MINTEK'S NEW 1 MW PLASMA FURNACE

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1. INTRODUCTION

Mintek's original 1 MW plasma furnace was installed and commissioned during 1983[1]. Between 1984 and 1986, a number of campaigns were carried out, which, although successful, highlighted a number of shortcomings on the facility. During 1988, the facility underwent a major reconfiguration:

(a) to increase the versatility of the facility, allowing it to cater for a wider variety of applications,

(b) to incorporate a number of technological improvements that had been developed on Mintek's smaller-scale plasma facilities, and

(c) to upgrade the facility, particularly for smelting work, and to include provision for the future installation of a converter.

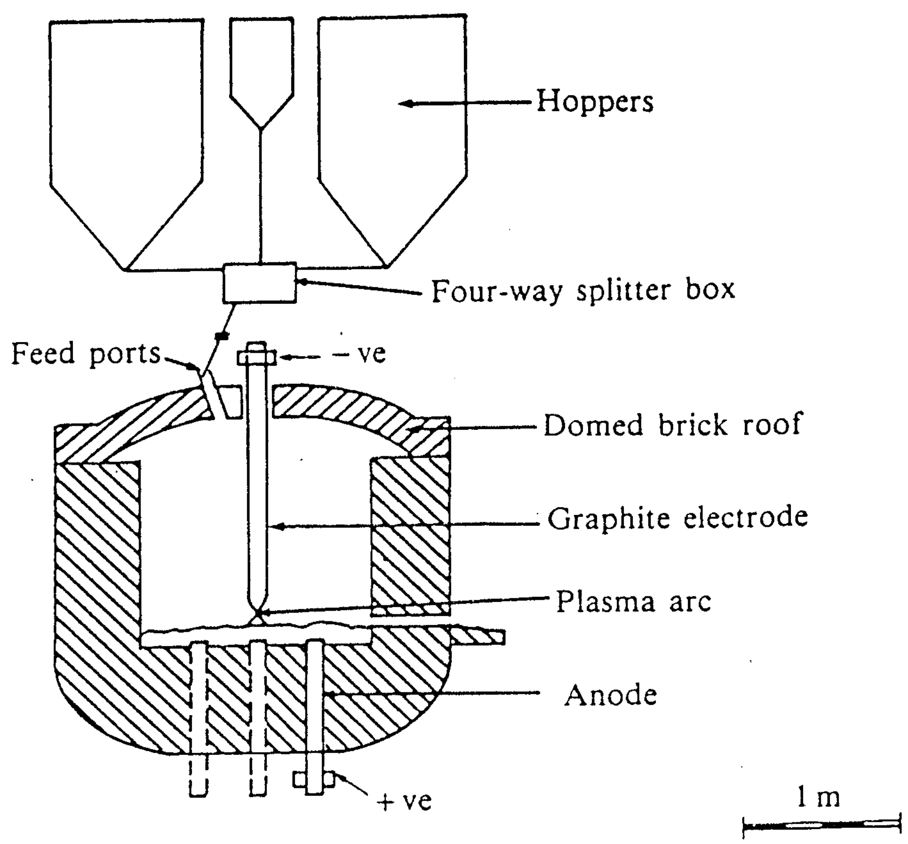
2. FACILITY MODIFICATIONS

The major modifications to the facility are described under separate headings. The basic differences are shown in Fig. 1.

2.1. The Support Structure of the Furnace

The original support structure of the furnace was fixed and specific to the furnace. This was replaced by a

