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DIRECT REDUCED IRON
RESEARCH AND DEVELOPMENT PROJECT**

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QUARTERLY TECHNICAL PROGRESS REPORT
PHASE II CALDERON PROCESS TO PRODUCE DIRECT REDUCED IRON
RESEARCH AND DEVELOPMENT PROJECT

CALDERON ENERGY COMPANY
COOPERATIVE AGREEMENT NO. DE-FC22-95PC92638

Reporting Period: 10-1-04 to 12-31-04

Date of Report: 1-25-05;

Phase II Award Date: 6-23-00; Anticipated Completion Date: 12-03-05

Total Project: \$ 14,732,316.00 Total DOE Share This Action: \$6,457,000.00

Contracting Officer's Representative (COR): John Stipanovich;

Project Director: Albert Calderon

Assistant Project Director: Reina Calderon

Abstract

This project was initially targeted to the making of coke for blast furnaces by using proprietary technology of Calderon in a phased approach, and Phase I was successfully completed. The project was then re-directed to the making of iron units. In 2000, U.S. Steel teamed up with Calderon for a joint effort which will last 42 months to produce directly reduced iron with the potential of converting it into molten iron or steel consistent with the Roadmap recommendations of 1998 prepared by the Steel Industry in cooperation with the Department of Energy by using iron ore concentrate and coal as raw materials, both materials being appreciably lower in cost than using iron pellets and coke.

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Executive Summary

The commercialization path of the Calderon technology for making a feedstock for steelmaking with assistance from DOE initially focused on making coke and work was done which proved that the Calderon technology is capable of making good coke for hard driving blast furnaces. U.S. Steel which participated in such demonstration felt that the Calderon technology would be more meaningful in lowering the costs of making steel by adapting it to the making of iron - thus obviating the need for coke.

U.S. Steel and Calderon teamed up to jointly work together to demonstrate that the Calderon technology will produce in a closed system iron units from iron concentrate (ore) and coal competitively by eliminating pelletizing, sintering, coking and blast furnace operation. If such process steps could be eliminated, a huge reduction in polluting emissions and greenhouse gases (including CO₂) relating to steelmaking would ensue. Such reduction will restructure the steel industry away from the very energy-intensive steelmaking steps currently practiced and drastically reduce costs of making steel.

The development of a technology to lower U.S. steelmaking costs and become globally competitive is a priority of major importance. Therefore, the development work which Calderon is conducting presently under this Agreement with the U.S. Department of Energy becomes more crucial than ever.

Consistent with the objective set in the Conclusion section of the previous report, as an initial step, Calderon, on November 1, sent part of one of the iron pigs cast on September 29th to U.S. Steel for analysis. The heat from which the pigs were cast was described in detail in the previous Quarterly report. Calderon requested U.S. Steel to analyze the Calderon iron and to compare it to U.S. Steel's iron made in its blast furnace operation; see Exhibit 1 attached.

A letter from U.S. Steel dated December 10, contained the analysis of the Calderon iron and was compared with the typical chemistry of hot metal produced by U.S. Steel; see Exhibit 2 attached. This letter made reference to the fact that the sulfur content in the Calderon sample was significantly higher than the typical hot metal made by U.S. Steel. This was expected by Calderon as its iron had not been desulfurized.

Calderon sent U.S. Steel's letter of December 10 to its consultant Al Terchick (formerly the Technology Director for Raw Materials and Ironmaking at U.S. Steel's research) for his opinion and input; his comments are in a letter dated January 9, 2005 (see Exhibit 3); it is to be noted that the lower silicon content in Calderon's iron may be a benefit. He described ways of achieving lower sulfur in the iron and at the end of the opinion letter, Al Terchick states the following: "Reducing the sulfur level would provide an excellent hot metal for steelmaking."

Experimental

During the 4th Quarter of 2004, which this report covers, five experiments were conducted; they numbered from Test Run #162 through #166 inclusive. The objectives of these tests were as follows:

Test Runs #162, #164, #165, and #166 were scheduled to run 72 hours each in order to establish steady state of long enough duration to give confidence to the process. Test Run #163 was scheduled as a special short run to gather data for the immediate design and construction of a “Dunker” to facilitate the immersion of the iron/carbon material into the molten bath when homogenizing the material into hot metal in the melting furnace.

Test Run #162 which was started at 12:48 p.m. on October 4, had a duration of 71 hrs:14 minutes.

