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ATTENDANCE AT A SYMPOSIUM ON ALTERNATIVE ENERGY SOURCES FOR THE STEEL INDUSTRY HELD AT THE STATE UNIVERSITY OF NEW YORK, BUFFALO AND TECHNICAL VISITS IN THE PITTSBURGH AREA

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by

D.A. Reeve

These dictated notes record the more important points from the Sixth C.C. Furnas Memorial Conference on the subject of Alternative Energy Sources for the Steel Industry, held at the State University of New York, Buffalo on November 10th, 1975, and from visits in the Pittsburgh area relating to the smelting of iron ores in low-shaft furnaces and conventional and non-conventional carbonization of coal.

Sixth C.C. Furnas Memorial Conference on Alternative Energy Sources for the Steel Industry

The purpose of the C.C. Furnas Memorial Conferences is to provide meaningful interchange among steel mill operators, researchers and academics in ironmaking and steel processing. The present conference was the third one attended by the writer, these conferences being very beneficial from the point of view of contacts and new information.

Papers presented are listed below; those with an asterisk are available from the writer.

1. "Alternative Energy Sources for the Steel Industry", Donald J. Blickwede, Vice President and Director of Research, Bethlehem Steel Corporation.
2. "The Meaning of the Energy Shortages to the Steel Industry"*, Thomas Nabors, Research Center, Republic Steel Corporation.
3. "Steel-Making Using Nuclear Energy"*, Rudolph Schulten, Professor and K. Kugeler, Institut for Reaktorentwicklung, Germany.
4. "Blast Furnace: Energy Requirements and Substitution"*, Philip L. Woolf, Vice President, Engineering and Development, American Minechem Corp.
5. "Potential for Energy Conservation in the Steel Industry", Harold W. Lownie, Jr., Manager, Primary Operation Section, Battelle Columbus Laboratories.

6. "Some Economic Aspects of Alternative Energy Sources", Richard J. Leary, Metallurgist, U.S. Bureau of Mines, Pittsburgh.
7. "Energy Balances - Profit or Loss?", J. Uvira and W. Douglas Porter, Research Department, The Steel Company of Canada.

Dr. Blickwede of Bethlehem Steel Corporation felt that the supply of U.S. lv coal would only last for another 35 to 40 years. To alleviate this shortage, he advocated the use of formed coke. He gave details, for the first time of the Consol-BNR Process. Briefly, high volatile coal (500°F) and char (1050°F) are pelletized with hot pitch in a drum at 830°F. The pellets are hardened at 1700°F in a Lurgi calciner. The plant at Sparrow's Point has yet to reach 500 tons per day, but the product is being stockpiled for a one month blast furnace trial in approximately one year's time. Bethlehem have a coal liquefaction plant at a scale of 10 tons per day. With regard to direct reduction, electrolysis of water to produce hydrogen is not an economic proposition. Nuclear steelmaking is calculated to become economic when coal costs more than $45.00 per ton, which it already has, but this presupposes a supply of natural gas. However, Dr. Blickwede pointed out that there is no viable U.S. gas-cooled reactor development program at present. He advocated more efficient use of electricity in electric furnaces and noted that hydrogen for direct reduction is not yet a commercial proposition, whereas mixtures of CO and H_2 have been used successfully. Bethlehem is saving $75,000 per year in lv coal losses from unit trains by spraying the open cars with a plasticizer emulsion.

Dr. Kugeler's paper on Steelmaking using Nuclear Energy was particularly interesting because it emphasized the scale of research being done in Germany. He felt that the current pressing problem with respect to using nuclear energy for the reforming of natural gas, is the production of gasoline using the Fischer-Tropsch synthesis. In conversation afterwards, he mentioned the "hot pipe" scheme in Germany in which nuclear energy is used for reforming natural gas away from a townsite and the CO plus H_2 mixture is pumped to the town. Methanation at the town provides heat for power generation and the methane is pumped back to the out-of-town site for reforming again. Lignite is being devolatalized in Germany on an experimental basis using a tube furnace; the rapid removal of water produces self-fluidization of the lignite in the reaction tube.