The previous 1MW furnace



The new 1MW furnace

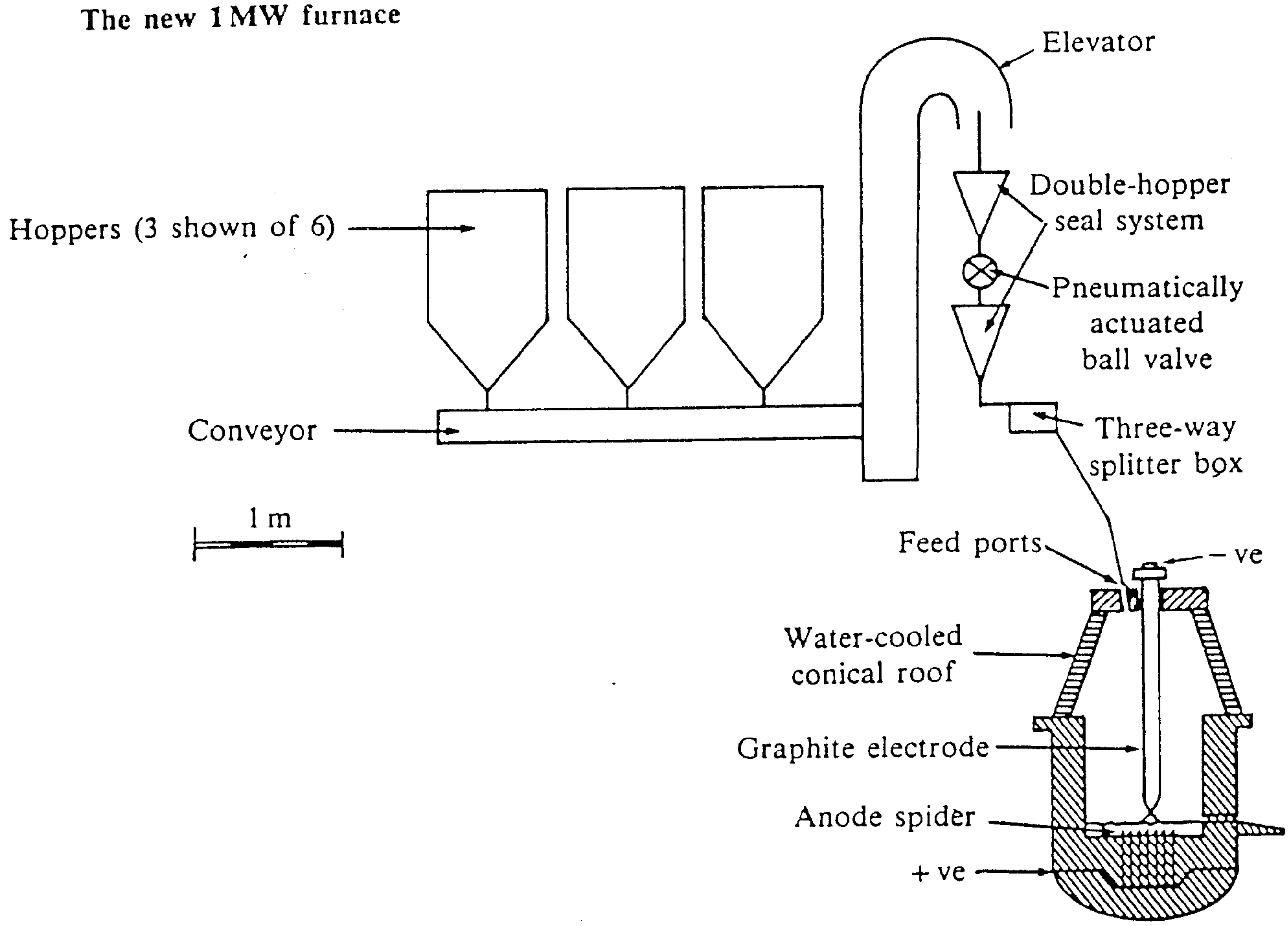


Fig. I.—A schematic drawing showing the basic differences between the old and new furnaces on the 1 MW facility bogey-and-rail system. The furnace-support bogey is flexible in that it can accommodate different furnace shells or reactors. The bogey rests on rails, which allow the whole furnace to be moved into the bay for easy access and the rapid replacement of furnace shells.

2.2. The Feed System

A new, sealed, 6-component feed system, capable of handling dry feed materials ranging from 100 μm to 12 mm, was installed. As a result, a wider range of metallurgical evaluations can now be covered, since a large number of components can be fed simultaneously to the furnace. The overall gas tightness of the furnace has been dramatically improved by sealing of the feed system by the use of a double-hopper seal with a pneumatically actuated ball valve, enclosed conveyors, and flexible bellows. This modification has reduced the escape of furnace off-gas and improved the safety of operation and pressure control in the furnace. Each hopper, which has a volume of 900 litres, is fitted with an independently controlled vibratory feeder. Table I gives examples of the quantities of various types of materials that can be accommodated in the hoppers. The feed system can deliver up to 2 tons of total feed recipe per hour to the furnace.

2.3. The Furnace Off-gas Cleaning Plant

The previous hydrosonic scrubber did not have a very high cleaning efficiency (less than 42 per cent collection of

TABLE I

Examples of quantities of materials that can be accommodated in the hoppers

Material	Bulk density t/m^3	Mass kg
Metal fines	3,0	2700
Chromite	2,0	1800
Quartz	1,4	1250
Coal	0,7	650

particles smaller than 1 μm), and the product was a very watery sludge that was difficult to process. A new reverse-pulse bag filter with a high cleaning efficiency was installed.

The filter, which is capable of handling 5000 m^3 of gas per hour at 190°C, has enabled Mintek to widen the range of investigations that can be undertaken, e.g. fuming processes where the product is carried out in the off-gas stream. The product is then easily recovered via a rotary valve at the bottom of the bag filter.

