	P	0.02	P	0.25
Mn	0.6				

Samples of Martin Steel:

	First sample	Finished Steel	Second Sample
C	3.34%	0.40%	C 0.64%
Si	- -	0.085	3rd sample C.0.50%
Mn	0.26	0.089	4th sample C 0.46
P	0.24	0.055	5th sample C 0.44
S	0.045	0.028	6th sample C 0.42
			7th sample C 0.27
			8th sample C 0.26
			9th sample C 0.22
			10th sample C 0.30
		Finished Steel	C.0.40

Analyses of other samples of steel:

Si	0.095%	0.079%
Mn	0.79	0.90
C	0.33	0.47
P	0.058	0.06
S	0.025	0.035

The greater part of the above analyses were made by myself, while working in the company's chemical laboratory.

Rail and Bolt tests - - -Peking and Hankow Railway Rails:

85-pound rails

Strength 61 kg. to 69 kg. Tensile Strength of Bolts 39.0, 38.0, 38.5 Kg.

Tensile Strength 37.3 Kg.

Elongation	17.5,	15.5%	27.0	29.0%	30.0%
Elastic Limit	35.0 kg.	35.0 kg.	28.8	27.0	27.5 Kg.
Contraction	39.0 %	36.0%	63.0%	62.0%	60.0%

The steel made by this Plant is of excellent quality in every respect. The rails for the Peking Hankow Railway were furnished by this company and they are now making rails for the Canton-Hankow Railroad and the new road that is being built to Chang Sha. The following two tests are perhaps the two most severe to which the rails are subjected; An eighty-five-pound rail, one hundred ten centimeters betwenn supports, stood a weight of forty tons for five minutes with a permanent deflection of 0.5 centimeters. A drop test of one blow with an one-thousand-kilogram weight falling 7.6 meters, caused a deflection of 6.25 centimeters.

EXPANSION AND NEW EQUIPMENT--The company is just completing a fine modern blast furnace, of the very latest German type. It will have a capacity of two hundred fifty metric tons of pig per day, it is thirty-two meters high, the diameter of the crucible is three and fifteen hundredths meters, and it has sixteen tuyeres, eight to be used at a time and eight to be held in reserve. The most interesting and modern thing about this furnace is the new method of water-jacketing. Small cast-iron pans, forty-five centimeters long and forty-two centimeters wide, by eleven centimeters deep, are set into the brick work, all around the outer circumference and flush with it--giving the outer circumference the appearance of almost a net-work of these pans, from the tuyeres to within three meters of the top of the furnace. These small pans are placed in horizontal rows around the circumference--the vertical distance between rows being seventy-five centimeters and the horizontal distance between the pans in a row is one hundred centimeters. The pans are so arranged that each pan in a row is not directly underneath a pan from the row next higher, but the space is so divided as to expose as little of the brick work as possible. The interior end of the pans is closed, but the outside end has an open or slit across the top, and through this a three-centimeter iron pipe passes, supplying the cooling water. Another similar pipe leads out of the bottom of the pan at the other side and delivers the water to the next lower pan and so on through the system, the water being kept in circulation throughout the net-work of pans. When the water has travelled through four pans, it has become hot enough to go to the troughs, which surround the furnace. So far as I am able to adcertain, this is a new idea and I am much interested to ascertain how efficient such a scheme will be. It obviously is going to mean a great deal of cooling water. Fearing that my description of this novel scheme is not only meagre, but also not clear, I attach a photograph of a small section of the furnace which I took. It was not possible to obtain a better photograph than the attached one, as there was no means of setting up a camera in any other position than this.

To give an idea of the slowness of construction in China, it might be noted that it has required three years to construct this furnace. The foundation is already laid for another furnace, precisely like this one and it is evident that the Company intends increasing the present capacity of the Plant several hundred percent. The present furnace will probably be blown-in about February fifteenth. The walls of this furnace are constructed of very large fire-brick and are strapped with very strong bands, two and one-half centimeters thick and twelve centimeters wide. It will be fed by hand boggies as labor here is so cheap and plentiful that mechanical devices are scarcely considered.