Test Run #163 which was started at 5:30 a.m. on November 16, had a duration of 34 hrs: 30 minutes.

Test Run #164 which was started at 5:20 a.m. on December 13, had a duration of 71 hrs: 40 minutes.

Test Run #165 which was started at 5:35 a.m. on December 20, had a duration of 47 hrs: 25 minutes.

Test Run #166 which was started at 5:15 a.m. on December 28, had a duration of 62 hrs: 45 minutes.

Results and Discussion

In order to quantify the degree of metallization of 80% at reasonably steady state for 72 hours as agreed with U.S. Steel before proceeding forward at a large scale which would lead to commercial application, Calderon established a procedure wherein several samples would be ground at six different points of each sample and determine metallization via sparking as shown by Photograph #1. Initially, the number of samples varied but as this procedure advanced it was mandated that four random samples be taken every hour and each sample ground at six different points. As a directional indicator for determining whether or not 80% (or better) metallization is being obtained, the total number of sparked points would be multiplied by 100 and divided by the number of grinds to result in a percentage. For example, during Test Run #162 at the completion of push 338, four red hot samples were taken randomly, cooled and ground- tested at six points of each sample which aggregated to 24 grinds. The result of this particular grind-test was that 17 grinds sparked and 7 grinds did not. Therefore, $(17 \times 100) \div 24$ resulted, an indication of 70.83% metallization. This degree of metallization is shy by 9.17% of the 80% target. Another test, as example, conducted during Test Run #166 at the completion of push 481, and following the same procedure as outlined above resulted in 23 grinds that sparked out of 24 grinds, indicating a metallization of: $(23 \times 100) \div 24 = 95.82\%$.

To sum up the results with respect to metallization of each Test run, the total percentages would be added and an average arrived at. Table 1 which follows shows the results with respect to metallization for the five Test Runs conducted during the Quarter. Although test-grinding is crude when compared to wet chemistry analysis (which is costly and takes a long turn around (about two weeks) with respect to knowing the results), test-grinding

does give an immediate guidance as to whether or not metallization is taking place during operation. Test-grinding does provide a very useful source of information which enables the making of proper adjustments while the process is in progress.

TABLE 1

Test Run #	Number of Samples	No. of Grinds	No. of Sparked Grinds	Average % Metallization
162	161	979	574	58.63
163	36	216	144	66.67
164	212	1272	1115	87.66
165	133	798	708	88.72
166	176	1056	933	88.35

Based on the low and unacceptable percentages of metallization in Test Runs #162 and #163, it was decided to take a breather while giving serious consideration of how sticking can be prevented and still produce acceptable metallization.

During the beginning of this development the coal was charged as a core and the mix surrounding it as an annulus with the horizontal lance penetrating the core; this approach produced decent metallization but sticking was prevalent causing over-oxidation of the reduced material and forced shut downs. In order to overcome sticking (based on knowledge from Calderon's coal gasification where coal is used exclusively and no sticking occurs) the procedure was changed during the recent months to charge the mix and coal in slices and also to increase the coal percentage in the charge, and Test Run #162 and Test Run #163 were conducted using slices. Following this approach sticking was drastically reduced but the

degree of metallization decreased to unacceptable levels, (see Table 1, Test Run #162 and Test Run #163, last column).

When receiving U.S. Steel's letter of December 10th, with its promising results except for the high sulfur content, it was decided to resume testing but revert back to the original procedure of lower coal useage in the charge to reduce the sulfur (since the coal is the source of sulfur), charge the coal as a core and the mix as an annulus, and introduce changes to the lance practice wherein the flow of oxygen would be diffused to minimize melting within the core. Test Run #164 was conducted under the above conditions and the following was accomplished. There were no pushing problems or material stalling during the entire Run, no sticking of material to the apron occurred, and grind-tests were markedly better than Test Runs #162 and #163 with respect to metallization; see Table 1. The pilot was shut down on schedule after 71 hrs:40 mins. from start-up--the smoothest Test Run ever.

Upon analysis of the reason as to why this test was the best , it was concluded that the diffusion of the oxygen in the lance was one factor, and the other factor being the manner in which the coal core co-acted with its surrounding annular mix. It is surmised that such co-action was accidental in nature when compared to previous charging procedures as it was discovered after the completion of the test that a limit switch had inadvertently been repositioned in the charging mechanism system.

