An Integrated Production System for Manganese Ferro-alloys

by T. TOMIOKA*, M. MISAWA*, and T. HANANO* (presented by Mr Misawa)

SYNOPSIS

The Japanese ferro-alloy industry in the 1970s is tackling the enlargement of its production facilities and undertaking various rationalization steps after emerging from old multitype, small-scale production systems. However, Japan is faced with various problems, such as over-dependence on overseas raw materials, a shortage of energy, and environmental pollution.

Under these circumstances, Japan Metals and Chemicals Co. Ltd has set up a rational closed system by efficiently combining both hardware and software and considering these problems fully in planning and constructing an integrated manganese ferro-alloy plant at our Takaoka Works. Such efficient, integrated plants will be required for the improvement of the world's ferro-alloy production facilities in the future.

INTRODUCTION

In recent years, especially after 1970, Japanese ferro-alloy companies constructed many large-scale, closed electric furnaces equipped with rational and pollution-free ferro-alloy production facilities to meet the increasing demands for ferro-alloys resulting from a rapid increase in the production of iron and steel.

Japan Metals and Chemicals Co. (JMC) started operation of a 35,85 MVA high-carbon ferromanganese electric furnace in November 1970 and a 6 MVA medium-carbon ferromanganese electric furnace in September 1971 at its main plant, Takaoka Works. Moreover, it started operation of a 51 MVA silicomanganese electric furnace in April 1972 and a 120 000 t fertilizer plant in October 1972, thus completing an integrated system.

The JMC group has carried out the engineering design of all these plants by the effective combination of hardware and software based upon their experience in the operation of closed furnaces.

Another characteristic is that a variety of new ideas has been adopted to combine all parts of the electric furnaces and their auxiliaries systematically and efficiently into a general plant. So we firmly believe that our unique system will play a very important role in the efficient utilization of material and energy resources and in the making of a pollution-free plant.

This paper describes our manganese ferro-alloy plant, its characteristics, and the state of operations.

EFFICIENT LAYOUT OF UNIT PLANTS

For more than ten years, JMC has been endeavouring, by systematic projects, to make efficient capital investments for concentrated production and to build up a consolidated manganese ferro-alloy plant by rationally combining the production processes of high-carbon ferromanganese, silicomanganese, and medium-carbon ferromanganese.

In the selection of equipment for the complete production plant, the interchangeability of equipment was examined carefully by our engineers, and we set up each piece of equipment in such a way that it could be efficiently connected with the remainder. Rather than set up independent plants, therefore, the rationalization of our equipment has eliminated many disadvantages, some of which include the unnecessary waste of capital investments caused by the overlapping of equipment, waste of time, transport loss, etc. Because of the recent use of especially large units, our plant as a whole has produced satisfactory results.

Figure 1 shows the interrelation between individual processes in the manganese ferro-alloy plant.