MANAGEMENT, CHARACTER OF LABOR, ET CETERA.---His Excellency, V. K. Lee, a versatile Chinese, is the General Manager, but all the other responsible positions and heads of departments are filled by German and French engineers and metallurgists. Many of the lesser foremen are Chinese and they are exceedingly proud of their positions.

The thing which impresses one most on entering the plant, is the almost innumerable heaps of scrap, old iron, brick, lumber, and junk of all descriptions that is piled about in almost every part of the works, no general junk yard being set apart, as we Westerners have, but the whole Works from end to end is littered up with junk. This is, however, in strict keeping with the Chinese mode of living.

Over five thousand Chinese are on the pay roll of this Works, they swarm about each operation as thick as bees about a honey-suckle, and it is next to impossible for one to understand why they are not burned, scalded, crushed, and killed by the score. Taking into consideration the fact that the Chinese are a very playful and usually careless people, the number of accidents which occur is surprisingly small. Of late years the company has been installing electric machinery, hoists, et cetera, and a great deal more of the work is being done by machinery. However, because of the abundance and cheapness of Chinese, hand-labor is resorted to wherever practicable. One sees all of the coke being carried about in bamboo baskets on the shoulders of the coolies, the blooms and ingots being pulled about with tongs by the coolies, all handling of the finished rails being done by hand, et cetera. These men really become very expert in the handling of steel and pig iron and as blacksmiths and foundry men, they are certainly hard to beat.

Many interesting incidents of the gross superstition of the Chinese people might be related in connection with this Works. Two of the most interesting can scarcely escape mention. Owing to the company's rapid expansion in the past few years, they are now dreadfully pinched for ground, being as they are, hemmed in on one side by the Han River, on another by the mighty Yangste Kiang, on the third by the Government arsenal, and on the fourth by the sacred Turtle Hill. So about three years ago the company proposed tunneling through this barren and unused hill. A howling cry arose from the people immediately and even the gentry and officials. Protests came in from all sides, that if they tunneled the hill they would disturb the sacred dragon, make him furious, and that he would then bring all manner of bad luck and disaster upon the people. So fierce and determined was the cry that the company was forced to abandon the proposition. The company then began to fill a small marshy pond which was near the base of the hill. Again a wild protest. This time, that the dragon washed his feet in this pond and that his sacred bath tub should by no means be disturbed. With great difficulty and tactful persuasion, the company finally convinced them that they wished only a very small part of the pond filled in and that they would leave a wholesome bath tub for the Honorable Mr. Dragon, and so they were allowed to proceed. As it is very essential that the company secures more ground and this Turtle Hill is their only possible means of acquiring more ground, they are now endeavoring to convince the Chinese that they will not bring disaster and destruction upon them nor will they anger the dragon. We are awaiting the outcome with interest.

It is interesting to note that several large shipments of pig iron have gone to New York from the Hanyang Works. In November a shipment of fifty thousand tons was sent to New York and about six months previous another large shipment was sent to the United States. It seems that pig iron from China can be laid down in New York for less than the price quoted in Pittsburg.

The Hanyang Works is a wonderful development for China and it is earnestly to be hoped that it will mark a new era for this conservative and poverty-stricken people and that in the near future they will wake up to the gross folly of allowing their vast hidden treasures to lie dormant.

THE DESIGN OF AN APPARATUS FOR REMOVING THE EXCESSIVE MOISTURE FROM THE AIR, BEFORE IT ENTERS THE BLAST FURNACES.--I dare say few places in the world have an atmosphere so laden with moisture as the Yangste Kiang Valley, and Hanyang is particularly unfortunate in this respect. Figures and data will be given later in this article but it is safe to say that the humidity here, especially in the summer months, far exceeds anything in America. As this excessive moisture obviously increases, the fuel consumption enormously, and moreover, coke being very expensive in China, I propose a scheme and the design of an installation to remove this excessive moisture from the air before it goes to the tuyeres. The system invented by Mr. Gayley, an American, in which an actual refrigeration plant is installed and the air cooled down to zero, is not deemed advisable or efficient for the Hanyang Works. In the first place, it means a very costly outlay, a large plant, and a tremendous amount of foreign-made machinery, et cetera. Such installation coming from Europe or America, as it necessarily must, would be exceedingly expensive and would require foreign construction and supervision. Secondly, I do not think Mr. Gayley's scheme would remove sufficient of the moisture to pay for its installation and maintenance.