Such good results begged a repeat. Test Run #165 which followed was started on December 20th and the plan was to duplicate Test Run #164. During Test Run #165, the results with respect to test-grind metallization, it was comparable to Test Run #164; see Table 1. However, a 72 hour test was not attained because the shift foreman made a change to the charging sequence of the coal in relation to the mix which he thought would improve the

operation and further increase metallization, but a forced shut down occurred 47 hrs:25 mins. after start-up due to the inability to push the charge. After the unit was cooled and taken apart, material was found stuck to the refractory at the discharge end of the reactor; see Photograph #2.

A second attempt to repeat Test Run #164 was scheduled for Test Run #166. It was started on the 28th of December and was run the same as Test Run #164 including the same charging procedure. It was scheduled to run 72 hours but because of bad weather and restrictions to travel, the unit was shut down 10 hours before schedule. However, grind-test metallization was comparable to Test Runs #164 and #165; (see Table 1).

During the melting of the iron/carbon product to homogenize it into hot metal as reported in the previous Quarterly Report and shown by Photograph #14 of the same report, the iron/carbon material tends to float on top of the molten bath. It was recognized that this problem needs an urgent solution as “dunking” the material manually requires excessive human labor because the bath has a density in excess of 7 times that of water; in addition, the hot working environment above the bath adds to the effort required to force the iron/carbon material through the slag and into the bath; see Photograph #3. It was decided that a short Test Run of about 36 hours be conducted to produce enough hot iron/carbon material (see Photograph #4), and melt such material in the furnace in order to study in detail the various positions and motions of the melter (see Photographs #5 and #6) while at the same time gather enough data to enable Calderon Energy to design and construct a mechanical device (Dunker) to relieve the arduous effort required of immersing the iron/carbon product into the bath. Test Run #163 was conducted on November 16 and 17, and such information was gathered and applied. Design of the Dunker was immediately initiated and partial construction of the Dunker

was completed during the Quarter; see Photographs #7, #8 and #9 showing parts of the Dunker.

In the development of a new process it is essential to continuously translate that which is learned at a small scale in practice with the overall concept as it would be applied commercially, since the ultimate objective is commercial application. As previously reported, Calderon built a physical model of the commercial plant as conceived with input from actual test work conducted. This model is being continually updated by adding, replacing and modifying in tandem with the progress made in practice. During the past Quarter, a scale model of the superheater referred to in the previous report, which is the candidate for use as homogenizer (melter) was constructed (see Photograph #10) and installed in the conceptual model plant to make iron via the Calderon process from iron ore concentrate (fines) and coal (see Photograph #11).

Conclusion

During the next Quarter, work will continue towards repeating Test Run #164 except for extending it to 84 hours in order to provide 12 hours of start-up to bring the process to steady state, and operate continuously at a reasonably steady state for 72 hours net, as agreed with U.S. Steel. The iron/carbon product produced during the 72 hours from the iron concentrate and coal will be melted, poured into pigs and shipped to U.S. Steel as iron for analysis. Complete information including data sheets will accompany the metal to enable U.S. Steel to perform a mass balance.

In view of the analysis of the iron produced by Calderon referenced in U.S. Steel's letter of December 10 and the positive opinion letter from Al Terchick, Calderon is encouraged and is anxious to continue this crucial development work. But inasmuch as the remaining Federal Government funds for this project are sparse, Calderon has agreed to temporarily reduce the cost sharing of the Government from 80% to 40% and to increase Calderon's share from 20% to 60% in order to insure the production of the sought for results of Calderon's unique process of making iron. Calderon is convinced that with persistence, such results are attainable.

Submitted by:

Albert Calderon
Project Director

References - Not Applicable

The work performed in this quarter which the report covers, was original work. No reference material was relied upon for the work.

CALDERON ENERGY CO. OF BOWLING GREEN

P.O. BOX 126, BOWLING GREEN, OHIO 43402
TELEPHONE (419) 354-4632
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November 1, 2004

Ms. Lisa A. Roudabush
General Manager Research
Research & Technology Center
U.S. Steel Corporation
4000 Tech Center Drive
Monroeville, PA 15146

Dear Ms. Roudabush:

Attached please find a copy of our Quarterly Report to U.S. DOE which I think you will find interesting. I am also including part of one of the several iron pigs we cast from a heat that is referenced in the report; the log sheet for the heat is attached. The raw materials used for this heat were ore concentrate and non-metallurgical coal (steam) exclusively. I would appreciate your analyzing this iron at our expense and letting us know how it compares with hot metal from the blast furnace; this iron was not desulfurized. If ore concentrate and non-metallurgical coal are each priced at \$30/ton, I believe that hot metal via our process can be made for about \$120 per ton, this would include capital cost and debt service.