The new bag filter was incorporated with the hydrosonic scrubber in such a way that they can be used independently, or the scrubber can be used after the bag filter to remove unwanted gases, e.g. sulphur dioxide.

2.4. The Water-cooling System

A multipurpose cooling-water delivery system was installed. The system is very flexible and is designed to meet the requirements of the wide range of reactors that the bogey can accommodate. Water is supplied at a pressure of 600 kPa, while the flowrates in the different circuits vary from 1 to 10 m^3/h at an inlet temperature of less than 20°C. Each circuit is fitted with a rotameter and resistance temperature detectors (RTD) for the determination of the heat loss from a particular section of the furnace. Table II gives a breakdown of heat losses on the water-cooled 1 MW furnace.

2.5. The Furnace Shell

The outer diameters of the furnace shells that can be accommodated have been reduced considerably, thus decreasing the refractory mass and the cost of a furnace re-line. However, no corresponding reduction in the maximum power levels or feed rates are expected and, because the internal diameter of the hearth has also decreased, higher power and feed fluxes onto the smaller internal area of the hearth can be attained. The height-to-diameter ratio has been increased, the overall height of the furnace being retained while the diameter was reduced. This has increased the available freeboard in the furnace for future developments such as inert gas stirring and gas injection. Table III compares the original 1 MW furnace and the new furnaces.

3. GENERAL OPERATION

3.1. The Furnace Power Supply

The power supply consists of two six-pulse thyristor drives, each capable of supplying 750 V at 1800 A. Each drive can be run separately for low powers (e.g. 100 to 400 kW), or they can be run together in the twelve-pulse mode in series to supply 1500 V at 1800 A or, in parallel to supply 750 V at 3600 A. The drives can be operated

TABLE II

Breakdown of the heat losses on the water-cooled 1 MW furnace

Furnace section	Measured heat loss* kW	% of total
Conical roof	80,6	13,4
Flat roof	26,2	4,4
Side walls	52,8	8,8
Off-gas port	11,0	1,8
Hearth	15,6	2,5
	185,6	30,9

* At an operating power of 600 kW and a tapping temperature of 1500°C

TABLE III

Comparison of the original and new furnaces on the 1 MW facility

Dimensions	Original furnace	New furnace	
		Air-cooled shell	Water-cooled shell
Shell diameter, m	2,5	1,5	1,8
Furnace height, m	2,4	2,5	2,5
Internal diameter, m	1,5	1,0	1,3
Internal height*, m	1,5	1,75	1,75
Height/diameter ratio	1,0	1,75	1,35
Power flux at 1 MW, MW/m^2	0,5	1,27	0,75
Feed flux at 2 t/h, t/m^2h	1,13	2,54	1,51
Maximum tilt angle, degree	20	35	-
Typical working volumes, ℓ	500-600	300-400	400-500
Typical tapping volumes, ℓ	200	300	300
Envisaged converter charge, t	-	1 to 1,5	-

* Distance from hearth to roof

under two different modes, namely constant current or constant voltage. Table IV shows typical operating ranges that have been used on the 1 MW facility. The power supply has been described in detail elsewhere[1].

3.2. Furnace Control and Operation

During the campaigns conducted on the original 1 MW furnace, an overall control and operating strategy was evolved[2], and it was found that accurate control of the feedrate and the power to the furnace was essential. An imbalance between the feed-rate and the power can lead to serious operating problems in the furnace. If the furnace is underpowered, the bath can freeze and, if it is over-powered, unwanted side reactions and refractory erosion can take place. This control strategy has been further improved on the new facility to account more accurately for the effects of down-times following the development of these techniques in the smaller-scale furnaces. The maintenance of a good balance leads to stable operating conditions, which promote consistent metallurgical results. Table V gives the overall results of the commissioning campaign conducted on the new facility.

4. CONCLUSIONS

As a result of the major development and successful commissioning of the 1 MW facility, Mintek now has a very

TABLE IV

Typical operating ranges used on the 1 MW facility

Arc current, A	100 to 3600
Arc voltage, V	100 to 400
Arc power, kW	100 to 1200
Arc length, cm	25 to 60

TABLE V

Results of the commissioning campaign conducted on the new 1 MW facility

Batch mass, t	1 to 1,5
Tap mass, t	0,5 to 1
Tap-to-tap time, h	1 to 2
Duration of campaign, week	1
Feed material processed, t	30
Number of taps	40

useful, versatile plasma facility that is able to provide for a wide range of metallurgical evaluations. These improvements are by no means complete; the development of new equipment to meet the needs of industry is an ongoing challenge that Mintek is constantly striving to meet.

5. ACKNOWLEDGMENTS

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6. REFERENCES

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