With the elimination of the Gayley scheme, it becomes necessary to resort to a chemical method. Calcium chloride is out of the question, as it necessitates hydrochloric acid and no such chemical is produced in China and it would be much more expensive to import than sulphuric acid--also the first cost would be much greater. So we eliminate calcium chloride. Quicklime might serve the purpose, but it is doubtful whether it would remove sufficient of the moisture as the percentage is very high.

With all of the above eliminated, we come to the best, most efficient, and thorough dehydrating agent of all--namely, sulphuric acid. As to efficiency, sulphuric acid is not to be questioned, and after careful consideration of all available methods, I hold that sulphuric acid is the proper one. The installation is simple and inexpensive. The questionable item is the price of the sulphuric acid.

OUTLINE OF PLAN, COST, ET CETERA.---The installations is to consist of two towers, each tower to be seventeen meters high and four and one-half meters diameter outside measurement.

Foundation for towers to be of concrete, one and one-third meters deep and six meters square. The outside shell of towers is to be eight-millimeter steel plate, to be made by the company. This shell is to be lined with two courses of good red brick. Next to the brick lining is to be a centimeter layer or wall of tar. This is to neutralize any possible sulphuric acid that may get through the acid-proof tiling, but there is a very remote chance of any acid ever getting through--I add the tar as an extra safe-guard.

Next to the tar is one course of heavy glazed acid-proof tiling, these tiles to be ten centimeters thick, thirty centimeters long, and twenty-five centimeters wide--to be set with plaster-of-Paris joints. No acid is to come in contact with these tiles, but it is to be confined to the packing tiles entirely. Inside this layer of heavy tiles, comes the checker-work of acid-proof glazed tiles, through which the sulphuric acid trickles and spreads in such a manner that the ascending air from the blowers comes in contact with the acid freely and thereby has the moisture removed from it. All of the tiles are to be made by the company, as they are equipped for such work and the raw materials are available. They are now making their own fire-brick and tiles for the Cowper stoves. Freight rates to China are very high and foreign goods must necessarily be very expensive. A drawing of the packing tiles appears with the blueprint of the towers, so it need not be described here.

There is to be a lead tank at the top of each tower, These tanks are to be of sheet lead, one centimeter thick. The tanks are to be of the same diameter as the towers, to be placed one and one-third meters above the tops of the towers, and to be supported by wooden timbers (twenty centimeters by twenty centimeters) and enclosed in a strong wooden crib, composed of ten by fifteen centimeter joists. In the bottom of each tank are to be placed ninety lead pipes of one-centimeter diameter (internal) and three centimeters external diameter. These pipes are to be fused into the bottom of each tank, each pipe is to have a plug of lead in the form of an inverted cone, which will slip into each pipe and close it entirely when found necessary. These inverted lead cones are to properly regulate the flow of acid, passing over the towers. These cones are to be attached to strips of lead and these strips are to be connected to a series of iron chains, which will pass over pullies, and thus give a means of controlling the acid-flow, the cones to be lowered or raised by these iron chains, thereby properly regulating the flow of acid.

The tops of the towers are to consist of sheet lead, of one centimeter thickness, the sheet of lead to extend down the edge of the outside row of acid tiles, a distance of seventy-five centimeters. This over-lap is to have tiles bound securely round it in such a manner that it is air-tight and does not allow any air to escape. The lead pipes are to extend through the lead top and into and around the acid tiles. They are to be fused in the lead top, no solder to be used in securing the lead in any part of the apparatus. This over-lap of the top must be carefully walled up by the tilers on the outside so as to allow no escape of air.

A foundation of concrete one and one-third meters high is to be built on top of the foundation, which supports the steel shell and the brick work. On the top of this foundation a lead pan is to be placed. The diameter of the lead pan is to be thirty centimeters larger than the outside row of acid tiles. This pan is to be made of the same kind of lead as the top tanks and it is to be sixty-five centimeters high. Into this lead pan the acid tiles are to be built. This open space of fifteen centimeters is to be left between the tile and the outside of the pan in order to see whether or not the acid is coming down the towers properly, whether in proper amounts, and so that dirt and broken tile may be removed from the pan, should any appear. An over-flow pipe is to be placed fifteen centimeters from the top of the pan--the over-flow pipe to be about twelve centimeters in diameter, much larger than is necessary, in order to avoid danger of choking.