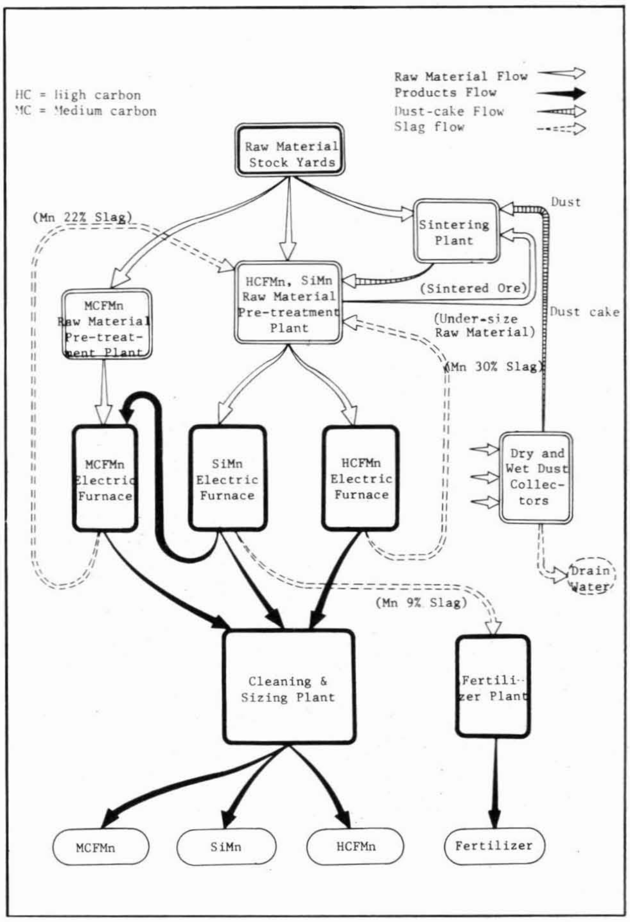

Figure 1
Interrelation between individual production units

THE EFFICIENT USE OF RAW MATERIALS

As mentioned before, the proper arrangement and combination of manufacturing processes plays an important role in raising the production efficiency. We shall

*Japan Metals and Chemicals Co., Ltd, Japan.

describe here the efficient use of raw materials.

Figure 2 shows the flow of materials involved in the whole plant, which consists of production units for high-carbon ferromanganese, silicomanganese, medium-carbon ferromanganese, and fertilizers.

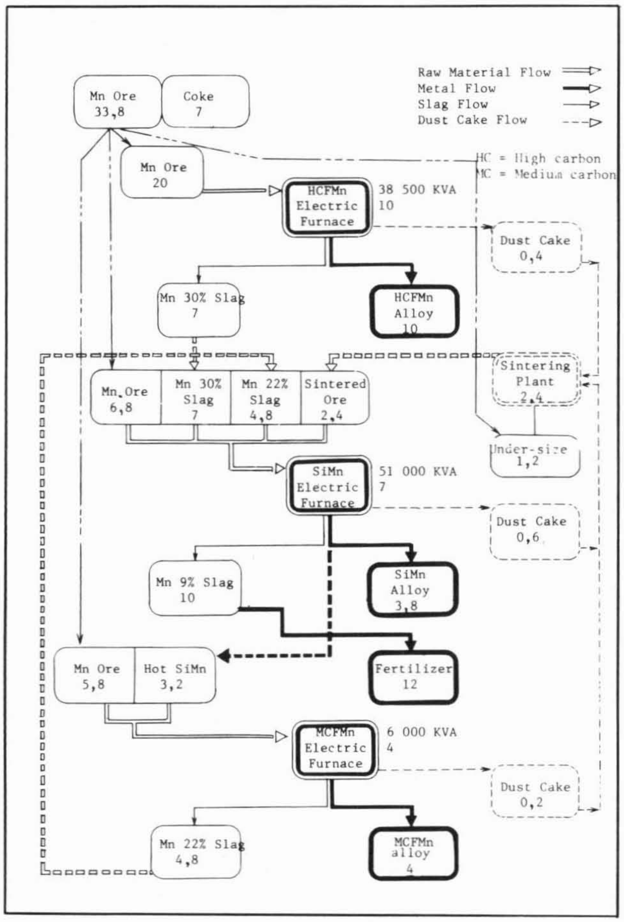

Figure 2

Efficient use of raw materials (unit 10 000 t on an annual basis)

In the first stage, the raw-material plant crushes, dries, and screens the raw materials for high-carbon ferromanganese, silicomanganese, and medium-carbon ferromanganese according to the requirements of the electric furnaces. The ores are crushed to between 70 and 5 mm, and the material smaller than 5 mm is sintered. Similarly, the coke is crushed to between 25 and 3 mm, and what is under 3 mm is used for sintering and prereduction. The water content after drying is set at 1 per cent in the ore and 3 per cent in coke.

This will therefore result in an economical process with improved evolution of furnace gas and smelting reaction, which will enable stable operation of closed-top furnaces to be conducted.

The dry dust and wet slurry cakes collected in this plant are sintered together with undersized ore. They are mixed in the ratio of 30 per cent dry dust, 20 per cent slurry cakes, and 50 per cent undersized ore. The sinter is then used as raw material for silicomanganese production.

