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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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Agenda item 5

DEVELOPMENTS IN IRONMAKING PRACTICE[1/]

by

J. M. Ridgion
(British Steel Corporation
Corporate Laboratories, UK)

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SUMMARY

DEVELOPMENTS IN IRONMAKING PRACTICE[1/]

by

Mr. J.M. Ridgion
British Steel Corporation
Corporate Laboratories
United Kingdom

The paper is a report of a conference organized in London in November 1972 by The Iron and Steel Institute under the title "Developments in ironmaking practice".

The topics dealt with in the conference were steelmaking requirements, burden preparation, high top pressure operation, and furnace control.

The requirements of the steel melting shop, especially those operating LD converters, are increasingly stringent, particularly in regard to the sulphur content of the hot metal. A high degree of consistency in hot metal analysis is essential.

Burden preparation covered both pellets and sinter as burden components. The use of a mixture of pellets and super-fluxed sinter is especially commended. Recent developments in the mineralogical study of sinter are reported. Consideration is also given to coal preparation and coking. Various methods of coal preheating are discussed, together with methods of coke-oven charging.

High top pressure is discussed in terms of engineering and operational requirements. The use of the bell-less top, using an internal chute for burden charging, favours high top pressure operation and results in lower capital and maintenance costs.

Computer systems for blast furnace control, in use in Italy and the United Kingdom, are discussed, based on different parameters. Again the importance of sulphur control is emphasized.

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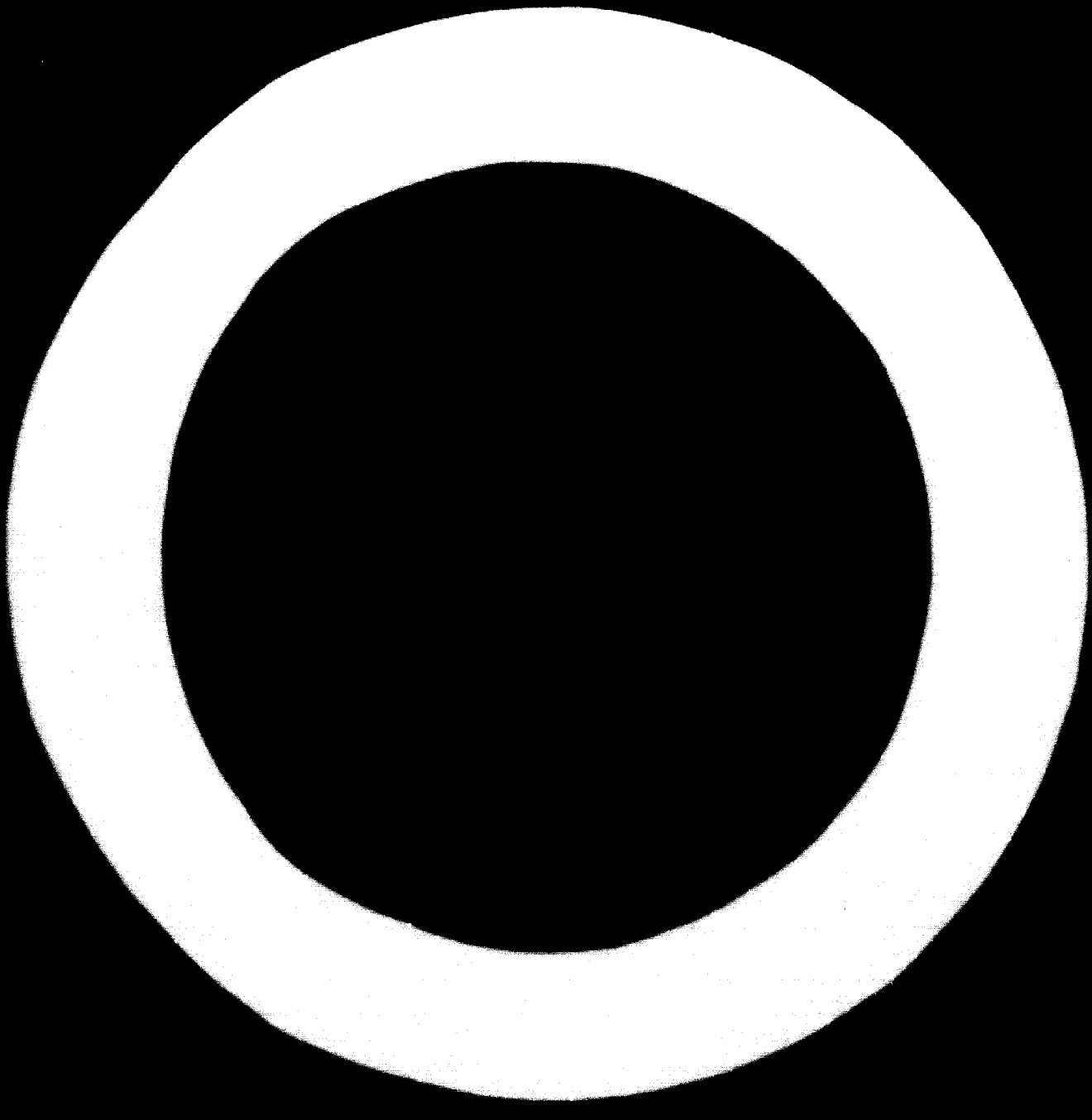