This arrangement thus allows a pool of sulphuric acid of the depth of fifty centimeters, to stand in the pan all of the time. This acid pool acts as a seal and prevents the escape of any air from the blowers. The acid will be carried by the over-flow pipe into a lead tank situated on the ground, a short distance below the over-flow pipes. This storage tank shall be of sheet lead, of the same kind as other tanks, one and three quarters deep and four and one-half meters square, and securely enclosed in a strong wooden crib. From this storage tank, the acid will flow by gravity into an ordinary cast-iron sulphuric acid egg of the type in common use in a sulphuric acid plant. This egg is to be buried one and one-third meters under the ground and the acid will be pumped from it to the tops of the distributing tanks on top of the towers, by compressed air. One storage tank and one acid egg will suffice for the two towers--the egg is to be cast by the Works.

Just in front of the over-flow pipes near the top of the lead pans, there is to be a large door in each tower. The steel will constitute the door and the brick work and the single course of heavy tiles are to be arched so as to expose the lead pan, and to observe the operation of the tower. In this way one will be able to tell whether or not the towers are working properly, whether the flow of acid needs regulation, et cetera. This door in the steel plate is to be two meters high from the top of the arch and one meter wide.

QUALITY OF ACID, ITS HANDLING, ET CETERA.--The common black, impure, chamber acid is to be used, sixty-degree Baumé, containing about seventy percent acid. In repeatedly passing over the two towers, the acid becomes weak, due to the absorption of moisture. When it is so weakened that an analyzed sample of the air issuing from No. 2 tower shows too much moisture, 33.33 percent of the acid is to be removed from the system. This is to be replaced by other acid kept in reserve and concentrated by boiling in an ordinary cast-iron concentrating pan. There are to be two of these pans, to be made by the Works, and to be one and one-third meters wide, two meters long, and fifty centimeters deep. These concentrating pans are to be built into ordinary brick work and to have a common grate underneath them. The weak acid is to be heated to such a temperature that the water will be driven off, but not so high that either sulphur dioxide or trioxide will be driven out. When the acid is brought up to sixty or sixty-three Baumé, it is again ready to go over the towers.

As this kind of an installation is an entirely new one, or at any rate, I am unable to learn of its ever having been used in any country, the quantity of acid which must be distributed over each tower must be determined by trail, as there are a number of conditions which will affect the quantity necessary. However, it must necessarily be far greater during the hot weather than during the cold. The atmosphere during the sweltering months is almost saturated.

After planning the above scheme, I wrote the chemist of the Works, regarding it. He replied that my scheme was unquestionably the most efficient and the only draw-back to it of which he could think might be the cost of sulphuric acid.

He further stated that it was only a question of time until the company would install some sort of apparatus to dehydrate the air, as they were aware that it would be a paying proposition and that in the summer months especially it would mean a tremendous saving in coke.

Just at present, I know of no sulphuric acid plant in China, but with this tremendous mineral wealth of lead, zinc, copper, pyrite, et cetera, it certainly does seem quite likely that sulphuric acid plants are sure to put in an appearance in the near future. In such an event, the price of sulphuric acid would not be a draw-back.

The idea of having the towers divided in the center and have the air ascend one side and descend through the other just as it does in the Cowper stoves, was considered, but as it would complicate the construction and likewise the operation, it was decided not to use this method. Moreover, if this should be done, it would mean that the air and acid would be traveling in the same direction through half of the tower and this would certainly not be good practice. The air is to enter No. 1 tower through an iron pipe one and one-third meters diameter, and placed two meters from the bottom of the lead pan. It is to leave No. 1 tower through a similar pipe placed the same distance from the top of No. 1 tower and is to be conducted into No. 2 tower in exactly the same manner, and from No. 2 tower, it is to go direct to the Cowper stoves. Samples of the dehydrated air leaving No. 2 tower will be analyzed at stated intervals and the flow of acid so regulated as to extract the moisture to the desired extent.

