A report on the 82nd Annual Meeting – Minnesota mining symposium

Attendance remained a healthy 300+ at the annual Minnesota mining meeting this year although a keynote presentation on Essar's activities in North America was cancelled and the panel discussion of mine managers was somewhat depleted.

By J J Poveromo*

HELD in Duluth, Minnesota, USA, April 14-15, 2009, was the 82nd Annual Meeting of the Minnesota Section AIME, & 70th University of Minnesota Mining Symposium. This annual meeting attracted those involved in mining the taconite deposits of Minnesota and Michigan Iron Range and pellet producers as well as the vendor base which supplies these plants. This meeting is the only international meeting held annually which addresses iron ore pelletising so it also attracts participants from Canada, Brazil, India, etc. Conference attendance exceeded 300, surprisingly about the same as last year when economic conditions were outstandingly good. The strong local presence undoubtedly helped to maintain attendance. The 'Iron Range' which contains the USA's largest deposits of this low-grade magnetite ore (typically 25-30% Fe content), has experienced downturns in the past, but the feeling this time is for an eventual rebound when the overall economy and steel production both recover. These past downturns were associated with uncertainty over the viability of North American blast furnace based steel production. The positive roles of consolidation, cost reduction and selective modernisation, as well as the favourable raw material positions, have advanced the competitive posture of North American BF based steelmaking.

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Introduction to ironmaking

The conference itself was preceded by a short course presented by the author of this report and John Engesser, Assistant Director, Minnesota Department of Natural Resources. The course attracted over 100 people mainly from the Iron Range. The first part introduced blast furnace and shaft furnace ironmaking with emphasis on the role of pellet properties. In North America over 90% of the blast furnace iron units come from pellets. On a global basis, the role of iron bearing materials (pellets, sinter, lump ore) in steel production is summarised in **Table 1** which compares outputs of all three sources for China where pellet production predominates.

Using the assumption that 1.5t of iron ore are required to produce 1t of pig iron or DRI, and with 2007 global lump ore production at over 200Mt, global sinter production was over 900Mt. Sinter is thus the main process source globally as it uses a wide variety of fine ores and also consumes steel plant waste oxides. Pelletising is a niche process but pellets are the primary BF feed in Scandinavia and North America, where local low grade ores need to be ground fine to be upgraded. Such fine sizing renders (in the USA) these ores unsuitable for sintering. Globally pellets are a supplement to sinter as well as the primary feed in gas based shaft furnace DRI processes such as Midrex and Danieli HyL.

Global pellet production for 2007 was distributed as indicated in **Table 2**.

	1991	2001	2003	2005	2007
Pig iron production	500	580	650	780	940
DRI & HBI	19	40	49	55	63
Pellet production – global	225	238	285	328	383
China	5 (?)	27	35	58	94

Table 1 Relative roles of iron bearing materials in steel production (Mt)

The role of pellet properties in blast furnace ironmaking is portrayed in **Fig 1**. The physical and metallurgical properties influence fluid flow, heat transfer and chemical reactions above the tuyere zone whereas pellet chemistry determines hot metal and slag chemistry.

For DRI processes, the chemical change is the removal of oxygen from ore, however the remaining gangue constituents remain with direct reduced iron product and increase in concentration due to the removal of the oxygen in the ore. This affects the process economics of subsequent EAF melting. By contrast, blast furnace and smelting reduction processes involve the formation of a refining slag that allows modification of the hot metal product to meet requirements of subsequent steelmaking process. Accordingly, DR pellets need to have very low (<2 % preferred) total acidic (SiO_2+Al_2O_3+TiO_2) gangue levels as well as low levels of key impurities (S, Mn and P) and very low levels of residual elements so as to be able to dilute these in the scrap supply fed to EAF.