DEVELOPMENTS IN IRONMAKING PRACTICE

Some Notes on The Iron and Steel Institute Meeting held in London, in November 1972

The basic theme of this meeting was improved product control. It is recognized that steelmaking operations in the future, whether large-scale batch operations or continuous techniques with rapid throughputs, will present more stringent demands for consistency in ironmaking. This will apply to both quality and quantity of product, so that it is evident that related factors cover a wide and interesting field.

In all, fifteen papers were presented by authors from six countries and arranged under the headings of :

- Steelmaking requirements
- Burden preparation
- Aspects of high top pressure operation
- Furnace control.

A list of the titles and authors is given at the end of this report.

The first session commenced with an attempt to characterise quality targets for hot metal. Detailed plant studies of LD steelmaking for flat products emphasized the special part played by sulphur in determining the grade and value of the product. Other factors under the control of the ironmaker, such as silicon and manganese contents and product variability, are important not only in themselves but also in their influence on sulphur control. The paper constituted a reasonable assessment of the importance of consistency in ironmaking operations.

The next broad section of the programme dealt with burden preparation : pelletizing and sintering. The pelletizing papers - one general and one specific - were of interest in that the emphasis was on handling a varied burden at the point of consumption rather than in the conversion of a single ore into pellets for long-distance shipment. The various alternative processes were critically compared, strong and weak points being analysed. A survey of pelletizing installations throughout the world was included. This paper discussed product properties and commented on a tentative quality specification.

The more specific paper in this field was of particular interest to European operators, since it gave an account of experience in pelletizing imported ore mixes at IJmuiden. This was based on a 3 million t/year straight grate plant which was considered to have greater flexibility in dealing with a variable feed. Details were given of the gradual increase in productivity since commissioning and the range of ore supplies successfully treated. Operating results on the blast furnace emphasised the advantages of using pellets in combination with super-fluxed sinter. This, coupled with the ability to allocate available ores most advantageously between the two processes, led to significant economic advantages.

Sintering was dealt with in a most comprehensive survey of the relationships between sinter properties, mineralogical composition, and chemical composition. An examination of the changes brought about by variations in gangue constituents demonstrated the directions in which to seek optimum physical and chemical properties and provided a basis for quality control. It was noteworthy that favourable combinations of quality parameters were much easier to obtain at high basicity ratios. This fact

tied up well with the IJmuiden experience of using high-basicity sinter and acid pellets. In general, the work brought out useful relationships between desired properties, readily measurable parameters such as magnetic susceptibility, and plant quantities like fuel additions.

This linked up with a later paper on sinter plant automation, which was in the nature of a final report on the control of fuel addition in relation to magnetic measurements on return fines and the control of moisture by measuring mix permeability. This system, the development of which had been reported at earlier international conferences, has now been used for some years, including long runs in full closed-loop mode.

There was a lively discussion on the appropriate balance between sinter, pellets, and rubble ores. In an analysis of coke rates at IJmuiden, it appeared that economies were to be ascribed to the consequent increase in sinter basicity rather than straight replacement of sinter by pellets. The diversion of excessive fine material from the sinter mix to the pellet plant had also been advantageous. Opinions on fluxed pellets varied. It was clear that it is easier to flux pellets at the user site than at the mine, but even then the sinter plant was more amenable to flux control, and acid pellets plus super-fluxed sinter was probably the best combination. Rubble ores were becoming relatively scarce and size characteristics, together with low-temperature breakdown characteristics in some cases, might be unfavourable. The balance between ore and pellets must be largely an economic question.

Operators reported advantageous results from application of the results of the work on sinter mineralogy, claiming significant improvements in both quality parameters and yields.