Table 1

Composition of dry dust and slurry cake

	Mn %	SiO_2 %	Fe %	Al_2O_3 %	CaO %	P %	K_2O %	Na_2O %	C %	Moisture %
Dry dust	30	17	9,0	5,0	6	0,06	1,5	0,5	8	—
Slurry cake	22	13	6,5	6,5	6	0,06	1,0	0,3	16	36

The carbon monoxide from the electric furnaces is used as fuel for drying and sintering of the raw materials.

Table 1 shows a typical composition of dry dust and slurry cake. The latter can be used as raw material for sintering because it contains a very small quantity of K_2O and Na_2O as a result of its wet treatment.

The content of water in the slurry cake should be a maximum of 40 per cent for transport and mixing. Table 2 shows a typical composition of dust-cake sinter.

Table 2

Composition of dust-cake sinter

Mn	SiO_2	Fe	Al_2O_3	CaO	P	K_2O	Na_2O	C
40	16	7	6	6	0,08	0,8	0,3	1

In the next stage of the manufacturing process for high-carbon ferromanganese in a completely closed electric furnace, slag with the composition Mn 30 per cent, SiO_2 23 per cent, CaO 16 per cent, and Al_2O_3 13 per cent and a high-carbon ferromanganese product of composition Mn 75 per cent, Si 0,2 per cent, C 7 per cent, and P 0,2 per cent, are produced. The product is shipped after it has been sized in the product-treatment plant. The slag is stored and subsequently recycled to the raw-material plant, where it is treated as raw material for the production of silicomanganese. Also in the silicomanganese manufacturing process, a slag of composition Mn 30 per cent and SiO_2 23 per cent, and dust-cake sinter are used as raw materials together with low-grade ores and quartz. The greater part of the silicomanganese (Mn 62 to 67 per cent, Si 15 to 19 per cent, C 2,3 to 1,5 per cent, and P 0,1 per cent) produced here is sized in the product-treatment plant and then shipped. A part of the silicomanganese, however, is hot-charged as raw material for the production of medium-carbon ferromanganese. The slag (Mn 9 per cent, SiO_3 39 per cent, CaO 27 per cent, and Al_2O_3 12 per cent) produced simultaneously with the silicomanganese is stored and recycled to the fertilizer plant, which ships it as a manganese-bearing or regular calcium silicate fertilizer after it has been properly processed.

Thus, the use of slag as a fertilizer lowers the production cost for silicomanganese by a large amount.

In the manufacturing process for medium-carbon ferromanganese, silicomanganese is hot-charged and promptly refined together with pretreated ores and lime. A medium-carbon ferromanganese product (Mn 77 to 82 per cent, Si 0,1 per cent, C 1,3 to 1,8 per cent, and P 0,18 per cent) is manufactured together with a slag (Mn 20 to 22 per cent, SiO_2 28 per cent, CaO 34 per cent, and Al_2O_3 4 per cent). The medium-carbon ferromanganese is sized in the product-treatment plant before it is shipped. The slag is stored and recycled as raw material for the production of silicomanganese.

As mentioned above, the goods manufactured in each process are shipped as products or recycled as raw materials. Thus there is no external discharge, which means no industrial waste.

Needless to say, as an antipollution measure, dust collectors, including equipment used for improving the working environment, and waste-water control equipment have been installed throughout these processes. The waste water is treated chemically and is finally discharged to the outside. When discharged, therefore, its pH value is maintained between 6 and 8, its SS at less than 20 p.p.m., and its cyanide concentration at less than 0,1 p.p.m. A part of this waste water is re-used as occasion demands.

These procedures serve the double purpose of preventing pollution and reducing the ferro-alloy production cost by a large factor.

THE EFFICIENT USE OF ENERGY

To make the most efficient use of energy, our manganese ferro-alloy plant uses 84,1 per cent of the carbon monoxide generated by the electric furnaces.

Table 3 shows an example of the composition of the cleaned furnace gas.