The alternative ironmaking presentation started out with the trend of USA steel production by type since 1991 through 2008 where the growth of EAF based steelmaking at the expense of the BF/BOF route is apparent (**Fig 2**). The growth of EAF steelmaking has been accompanied by an increase in imports of DRI and pig iron to dilute the residuals in the scrap supply that comprises over 70% of the feed for these EAFs (**Fig 3**). To capture some of this market as well as to break the dependence of the US Iron Range on blast

North America (USA 51, Canada 25, Mexico 14)	90
South America (Brazil 53, Other 16)	69
Europe (CIS 72, Sweden 17, Other 4)	93
Asia (China 94, India 18, Middle East 14, Japan 2)	128
Australia	3
Total	**383**

Table 2 Global pellet production for 2007 (Mt)

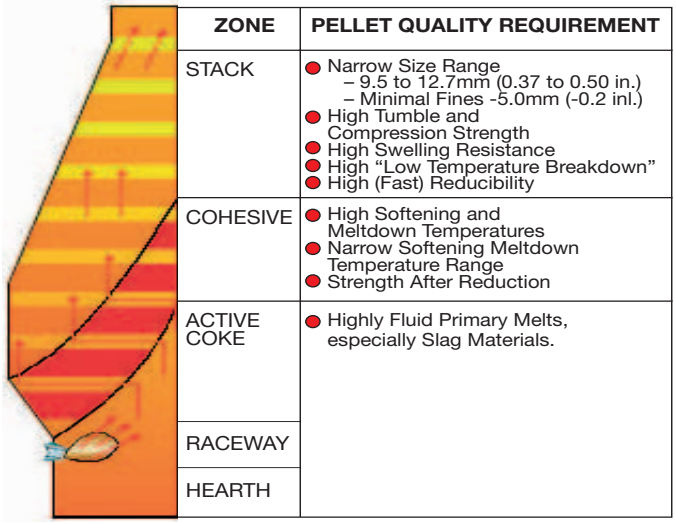

Fig 1 Quality requirements for pellets

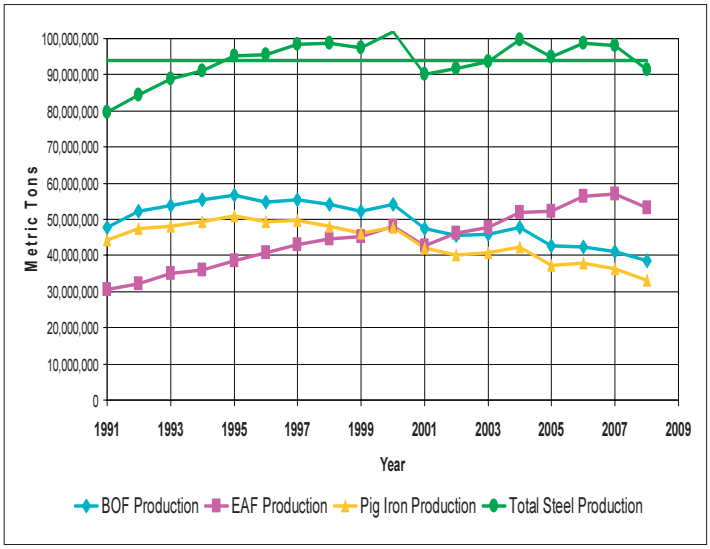

Fig 2 US pig iron, BOF and EAF output 1991 - 2008 (metric tonnes)

furnace pellet consumption, the encouragement of processes to feed EAFs with alternative iron units has long been welcomed. Two major projects are moving forward: the Mesabi Nugget (pig iron nugget) plant (a joint venture of Steel Dynamics and Kobe Steel using a rotary hearth furnace using coal as reductant to produce a pellet of iron formed in the molten state, thereby enabling separation from gangue as a slag) is nearing completion at Hoyt Lakes, MN. While site preparation has begun at the Essar Minnesota Steel project at the site of the former Butler Mine in Minnesota which will use a DRI shaft furnace. The first phase will be the reconstruction of the Butler mine site, concentrator and pellet plant followed by a direct reduction shaft furnace/EAF/slab caster steel plant.