The labor required in this scheme will be practically nil, but in any case labor is an item of no consequence. One man to pump the acid from the egg to the top of the towers is all that will be required, and it need not require all of his time.

The following is the amount of material necessary for this installation, its estimated cost, et cetera:

Red Brick, 95,000, at $9.50 Mexican, per thousand . . $902.50

Sheet Steel, 40.5 tons at $70.00 Mexican per ton . . 2835.00

Heavy Acid-Proof Tiles, 10 cm. x 25cm. x 30 cm.--- 5500 at $20.00 per ton 110.00

Tar for painting the tile and for the twelve centimeter-layer between the red brick and the heavy acid-proof tiling will be very cheap, but I am unable to obtain any authentic figures.

Acid Packing Tiles, 5400 at $22.00 per thousand. . . . 118.80

Lead Tanks, including two covers, 25.5 tons, at $140.00 per ton 3570.00

Lead Pipes 325.00

Concrete required for the two towers, 33.33 cu.m. at 3. 100.00

For wooden timbers, et cetera. 80.00

For Bolts, et cetera. 150.00

As construction here is notoriously cheap, probably would get both erected for 800.00

It is difficult to ascertain just the amount of acid required so no figures are of value.

Total as far as can be ascertained . . . . $. 8991.30

These two towers could certainly be constructed for $10,000.00 Mexican, or about $4,200.00 gold, this allows a very liberal margin.

Amount of air blown to the furnaces, etcetera,--Each furnace requires four hundred cubic meters of air per minute, or for the two blast furnaces per twenty-four hours, this amounts to 1,152,000 cubic meters.

I regret exceedingly to state that the company has not deemed it expedient to give me data necessary to figure just what the saving of fuel would be. However, this is partly due to the fact that they do not have a part of it available, but they admit that an efficient dehydrating scheme would be a great money- saver.

Very frequently the temperature here will register from ninety to one hundred six degrees during the summer months and the humidity will register as high as ninety-eight percent, and has even reached ninetynine percent.

It now becomes a simple matter to calculate the total quantity of moisture in the air blown to the blast furnaces per twenty-four hours. The calculation is as follows:

One cubic foot of air at 0 degrees Farenheit, is capable of holding one-half grain of moisture; at sixty degrees Farenheit; five grains; at eighty degrees Farenheit, eleven grains; at one hundred degrees Farenheit, twenty-one grains. Four hundred cubic meters of air are delivered to each blast-furnace per minute. This amounts to 1,152,00.00 cubic meters per twenty-four hours for the two furnaces.

1 cubic meter equals 37.0 cubic feet

1,152,000 by 37 equals 42,624,000 cubic feet.

When the humidity test is ninety-eight percent and the temperature one hundred degrees Farenheit, each cubic foot of air would contain 20.6 grains of moisture and 42,624,000 cubic feet of air (the total delivered to the furnace per twenty-four hours) would contain 878,054,400 grains.

1 grain equals 0.0648 grams

878,054,400 grains equals 56,897,925.12 grams equals 56,897,925 kilograms equals 56.897,925 metric tons of moisture per twenty-four hours.

To raise 1 gram of water 1 degree Cenitgrade required 1 calorie, Assuming thirty-eight degrees Centigrade as the ordinary atmospheric temperature and 1550 degrees centigrade as the average temperature at the tuyere, this tremendous quantity of water must be raised to a temperature of 1512 degrees Centigrade. This will require 86,029,662,782.44 calories (56,897,925.12 by 1512 degrees) in all.

The above calculations are, in all probability, based upon the maximum amount of moisture which the air will contain, or, at any rate, above the average.

The works were rather reluctant in furnishing me data as to amount of coke used in winter and that used in summer and they have no record of the average monthly or yearly humidity tests or temperature of atmosphere, hence, I am not able to base my calculations upon any definite experimental data. However, I am informed by the chief chemist that he has often observed the humidity register to show ninety-eight percent and occasionally ninety-nine percent.