Table 3
Composition of furnace gas

	Furnace for high-carbon ferromanganese %	Furnace for silicomanganese %
CO	45	70
CO_2	50	25
H_2	3	3
O_2	0,2	0,2
N_2	Rest	Rest
SO_2	Trace	Trace
kcal/Nm^3	1432	2192
kcal/t	7,5 x 10^5	15,3 x 10^5

The gas generated in the electric furnaces is sent to a gas-holder, and is mixed and distributed to the combustion equipment of each plant. One characteristic of this gas is that it contains little SO_2. As a fuel, therefore, it is much superior to heavy oil.

Figure 3 shows an example of the utilization of the carbon monoxide.

About 16 million litres of heavy oil can be saved annually by the effective use of the carbon monoxide as an energy source in this way.

RESULTS

As mentioned before, the profits will be tremendous if the equipment is laid out efficiently and the materials and energy are used and combined in the most efficient way.

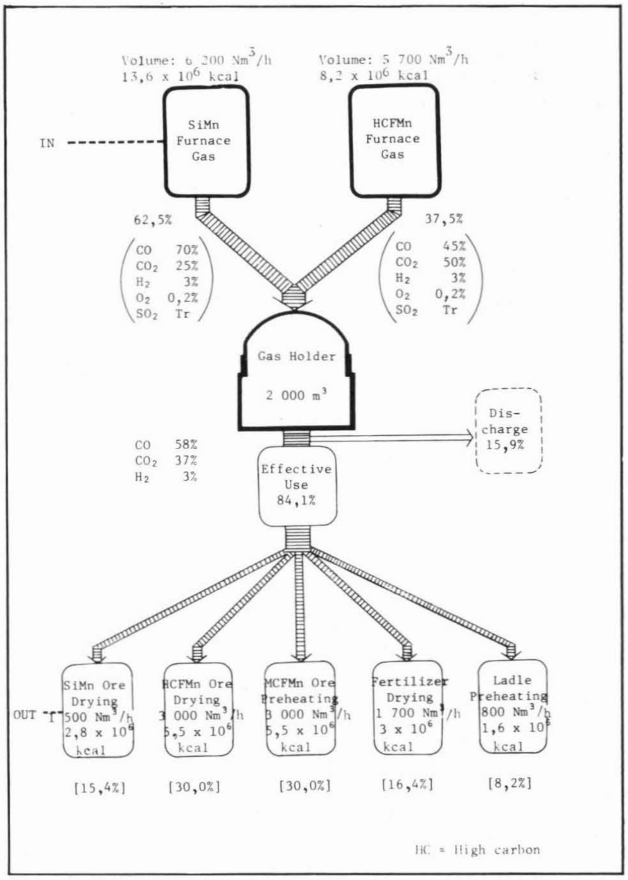

Figure 3
Efficient use of carbon monoxide gas

Today's ferro-alloy industry is making great efforts to improve its productivity on a worldwide basis. It is believed that the abovementioned establishment of an integrated and closed system having a high production efficiency should constitute one of the ways in which this can be done. In addition, this will automatically release us from the environmental pollution problem.

Table 4 is a list of operation records of high-carbon ferromanganese, silicomanganese, and medium-carbon ferromanganese plants at JMC's Takaoka Works.

Table 4
List of operation records

	High-carbon ferromanganese	Silico-manganese	Medium-carbon ferromanganese
Capacity of transformer, kVA	38 500	51 000	6 000
Load, kW	23 000	33 000	3 100
Power consumption, kWh/t	2 100	3 700	500
Material consumption, kg/t	Ore 2 080	Ore 3 040	Silico-manganese 800
Mn recovery, %	78,0	85,0	75,0
Composition of alloy, %			
Mn	75	62	82
Si	0,1	15	0,1
C	7	2	1,3
P	0,2	0,1	0,18
Composition of slag, %			
Mn	30	9	22
SiO_2	23	39	28
CaO	16	27	34
Al_2O_3	13	12	4

In presenting the paper, **Mr Misawa** pointed out that internal circulation and the usage of byproducts (furnace dust, slag, and off-gases), when incorporated from the beginning of the planning, will result in a very compact design (see Diagram 1). This practice also reduces pollution and byproduct dumps, which are seen all too often in ferro-alloy plants.

