BOS challenges EAF scrap melting

A report on the 1st European Oxygen Steelmaking Congress – Düsseldorf, June 1993

Basic oxygen steelmaking has been with us for 41 years, and, one might expect, has developed technically as far as it can. According to some speakers at the 1st European Oxygen Steelmaking Congress, held in Düsseldorf, Germany in June, in some aspects this is true. In other areas, in particular scrap remelting and environment control measures, there is still room for progress, and, unless this is achieved, the BOS converter will lose its predominant position in world steelmaking (59.2% of the total in 1992), to the electric arc furnace (29.4%).

Henri Faure, Director General of the Usinor Sacilor research centre, IRSID, in his opening address, predicted that the present 2:1 share of BOS:EAF steelmaking would eventually reverse as the integrated coke oven – blast furnace – BOS route is too environmentally damaging and energy intensive, and insufficiently flexible to meet changing steel consumption needs. Developments in EAF steelmaking, in particular DC furnaces and near net shape casting, makes this route increasingly attractive. Industrialised countries should be considered as 'scrap mines', with today's recycling rate in Europe – averaging 32% – being increased to 70% or more by the year 2005. Quoting Nucor Steel President, Ken Iverson, M Faure said *'the next steel industry battle will be a raw materials one'*. Scrap and supplements to scrap charges, including direct reduced iron (DRI) and iron carbide, will be increasingly in demand as the 'raw' materials for quality steelmaking in the EAF.

Table 1 *Consumptions and hot metal yields for 100% converter scrap charge and conventional operation.*

	Z-BOP-100		Conventional BOS
	ZSMK	Bethlehem	Bethlehem
Hot metal (kg)	0	0	720
Scrap (kg)	1235	1275	370
Coal (kg)	57-60	68	13
Oxygen (m^3)	118-122	125	66
Burnt lime (kg)	33	14	56
Dolomite lime (kg)	0	11	19
Yield (%)	81	78	92
Melting time (min)	64-72	85-89	–
Productivity (t/h)	123	117	224

Scrap melting

The requirement of a higher degree of superheat for continuous casting compared to ingot casting has led to a reduction in the amount of scrap normally consumed in the converter from typically 30-35% for ingot casting to 25% or less for continuous casting. BOS operators are thus more limited in their consumption of scrap than EAF operators and lose out on the cost savings achievable by using scrap which is presently much cheaper than liquid pig iron.

High scrap charge

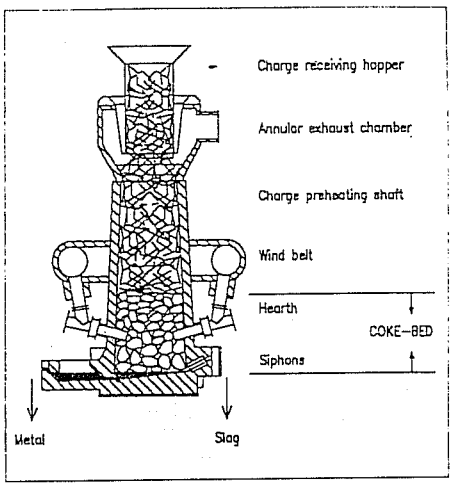
Using a method developed in Russia, Bethlehem Steel in the USA is charging 45% scrap to the converter with top charging of lump coal and additional oxygen as a fuel. Although productivity and yields are reduced (the exothermic oxidation of some of the scrap helps fuel the process), under Bethlehem's particular circumstances of limited hot pig iron and excess steelmaking capacity, the process is economical. No modifications were required to the converters – there are no burners – and the process can be achieved by top blowing alone, although it does benefit from combined top and bottom blowing. The system, known as Z-BOP, was developed in the West Siberian Steel Works, Novokuznetsk (ZSMK) and has been used with scrap charges of up to 100%. Under these circumstances, hot slag is first added to the vessel. Yields for 100% scrap melting at ZMSK average 81% and the charge includes 30-35% heavy scrap. Trials at Bethlehem Steel using 100% scrap achieved a yield of 78%, the lower value being attributed to only 15% heavy scrap being available. In addition, the lack of heavy scrap in the converter base can result in problems when tipping the vessel as the drive mechanism is not designed to cope with the higher centre of gravity resulting from the high scrap level when filling with light scrap. Table 1 compares the performances when using a 100% scrap charge with those for conventional operation.

52 heats using 100% scrap were made at Bethlehem during which time no increase in refractory wear was measured. NOx and SOx emissions were considerably higher than in conventional practice as was fume production. However, at no time did any emissions exceed the EPA regulations. Dioxin levels were not determined. However, EPA regulations have currently forced Bethlehem to reduce the scrap proportion to below 50% as otherwise the dust collected is classified as 'hazardous' (as EAF dust), irrespective of its composition.

The attraction of the Z-BOP is its simplicity and no capital cost to introduce it into an existing converter shop. As well as being used at Bethlehem Steel, the process is employed at Iscor's Newcastle works, where a 75% scrap charge is used, as well as other sites in the CIS. The disadvantages are the lower yield and productivity and a higher FeO content in the slag when 100% scrap is used.

Cupola melting

In regions where scrap is plentiful, steelmakers are actively investigating 'borrowing' the foundry practice of producing high carbon liquid iron from scrap by using the coke fired Cupola shaft furnace (Fig 1). Modern furnaces with air pre-heat can produce 100t/h (800 000t/y) of hot metal.



1 *An air preheated cupola furnace can melt 800 000t/y of scrap.*

Operation is relatively clean and complies with TA-Luft legislation. Typical emissions when melting automobile scrap are given in Table 2.

The main drawback with the furnace is its short campaign life of 6-8 weeks due to refractory wear in the hearth. Downtime can be minimised using a shuttle hearth system using a second hearth, relined in readiness for rapid replacement of the worn unit.

Table 2 *Cupola emissions when melting car body scrap (mg/Nm³)*

Dust	10
CO	50
SO_2	50
NO_x	200
HCl	10
Hg, Cd, Tl	0.05
Other heavy metals	0.5
Dioxin (ng/Nm³)	0.1

The net operating cost of hot metal production, excluding scrap cost, is calculated as Dm48.3/t (£20/t) taking into account a heating credit of Dm17.5 for steam production. With scrap costs included, the cost is about Dm125/t. Particular interest is being shown in parts of eastern Europe in this form of melting because of the need to close elderly, polluting blast furnace, coke and sinter plant, and the availability of an abundant supply of scrap as heavy industry is modernised.

Energy Optimising Furnace

Two papers were presented on the Energy Optimising Furnace (EOF) developed by Korf Lurgi, and its commercial operation at Pains in Brazil. A furnace was also