The energy and CO_2 emission implications of these new projects were examined. The energy requirements (in MMBTU/ton) for iron unit production are predictably dependent upon both the process and the form of the final product. They are for: liquid pig iron, 13.5; pig iron nuggets 11.5 and DRI 8-9 depending upon ore type, reformer, etc. However, the final energy consumption for steel production covers a much narrower range (13-14) except for the unlikely use of 100% cold pig iron nuggets (15.5). However, the CO_2 emission differences are more pronounced as shown in **Fig 4** where the advantages of lower carbon levels in natural gas as compared to coal are apparent in the total CO_2 emissions. However, for North America (and Europe) use of >70% scrap in EAFs is more realistic; this comparison is shown in **Fig 5**. The lowering of CO_2 is even greater. While the production route using gas based DRI might not be economically attractive outside of regions rich in natural gas, the route using pig iron nuggets/scrap in EAFs could be attractive from both an economic and CO_2 perspective. However, the pig iron nugget production process needs to be fully demonstrated.

Environmental session

Presentations on environmental impacts included papers on: wetland mitigation inventory, airborne particulates in population centres on Mesabi iron range, sulphate and mercury variations in the St Louis river watershed, membrane treatment of a taconite process water for sulphate removal and controlling mercury in taconite stack emissions. The fact that papers are presented on such topics as mercury (where levels in iron ore can be measured in *parts per billion*) underscores the environmental challenges of launching steel and mining projects in Minnesota. The economics in terms of project delays, cost escalations and missed opportunities must be factored into any comparative project economic analysis.

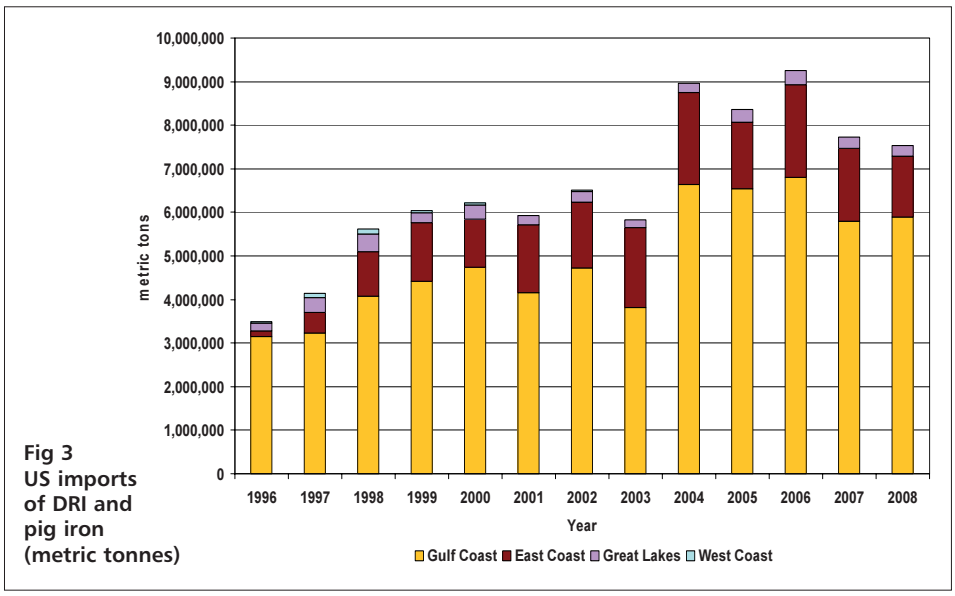

Fig 3 US imports of DRI and pig iron (metric tonnes)

Non-ferrous mining

A session on Non-ferrous mining included papers on Duluth Metals including the Nokomis Deposit, the Mesaba Deposit, the PolyMet NorthMet project, and the Birch Lake Deposits of Franconia Minerals. All of these deposits pursue base metals (mainly copper and nickel) but also cobalt and the PGE (platinum group elements): platinum, palladium and gold. It is likely that decreases in base metal prices will delay or derail these projects. Only the PolyMet project is far enough along in mine and concentrating plant construction to be assured of achieving operational status. The PolyMet concentrating plant is using some of the existing infrastructure and processing equipment of the former Erie (later LTV) Mining Company taconite pellet plant complex.