In view of the fact that it is impossible to secure this date, my only recourse is to assume an approximate maximum and minimum and then strike an average. This answers for our present purpose and it will require some experimenting to learn the proper quantity of sulphuric acid to run over the towers and also the quantity of coke which this scheme will save.

Assuming the temperature for the months of May, June, July, August, and September, to be 86 degrees Farehheit and the humidity test at 75 degrees (which is more than likely somewhat low) the total amount of moisture in the air would be just a little over half the above figure so that somewhat over half the above calories would be required.

The calorific power of Hanyang coke (so far as I am able to ascertain) is about 6900.

It is then an easy matter to calculate theoretically the quantity of coke required to give 86,029,662,782.44 calories (the maximum) or the assumption for the average. However, as many other considerations enter in and the theoretical would not work out properly in practice, I do not give theoretical figures.

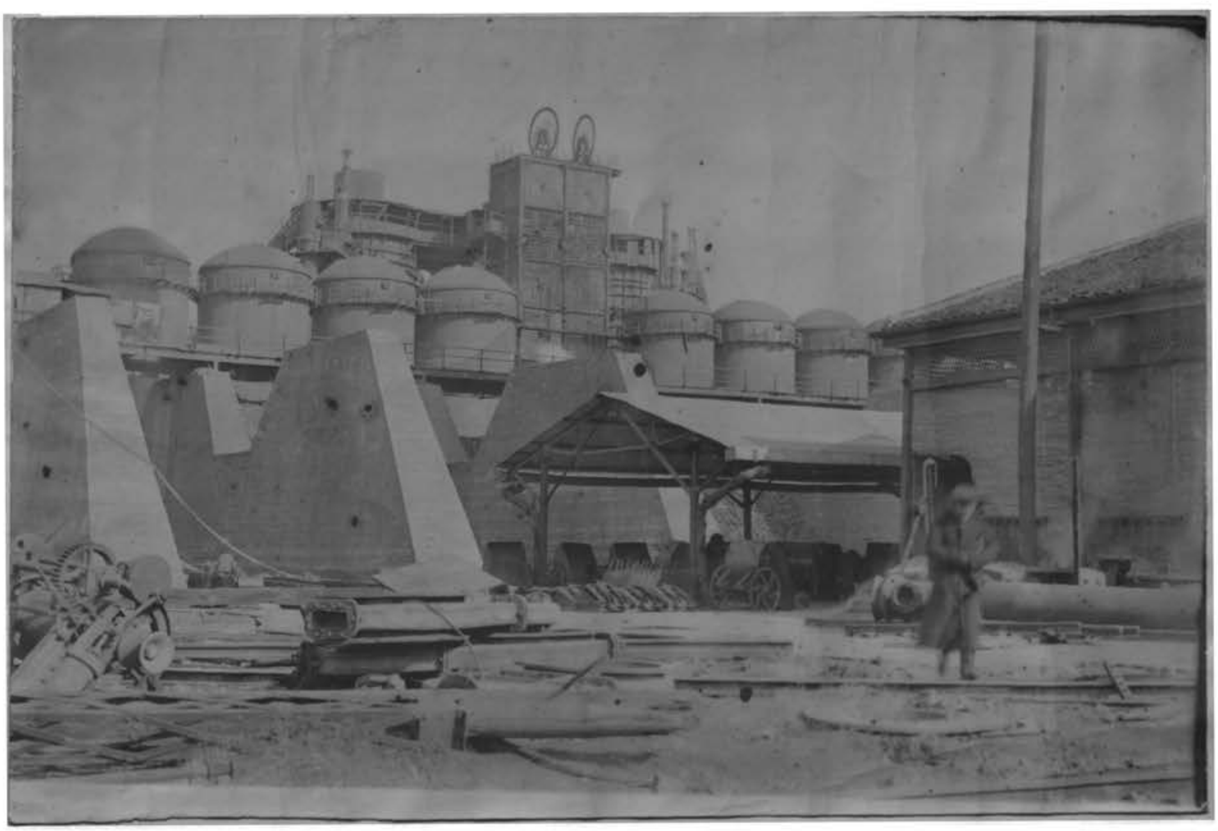
Another improvement which would add greatly to the output of the works deserves mention. As stated above, the company at one time used the Bessemer process, but owing to high phosphorous and executive complications as well, it was abandoned and they have never been favorable toward it since. The output could be increased tremendously by blowing all of the pig as it is drawn from the Wellman mixer in a Bessemer converter for thirty minutes, and thus disposing of practically everything but the phosphorous, and then transfiguring it to the present Siemens-Martins for a short time to take out the phosphorous. This combination scheme would increase the amount of steel per day over 200 percent.