In the United Kingdom, the quality of blast-furnace coke is of paramount importance, and any means of improving it are most relevant to the Conference theme. Two papers on the preheating of coal before carbonization were consequently important. The first paper dealt with alternative techniques for preheating coal and for charging it into the oven. Alternative methods of preheating involved entrainment heating and treatment in a fluidized bed, both having proved successful on a reasonably large scale. The charging operation was analysed in detail and the relative merits of alternative systems were discussed. In the one, the hot coal was charged by a car modified from the conventional type; high oven throughput and improved coke quality were claimed. In another system, the coal batch was introduced into the oven by a chain conveyor, while in the third the entire charge was blown into the chamber from a pipeline; this technique was most effective in avoiding atmospheric pollution.

A large-scale experimental application of coal preheating with gravity charging has been in progress in the UK during the last year, and this was the subject of the second paper. This work has shown significant improvement in coke quality, notably the micum 10 index. The increase in bulk density, coupled with reduction in carbonizing time, indicated a potential increase in productivity of 47%.

There was a lively discussion centring on the relative merits of the different methods of charging. It appeared that pipeline charging was the more effective in reducing atmospheric pollution, but was subject to greater loss of fine coal from the oven into the main. It was generally considered that preheating led to an improvement in quality or an ability to use a wider range of coals. Much remained to be learnt, but substantial benefits were to be expected.

One session was devoted to various aspects of high top pressure operation, there being papers concerned with broad principles, engineering aspects, including an account of a new charging device, and plant experience at the highest outputs.

General principles were discussed and the characteristics of elevated pressure operation analysed in relation to the effects of burden preparation. Influences on burden productivity were examined and illustrated by published statistics. The discussion was extended to include secondary effects on fuel consumption rates, iron quality, and refractory life.

A paper on engineering for high top pressure laid stress on the twin roles of the furnace top in securing controlled distribution and in providing a gas-tight seal. Increased pressures in recent years have made it necessary to separate these functions by providing separate bells or seating valves. In addition, more attention has had to be paid to ancillary details - pressurizing equipment, etc. - while gas-cleaning systems have had to be extensively redesigned.

An interesting development, the subject of a separate paper, was the bell-less top, employing an internal chute adjustable for throw and rotational angle. This opened up possibilities of much more elaborate control over the placing of the charge materials than hitherto, while top gas sealing systems were relegated to relatively small protected valve systems. A feature of the paper was an account of a year's operation on a furnace of 9.5 m hearth diameter. Although experience in making use of the wide range of charging patterns was incomplete, the results had been most encouraging and the claims of lower capital and maintenance costs had been largely substantiated.

The paper on practical operation with high top pressure at high outputs related to Fukuyama No. 4 furnace, which had achieved average productions of over 10,000 tonnes per day. This was currently the culmination of continued development at the plant and incorporated lessons gained in engineering and operating earlier units. Increase of top pressure to 2.5 kg/cm^2 necessitated important design improvements but contributed largely to smooth operation and high output. The paper gave a valuable account of the physical relationships which determine the appropriate pressures to be applied to furnaces of the greatest size and productivity.

In discussion, stress was laid on the importance of adequate knowledge of gas distribution in the furnace. The extensive range of control of the bell-less top made it necessary for the operator to have a full appreciation of its effects. Horizontal probes and stockline monitors were an increasing necessity. Admiration was expressed for the achievements of the NKK team in attaining an output of 10,000 tonnes per day.

A group of papers was presented relating to blast-furnace control techniques and the mathematical models upon which such systems must be based. Two of these related to existing computer systems, one in South Wales and the other in Italy. Both were designed to deal with transient states in the blast furnace. The former was based on a computer model representing the furnace as a series of horizontal slices. In simulation, the slices were sequentially processed to represent the passage of the ascending gases so that the development of the furnace parameters, including metal and gas analyses, could be forecast under various conditions. In particular, the effects of transient disturbances and various corrective actions could be assessed and optimum control choices made. Feedback from the furnace to the control system was used to modify and update the parameters of the process simulator.

The Italian model embodied transfer functions representing the response of the furnace to variations in a number of controllable parameters. The corresponding control system utilized blast temperature, blast humidity, and ore/coke ratio to maintain constant silicon in the product. The three parameters employed different response times and could be used over different ranges of corrective action. Considerable experience had been gained on three furnaces using an operator guide system, and significant improvements in uniformity had been achieved.