Mining

Although the Mining session was focused on mining, two of the six papers reviewed remediation of abandoned mine sites, still another cost to be factored into mining in Minnesota as well as in Wisconsin where some groups are exploring potential iron ore mine sites. Other papers focused on blasting optimisation such as rock fragmentation using electronic detectors by well known blasting expert Jack Eloranta and 3D laser scanning at Hibbing Taconite.

The paper of most interest to steelmakers focused on the Essar Steel Minnesota project to reopen the former Butler Mine and pellet plant site. This property had been mined as part of a JV involving Inland Steel, Wheeling-Pitt and Hanna Mining from 1966 to 1985. The scale was small (only 2.6Mt/y) but the costs were low due to the compact concentrator flow sheet and the excellent liberation characteristics of the ore. In fact the Butler ore was identified as the ore most amenable to upgrading to DR quality in some industry wide studies conducted with AISI support in the 1980s. However, the JV agreement had no provision for a Chapter 11 filing by Wheeling-Pitt in November 2000 so the operation shut down. To make matters worse, Minnesota state law at that time required demolition and return to natural state of any permanently shut

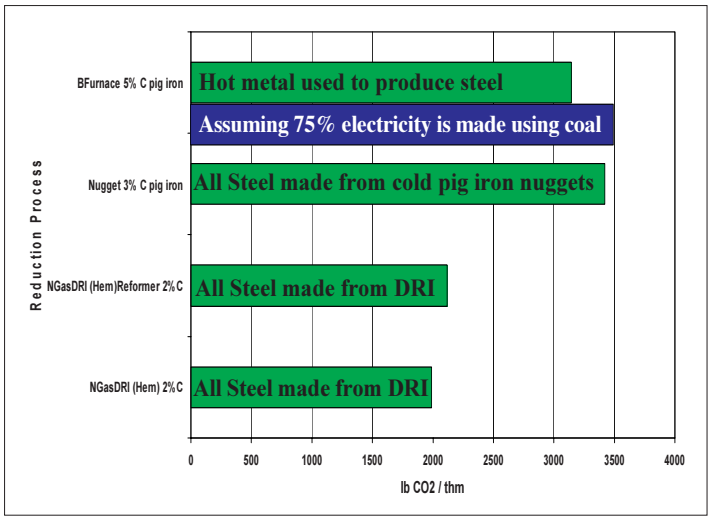

Fig 4 CO_2 emissions in EAF steelmaking using 100% alternative iron units (pounds per ton hot metal)

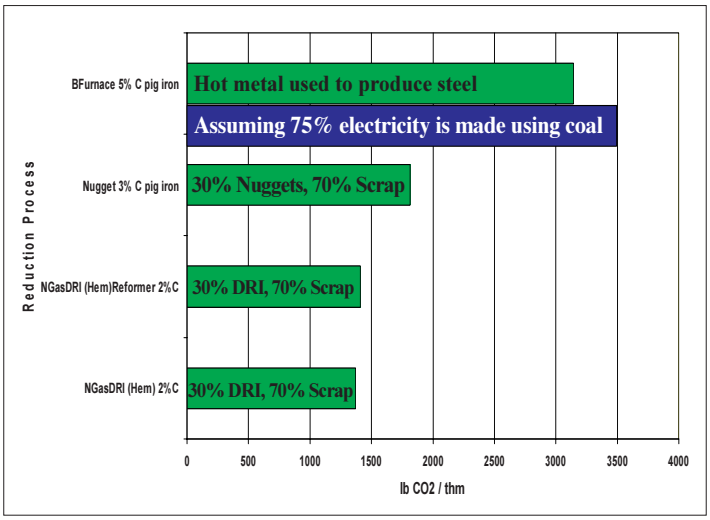

Fig 5 CO_2 emissions in EAF steelmaking using scrap and alternative iron blends (pounds per ton hot metal)

down mine sites. So all of the mine buildings, concentrator and pellet plant equipment were demolished. Adequate reserves are remaining for Essar to plan a mine/concentrator/pellet plant complex in the scale of 3-5Mt/y to produce DR grade pellets for the proposed Minnesota Steel DR/EAF/slab caster complex and also to supply blast furnace pellet for their operation at Algoma in Canada.