Up to the present time the company has made rail, sheet, bolt, and fish-plate steels only and until they wish to make general structural steel, I dare say they would not entertain a proposition of installing the combination scheme--open -hearth process producing better rail-steel.

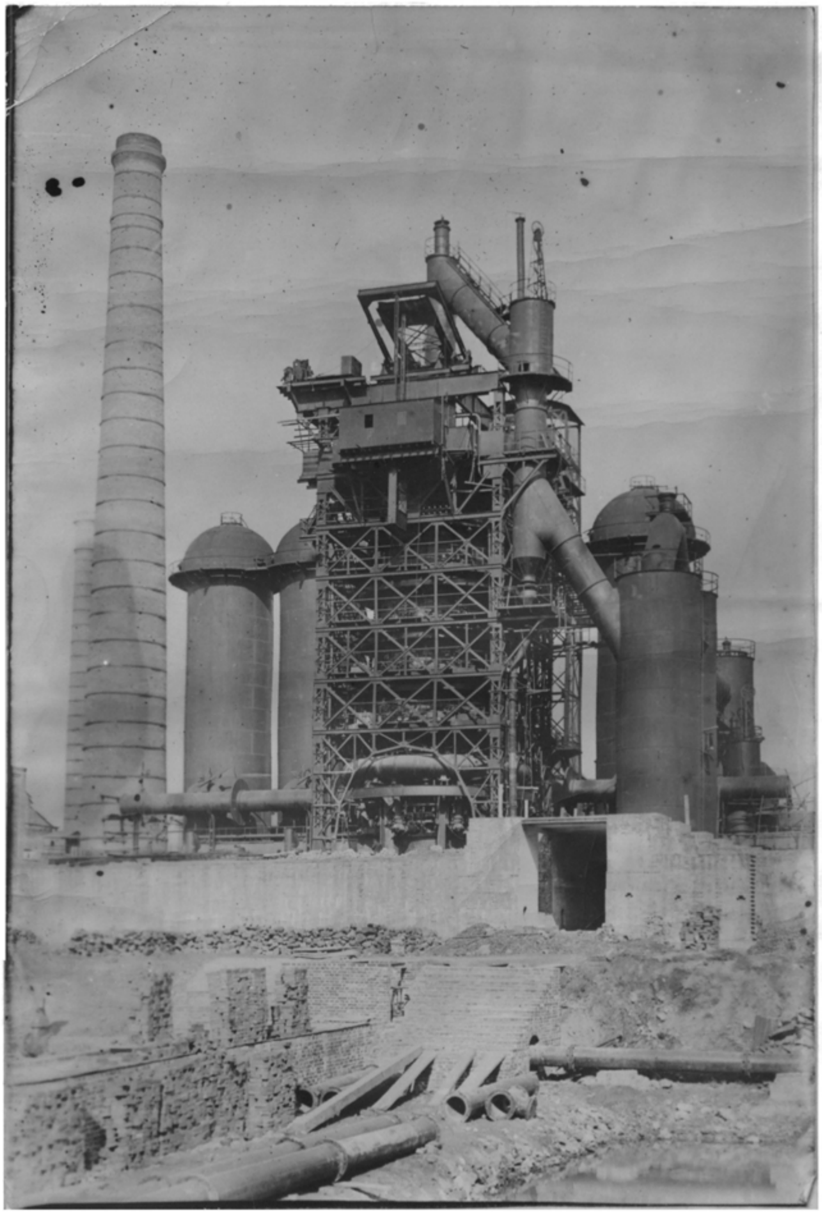
It was stated that the most important of the analyses given ware made by myself. This statement needs modification. When this thesis was first begun, I had planned to make practically all of the analyses used in it, but owing to my decision to leave China several weeks in advance of my first intention, I was unable to give the time for all of the analyses used. However, I did make similar analyses on the rail-steel, bolt-steel, and total carbon in pig iron; that is to say, I did exact analyses on steel for combined carbon, graphite carbon, sulphur, manganese, silicon, phosphorous, and the total carbon in pig iron, phosphorous, and sulphur in pig iron.