In conventionally built plants, 15 per cent of the useful solid products and about 50 per cent of the useful gases are normally wasted. In the integrated plant described, such wastage has been reduced to a negligible amount. A saving of heavy oil – very valuable in today's energy crisis – is also reported in this plant.

DISCUSSION

Mr M. Sciarone:*

To what temperature do you preheat the ferromanganese ore?

Mr Misawa:

To between 1100 and 1200°C.

Mr A.G. Arnesen†:

Figure 2 of your paper seems to indicate that you sinter 24 000 tonnes a year. What is the capacity of the sinter plant, and do you operate the plant continuously?

Mr Misawa:

The capacity is 400 tonnes per day, and the plant operates most of the time.

Mr A.G. Arnesen†.

Do you have any problems with the mixing in of wet sludge?

Mr Misawa:

The moisture content of the slurry cake is 20 per cent, and we do not have any problems.

Mr Nauta:*

What is the secondary current in your high-carbon ferromanganese furnace?

Mr Misawa:

It varies between 100 000 and 120 000A.

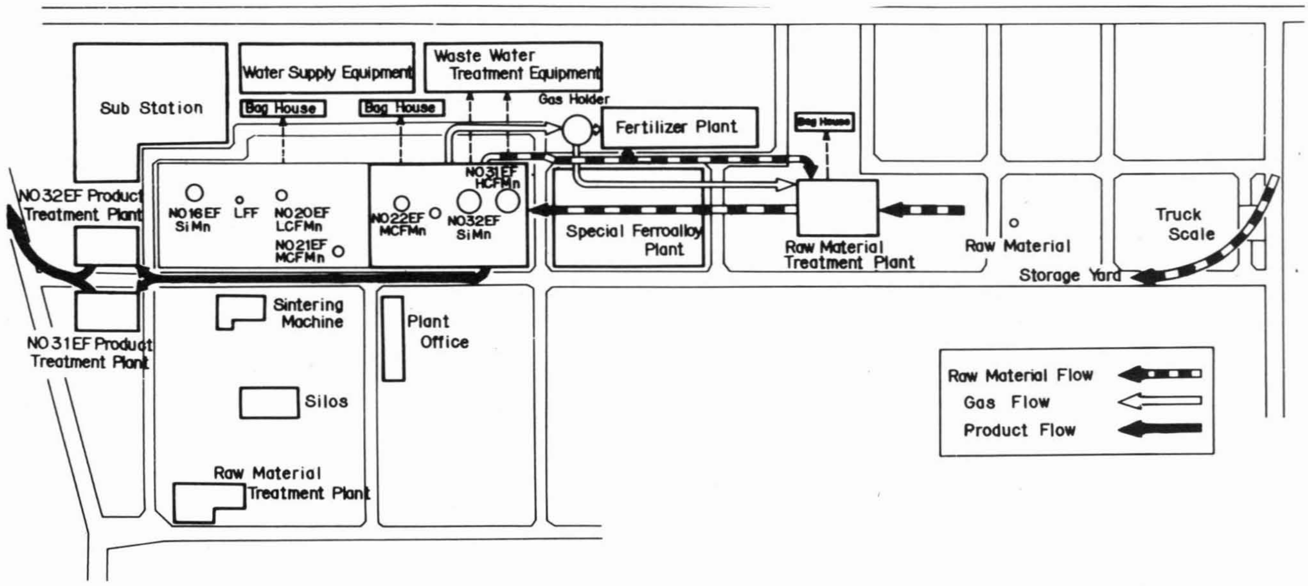

Diagram 1

Layout of the Takaoka works, Japan Metals and Chemicals Co., Ltd

*Metalloys Limited, South Africa.

†Elkem-Spigerverket a/s, Norway.

*Amcor Limited, South Africa.