Processing

This technical session on processing covered a wide range of topics. The first paper showed how stack CO_2 emissions vary widely for taconite pellet plants depending on whether acid or fluxed pellets are produced (due to CO_2 emissions from carbonate decomposition of flux); it also showed the variability within each plant's own data. Professor Jim Miller of The University of Minnesota Duluth then showed how the departments of Geology, Civil Engineering and Chemical Engineering are working together to prepare students for careers in mining and mineral processing (as formal academic departments in the latter areas have been widely phased out in the USA). Professor Kuwatra of Michigan Tech showed how the presence of carbonate minerals can increase indurating heat loads. Metso personnel presented their latest advances in vibrating equipment monitoring technology while US Steel Minntac outlined their use of a mill sensor to optimise secondary ball mill charging. The most interesting paper for the general audience concerned the Essar Steel concentrator flow sheet development presented by Barr Engineering personnel. They plan to replicate and improve upon the original Butler taconite flow sheet; autogenous grinding, magnetic separation and fine screens followed by a flotation option when producing DR grade pellets. The flow sheet is shown in **Fig 6**.

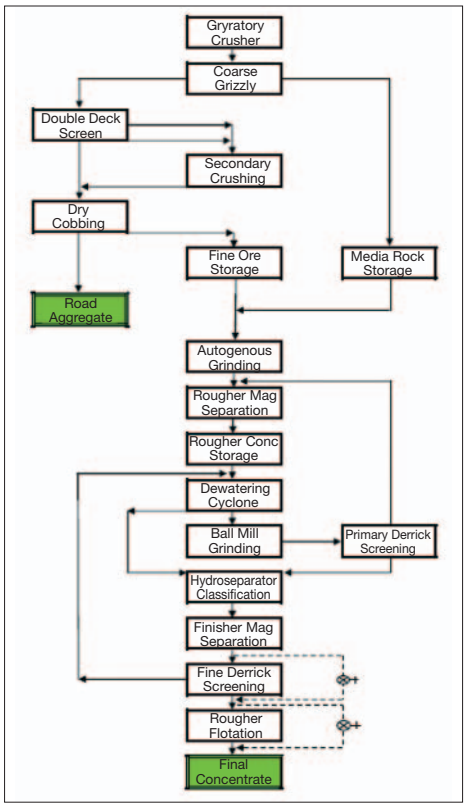

Fig 6 Concentrator flow chart for Essar Steel Minnesota

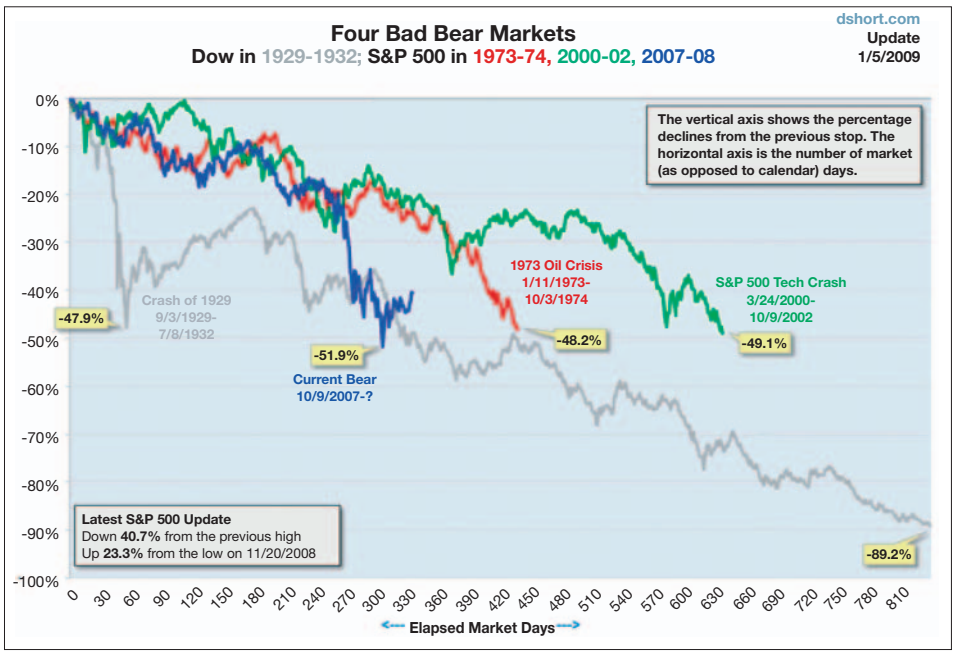

Fig 7 Comparison of four depression of markets during four bad bear periods

	Nominal capacity (Mt)	Planned 09 production (Mt)	Capital spending (M$)	
			2008	2009
ArcelorMittal, Minorca Mine	2.8	2.1	–	9
Cleveland Cliffs/Hibbing Taconite Co	8.5	2.8	48	28
Cleveland Cliffs/United Taconite*	5.6	3.4	12	10
Cleveland Cliffs/Northshore Mining	6.0	3.7	35	30

Notes: All of the operations above produce acid pellets except for AM Minorca which makes fluxed.
*A $100M project is still being planned to increase concentrate production from 5.6 to 6.0Mt/y over a three year period.

Table 3 Pellet production and capex data in Minnesota

Keynote Session