The other determinations which I have used were made by the chemist.

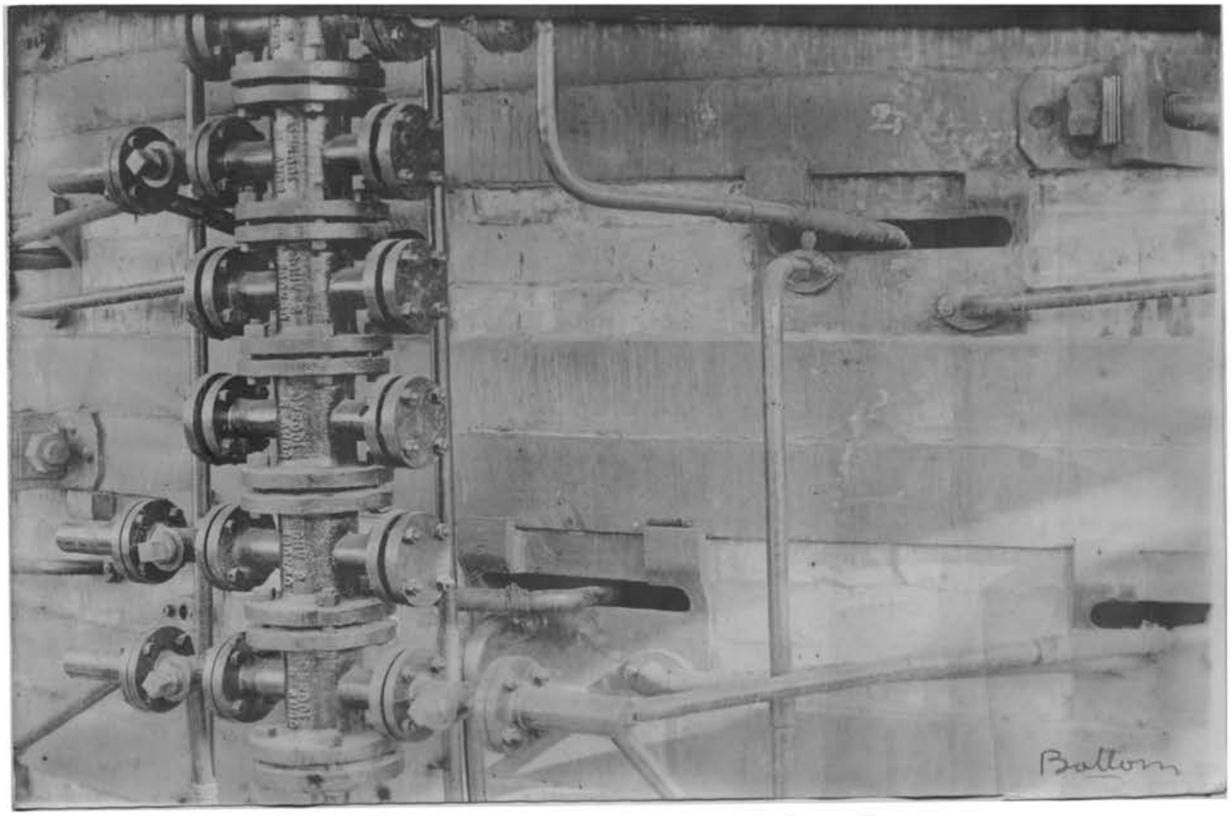
1-General View of Plant as far as Blast Furnaces--
New Furnaces to Left; Old Furnaces beyond it.



2-Blast Furnaces which are now in Operation--One-
storage compartments just in front of Furnaces.



3-View of New Blast Furnace (250-ton pig per day), to be blown-in April tenth.



4-View Showing New Method of Cooling Furnace. (It was impossible to take this from a better standpoint).

5-Another General View of Plant, New Furnace in Background to left; Old Furnace just back of it, and Hankow in distance (across the Han Kiang).