Mr. Lownie of Battelle described the Battelle report entitled

"Potential for Energy Conservation in the Steel Industry" (NTIS Springfield, Virginia, Battelle for FEA, May 30th, 1975, PB244097/AS). The report claims a 15 percent energy saving in the steel industry is possible. Ten percent of this energy saving can be obtained through dry quenching in which 1.2×10^6 Btu's per ton/coke applied to 50 million tons of coke can be saved. However, dry quenching produces a negative return on investment. The preheating of coking coal saves 2 percent of the predicted overall saving, equivalent to 0.2×10^6 per ton/coke applied to 50 million tons of coke.

Visit to the Obenchain Corporation
1742 North Highland Rd., Pittsburgh, Pa.
November 11, 1975

This visit was made because the Obenchain Corporation is working with Bethlehem Steel at Sparrow's Point to develop a method for smelting to liquid iron composite pellets using 48-inch cupolas. The overall concept is the same as being used in CANMET for the smelting of low grade Peace River iron ores using a low rank char from western Canada.

Four tests were run at Bethlehem using a cold blast and composite pellets of (i) coke breeze and BOF wastes and (ii) iron ore concentrate and anthracite. Obenchain became involved in this work through an interest in recycling of in-plant wastes; he built a rotary hearth system for McClouth Steel in the first instance which was not too successful and cost him $1,450,000. His tests at Bethlehem have been recently successful but he felt that with the low grade Peace River iron ore, our tests in Ottawa would be only partially successful because of an anticipated high iron loss in the slag. Frank Broglie of Bethlehem (Assistant to Vice President, Steelmaking) also was present for part of the day and was enthusiastic about progress at his company. He felt that the blast furnace under consideration at Bethlehem presently would be the last one built because of the extremely high capital cost ($200,000,000) and he hinted at a system of smelting of composite pellets with the liquid metal running directly into an electric furnace for refining, the noise caused by cold metal heat-up being eliminated. Obenchain claimed to have made steel (0.08 percent carbon) in his reactors.

Obenchain would not disclose all his data because of patents pending but claimed to have found a reduction mechanism not generally known which has prompted him to redesign his cupola system for efficient operation. He did note that controlled combustion is the key to success. The following observations

were not disclosed by Mr. Obenchain but were only inferred by the writer. Single pellets when heated rapidly in an oxidizing flame had shown CO combustion from cracks; this observation seems to indicate internal reduction to iron rather than the classical topochemical mode. Such behaviour has been observed before, e.g. by J.H. Walsh for very fine particles of iron oxide. This inference was made after a discussion when the theory was explained of a double boundary layer surrounding reducing composite pellets such that carbon monoxide diffuses out from the pellet and oxygen inwards from the bulk gas, burning at a flame front between the two boundary layers with CO_2 counter-diffusing back towards the pellet and out towards the bulk gas.

The point of the matter is that it is generally agreed that iron oxide under these conditions can be reduced in an oxidizing atmosphere. The Japanese are also interested in this concept and apparently are not far behind. Whether or not success is achieved at CANMET with Peace River iron ore will depend upon the rate of fayalite formation. High gangue presence also will detract from carbon-iron oxide point contact within composite pellets. Obenchain hopes to build a 5 ton an hour reactor at Bethlehem and is also planning a similar one in Honduras to prove out his predictions.

He did suggest treatment of the Peace River iron ores in Mitchell-type sole heated coke ovens; he has adapted this basic design with cross over flues to obtain more efficiency. His concept of producing ferro-coke in such ovens for a blast furnace feed, apart from causing refractory problems, would not be suitable for the Peace River case because a blast furnace is not contemplated.

The meeting with Obenchain lasted all day and was most fruitful. Without a doubt, CANMET is operating in the right area, but whether or not this process should be tried first on Peace River iron ores may be in some doubt. Obenchain is interested in going into partnership with Canadian interests in this area.

Visit to Mr. M. Jessen
Research Division
Consolidation Coal Company, Library Pa.
November 12, 1975

This visit related mainly to conventional coal carbonization, although the Consol Formed Coke Pilot Plant could be seen. It was not in operation and the inclement weather prevented a closer visit.

Consol have an 18-inch movable-wall oven. Their charges for a test are $1,250.00 and $200.00 for petrography. Their back pressure control system using a water-scrubber system in a tower half full of coke, a back pressure control valve, and a centrifugal fan, was seen. The oven is very pressure-sensitive, so much so that it has to be divided from the rest of the building by a partition and changes in atmospheric pressure can affect pressure readings.