I would like to take this opportunity to invite you to observe our small pilot in operation converting ore concentrate plus non-metallurgical coal to hot metal and explain in detail the potential of our process in its capability to lower the cost of making molten iron; this will give U.S. Steel a major advantage over its competition. I think you will be impressed with the simplicity of our process.

Further, I am confident that U.S. Government financial support can be secured to scale-up our technology to a full size commercial reactor which can be replicated to form a battery which will result in producing large quantities of iron/carbon product to be homogenized into hot metal by an Ajax Magnethermic channel furnace (superheater) of 1500 to 2000 ton capacity similar to the one furnished to Nippon Steel and referenced in the attached quarterly report.

I realize that you are quite busy; if you can take the time to visit us, we would be honored and I assure you it will be productive. If you do come we would like to also demonstrate to you our coal gasification to make low cost gas to mitigate the cost of natural gas; we have a small pilot in operation (see photograph attached). We both know that low priced iron units and low cost gas are essential to the making of low cost steel.

Sincerely,

Albert Calderon
President

Enclosures

Exhibit 1

United States Steel Corporation
Research and Technology Center
4000 Tech Center Drive
Monroeville, PA 15146

D. M. Rohaus
Associate Research Consultant
Raw Materials & Ironmaking
Process Technology
412 825 2074
Fax 412 825 2800

December 10, 2004

Albert Calderon, President
Calderon Energy Co.
500 Lehman Avenue
PO Box 126
Bowling Green, OH 43402

Dear Mr. Calderon:

Dr. Defilippi asked me to respond to your request to analyze a sample of metal you provided with a letter addressed to Ms. Lisa Roudabush on November 1, 2004. The sample has been analyzed by Clark Laboratories. In the table below, those results are compared to the typical chemistry of hot metal produced by U. S. Steel. Note that the sulfur content of the material is significantly higher than that of typical hot metal.

ELEMENT	TYPICAL HOT METAL CONCENTRATION RANGE (%)	CLARK ANALYSIS OF SAMPLE PRODUCED BY CALDERON (%)
Carbon	4.3 - 4.7	4.22
Phosphorus	0.04 - 0.09	0.064
Silicon	0.3 - 1.2	0.15
Sulfur	0.03 - 0.06	0.291
Manganese	0.2 - 0.7	0.062
Iron	93.3 - 94.8	95.1 (By Difference)
Copper	<0.1	0.013
Nickel	<0.1	0.032
Molybdenum	<0.1	<0.002
Vanadium	<0.1	0.035
Titanium	<0.1	0.029

Please let me know if you have any questions about the analysis.

Sincerely,

D. M. Rohaus

January 9,2005

Albert Calderon
Calderon Energy Co.
PO Box 126
Bowling Green, Ohio 43402

Dear Mr. Calderon:

As per your request I have reviewed the hot-metal analysis that you sent me. The analysis is very typical of that found in the steel industry with the exception of the lower silica and the higher sulfur contents. The lower silicon could be a benefit in the steelmaking process if the oxygen blowtime could be reduced, resulting in a higher productivity. Reduction of the sulfur level to the more desired level of .002 to .005 percent required for steelmaking could best be achieved by adjusting the slag chemistry in the melting furnace and enhancing the mixing of the slag and the metal. This would reduce the sulfur level to about the same level as is typical of blast furnace hot-metal. Final desulfurization to the .002 to .005 level could then be achieved in ladles by injecting mag-lime. It would also be possible to do the entire desulfurization in a ladle by injecting mag-lime and adjusting the chemistry as required, but this would be more costly. Reducing the sulfur level would provide an excellent hot-metal for steelmaking.

Yours truly,

Al Terchick,
Consultant-formerly
Tech. Dir. Raw
Materials and
Ironmaking USSteel
Research

Photograph #1

Photograph #2

Photograph #3

Photograph #4

Photograph #5

Photograph #6

Photograph #7

Photograph #8

Photograph #9

Photograph #10

Photograph #11