Again, Essar's plans on the Iron Range were to be presented but the audience was to be disappointed by the cancellation of their presentation *An Overview of the Core Businesses and the North American Operations,* perhaps an ominous sign about the reported challenges facing Essar in securing financing in today's economic climate for the Minnesota Steel project. This paper was replaced by: *Impact of Iron Ore Mining on Economy of Minnesota* by Prof Skurla of the Economics Department, University of Minnesota. He presented statistics showing the direct impact of $1.5bn/year in wages and rents and $3bn/year in production as well as over 10 000 jobs, from mining in the region.

The audience then enjoyed a good, comprehensive presentation that covered the world economy and key non ferrous metals as well as iron ore and steel by Curtis Clarke of Behre Dolbear, a mineral industry consultancy. His paper on *The State of the Mining Industry* included the comparisons of the current bear market with three prior bear markets including the Great Depression with respect to the depth of market losses and the time extent of the downturn (**Fig 7**). His long term assessment was positive as expected growth in the developing countries including China, India and Brazil will lead the recovery while long term supply/demand dynamics favour a return to growth in the mining sector. Further consolidation in the mining sector was also noted.

Every other year this Keynote Session features presentations by the general managers of the taconite plants in Minnesota (and sometimes Michigan); some key pellet production and capex data are presented in **Table 3**.

Representatives of the US Steel Minnesota Ore Operations failed to appear but the audience probably did not miss much as their 2007 presentation, in the opinion of the author, added little to that event. Industry information indicates that KeeTac has been shutdown all year while Minntac is only producing at a rate of 10 000 tons/day or about 3.6Mt/y; however, earlier production at higher levels should push their annual total to about 4.5Mtons. They are producing only fluxed pellets this year.

The Michigan and Canadian operations did not participate in these panel discussions but it is understood that Wabush will produce only 2.5Mtons in 2009 while IOC and QCM may each produce 8.0Mtons in 2009. The Cliffs Michigan operations plan to produce 8Mtons in 2009. These operating levels represent cutbacks of 15-50% of capacity with the 15% at QCM (now ArcelorMittal Mines Canada) even significant as this is a 100% captive operation.

Meeting participants were hopeful that industry conditions will be rebounding strongly by the time this meeting is held again in April 2010. ■