When the oven was commissioned, the silica bricks were dried out by blowing hot air through the oven for four days and during heating, hot spots were checked for using many thermocouples.

Visit to Bituminous Coal Research Inc.
340 Hochberg Road, Monroeville, Pa.
Mr. R.K. Young, Manager, Project Control and Data Processing

Mr. Young's main interest was coal gasification and he extended an invitation to the writer to visit the Bi-Gas Coal Gasification Plant currently nearing completion at Homer City, Pa. (500 tons per day).

Mr. R. Moses demonstrated the small-scale coal carbonization test which is now being used successfully by Dofasco. Details of the procedure were given in the Fifty-Seventh CCRA Technical Committee minutes. The method is similar to the canister test being developed at CANMET although it does not require a movable-wall oven to carbonize the samples and the correlation between test index and ASTM stability is linear rather than parabolic.

With regard to coal gasification, BCR are starting a combined project with Phillips and MIT on the kinetics of coal gasification.

Visit to U.S. Steel Applied Research Laboratory
Monroeville, Pa.
Mr. R.W. Schoenberger

The silicon-carbide variable width movable-wall ovens at U.S. Steel did not have any back pressure control. One useful feature which would have helped operations at CANMET was the installation of a thermocouple above the charge. This would normally read about 600°F but a reading of up to 800°F would indicate coke burning whereas lower temperatures (350 to 400°F) would indicate that the stack needed cleaning. The 12-inch width ovens are sensitive to pressure provided the coking rate is kept down. U.S. Steel use the 30-pound oven for pressure measurements when operated isothermally at 1850°F but for coke quality when programmed from 1250°F. After tumbling, coke was screened

on mechanical Gilson screeners. A new silica brick oven is being constructed (fixed wall) to investigate carbon build-up problems etc. A heating profile for this oven was supplied.

U.S. Steel have done research experiments using agglomerates added to a coke oven charge and found that as well as increases in coke quality due to increases in bulk density, coke hardness increased considerably.

Carbonization aspects of the U.S. Steel Clean Coke Process were seen. In the process, low rank high sulphur coal is split into two streams, one stream being hydrogenated under high pressure and the other one charred in a fluid bed system in the presence of hydrogen to remove sulphur. The cenospheres from the fluid bed charrer are ground and pelletized on a disc with 33 percent pitch at 375°F. The char is heated to 150 to 175°F prior to pelletizing. This high pitch requirement is admissable because of its availability from the overall process. The pellets are cured at 500°F in air, actually in a bed of coke breeze on a modified pot grate using 18 percent oxygen. Final calcination of the pellets is done in a vertical reactor using nitrogen preheated in a recuperator to 1800°F. Sliding gate valves provide control of the downward movement of the pellets. ASTM hardness of 3/4 x 1½ inch pellets was quoted at 74 although it was as low as 50 when the cenospheres were not ground.

The U.S. Steel approach to petrographic prediction of coke quality was discussed with John Goscinski. He pointed out that western Canadian coals contain reconstituted micro-brecciated material which acts as a coherent particle in coking. For coals containing larger amounts of this brecciated material (7 to 8 percent) it is counted as inert but if there is less present, it is counted as semi-inert. Mr. Goscinski felt that this material is more significant than pseudo-vitrinite. He was interested in receiving coals from John Jorgensen, especially from western Canada, to attempt to predict coking properties himself. The U.S. Steel carbonization reference conditions are oven bulk density 53 to 54 pounds per ft.^{3}, 1.03 iph, 8 percent minus 1/8" charge and 12 hours coking in a 12.2 inch oven.

U.S. Steel does not agree with Bethlehem's views on coke reactivity and its importance in the assessment of coke quality. It was noted that coke after crushing has a different porosity with respect to reaction with carbon dioxide than before crushing, the porosity depending upon the component coals. Also, the types of carbon present from different coals in the blend (e.g. isotropic and non-isotropic) affect reactivity in that one carbon may coat

another during the carbonization process, shielding the inner carbon from attack from carbon dioxide. Obviously the question of coke reactivity remains open and its value with respect to blast furnace performance remains in doubt.