A rather different model was described which related to the physics of the blast furnace process which essentially influence production rather than fuel efficiency. Studies of flow and pressure drop had been made in a model blast furnace stack and related to material size and other characteristics. Attention was also directed to the phenomena of hanging and flooding and the determinative criteria. Comparison with plant data had shown the utility of the model and in particular the value of burden characteristics such as the "bulk fines index".

The final paper in the series was concerned with sulphur control and removal, and this related to the first paper, which had laid such emphasis on the importance of sulphur in the steelmaking operation. The author examined the various possibilities of producing low-sulphur iron from the blast furnace, with particular reference to practices involving high-sulphur fuels. He concluded that for the more stringent steel specifications some form of external desulphurization was almost inevitable. Various alternative desulphurizing agents were described and an account was given of a wide range of experimental and production techniques of application. It was pointed out that effective intermediate treatment would lead to a relaxation of technical constraints in both iron- and steelmaking from which economic advantage could be gained.

In discussion, reference was made to the importance of separating iron from slag, whether normal furnace slag or one formed in a special desulphurising operation. Carry-over of slag to the steel plant introduced disproportionate amounts of sulphur; it increased slag bulk, and also iron losses; the balance of the process chemistry was upset; and operational delays were increased. Graphs were presented which quantified many of these effects and showed the serious financial penalties that could be incurred.

Reference was made to the effects on blast-furnace operation of using high-sulphur oil, and some operators considered that sulphur from oil was less deleterious than that from coke.

Some discussion took place on the appropriate overall policy for sulphur control, and the opinion was expressed that a relatively simple technique should be employed at the blast furnace to maintain sulphur at 0.03%, a more sophisticated system being subsequently used for special heats.

LIST OF PAPERS

1. "Iron quality for LD steel making with special reference to flat rolled products" by J.B. Thiokins (British Steel Corporation, Strip Mills Division, Llanwern Group)

2. "Two years pelletizing at Hoogovens-IJmuiden" by W. Koen (Koninklijke Nederlandse Hoogovens en Staalfabrieken, Netherlands)

3. "A survey of modern pelletizing techniques" by F.B. Traice (BSC, General Steels Division, Research Centre) and R.L. Lappin (BSC, General Steels Division, Cargo Fleet Works)

4. "The relationship between sinter chemistry, mineralogy, and quality and its importance in burden optimization" by D. Wasse (BSC, Corporate Laboratories) and C. Price (BSC, Strip Mills Division, Research Department)

5. "Considerations on methods of charging preheated coal" by V.J. Pater (British Coke Research Association) and J. Webster (BSC, Strip Mills Division, Ravenscraig Works)

6. "Some aspects of experience on the Brookhouse project" by J. McN. Bruce (BSC, Chemicals Division) and W. Staniforth (BSC, Chemicals Division, Brookhouse Works)

7. "The benefits of high top pressure" by R. Else (BSC, Head Office) and R. Thomas (BSC, Strip Mills Division, Pye Corner Research Laboratories)

8. "High top pressure equipment" by G.C. Carter and M. Adamson (Ashmore, Benson, Pease and Co. Ltd)

9. "High top pressure operation of blast furnace in Nippon Kokan K.K." by M. Higuchi, M.Iizuka, and T. Shibuya (Nippon Kokan K.K., Japan)

10. "Top without bells for high top pressure operated blast furnaces" by G. Heynert (August Thyssen-Hütte AG, FRG) and E. Legille (Paul Wurth, Luxembourg, GD)

11. "Automation of sinter plants" by G. Meunier, J. Lückers, and A. Poos (Centre de Recherches Métallurgiques, Belgium)

12. "Control of blast furnace hot metal quality using a computer-based system" by B.I. Wood (BSC, Strip Mills Division, Port Talbot)

13. "Application of a dynamic model for hot metal silicon prediction in blast furnace control" by M. Castore, G. Gandolfi, S. Palella (Centro Sperimentale Metallurgico, Rome, Italy) and G. Traspedini (Acciaierie di Piombino, Italy)

14. "An aerodynamic model of the blast furnace" by M. Bates (BSC, Strip Mills Division, Pye Corner Research Laboratories)

15. "Sulphur control by furnace and external means" by R. Brunger (BSC, Corporate Laboratories)

All the above papers, together with a full report of the discussions at the Conference, will be published under the title "Developments in ironmaking practice" in the summer of 1973. Copies may be obtained from the Publications Department, The Iron and Steel Institute, 1 Carlton House Terrace, London SW1Y 5DB.