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DRY COKE QUENCHING STUDY

FINAL REPORT

SEPTEMBER 1978

National Steel Corporation

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DISCLAIMER

SECTION I

CONCLUSIONS

The financial evaluation of capital and operating cost estimates for a dry coke quenching facility installation at the Weirton Steel Division, National Steel Corporation, Brown's Island Coke Battery, indicates a marginal return on investment if the evaluation is based exclusively on steam credits. However, the potential improvements in environmental emissions and reported, but unverified blast furnace operations may justify the expenditure. The Russian and Japanese claim of 2 to 4% reduction in blast furnace coke usage with up to a 4% increase in iron production has not been demonstrated in the domestic steel industry and, therefore, is not included in the financial analysis. A 2% coke reduction represents a savings of approximately $0.81 per ton of hot metal produced or an additional annual credit of $1,800,000 for dry coke quenching, exclusive of productivity gains. This magnitude of additional credit would favorably increase the estimated discounted cash flow return from 10% to approximately 16% for the estimated capital expenditure of $21,742,652.

The projected world escalation in fuel cost, National conservation goals, possible energy supply shortages, and environmental considerations in conjunction with the need for a full scale, controlled test of dry quenched coke in a dedicated blast furnace are decisive factors in considering the merits of this proposal. National Steel Corporation, as previously stated, is prepared to cooperate in the development and implementation of this program.

SECTION II

RECOMMENDATIONS

It is recommended that a full scale demonstration unit be installed at National Steel Corporation Brown's Island Coke Plant, and pertinent operating, environmental, maintenance and performance data be assimilated.

National Steel would furnish the site, a current state of the art operating coke battery, research, engineering, operating management, and adaptable existing equipment and services valued at several million dollars, to reduce the investment cost for the DCQ.

However, it must be recognized that the highly capitalized steel industry, burdened with unfavorable profit margins, cannot unilaterally afford this risk investment solely on the potential benefits of marginally lower cost steam. As noted under Section I, Conclusions, the cost reductions attributable to coke quality and iron productivity must be unequivocally demonstrated before dry coke quenching can be justified in the near future. As evidenced by previous studies and numerous discussions, the acceptance of dry coke quenching is contingent upon the factors enumerated and subject to a full scale controlled test program requiring the installation of a domestic dry coke quenching facility.

SECTION III

INTRODUCTION

On August 1, 1977 a contract (EC-77-C-02-4553) was awarded to National Steel Corporation to perform a feasibility study for the installation of a dry coke quenching facility at National Steel Corporation's Brown's Island Coke Battery.

The study was to provide up-to-date estimated installed costs of the necessary equipment required to permit the dry quenching of hot coke and to estimate the operating and maintenance costs. These estimates in conjunction with the credit taken for the steam generated by the process will provide the basis for an economic analysis.

Pennsylvania Engineering Corporation, the exclusive licensee of the Waagner-Biro dry coke quenching process in the United States, was granted a subcontract on March 1, 1978 to provide the design engineering and solicitation of the necessary pricing for the equipment. The study was originally to be completed in May 1978, but due to delays in receiving approval of the terms and conditions for the subcontract, the completion date was extended to September 30, 1978.

The basic contract is a cost sharing effort of three organizations. ERDA (now DOE) and EPA are to pay 77.5% of the allowable costs and National Steel Corporation is responsible for 22.5%. In addition, National will not bill the project for indirect costs over 30% of salaries.

The original estimate of costs was $470,950. It now appears that the costs will not exceed $300,000 due to the abbreviated time period. The study, however, will include all of the tasks originally contracted and will provide the information necessary for the financial analysis based on steam credits.

SECTION IV

TASK SUMMARY

In order to provide the information under the terms of the contract, it was necessary to perform the 15 tasks listed below. Completion of these tasks provides for:

a. The preparation of a definitive capital cost estimate for the purchase, installation, start-up and operation of a dry coke quenching facility.

b. Establishing a level of potential energy conservation from heat reclamation during the dry quenching process.

c. Establishing potential environmental control benefits (including improvements in air quality and elimination of waste water problems) that can be accomplished by the practice of quenching coke dry.

TASK 1

Description: Process design including process flow diagrams with heat and material balance, material flow diagrams with time cycles, utility single lines, motor lists, equipment list and an analysis of dry coke quenching in terms of dollar per ton of coke quenched.

The information required in the task will be found in Volume 1, Section 3 and Volume 2 of the Pennsylvania Engineering Corporation reports and attached drawings marked Volume 3.

The D.C.Q. plant is designed to successfully dry quench the coke production of the 87 oven battery on Brown's Island. Normal production is approximately 1,000,000 tons of coke per year. The present day cost of this D.C.Q. facility installed is approximately $21,742,652. This cost includes escalation and contingencies, but not equipment that presently exists, such as coke transfer cars, gas cleaning cars, fume exhaust system, etc.

On an annual basis the installed cost (as given) related to the annual coke production will be $17.58 per ton of coke for this installation.

The plant is sized for normal production of 1,026,000 tons per year, which is 85% of the design capacity of the plant.

TASK 2

Description: Facility general arrangements consisting of plot plan, facility plan at different elevations, front and side elevations and sections.

This completed task is to be found in the P.E.C. final report - Volume 2, Section 14.

The plant is located alongside the existing enclosed coke quenching foundation. In one proposed arrangement a portion of the existing foundation, control room and fume exhaust system is reused along with the existing coke car and gas cleaning car.

The second proposed arrangement does not use the existing foundation and requires a new coke transfer car and bucket. The advantage to this plan is that the coke is not transferred from the coke car until it is discharged into the dry quench bunker.

The plant is laid out so that if there is a main coke belt failure, it will be possible to direct the coke to the emergency pit for load-out with mobile equipment.

TASK 3

Description: Equipment specifications and drawings complete in a form suitable for obtaining firm quotations.

The specifications and drawings are to be found in P.E.C. final report, Volume 2 and drawing package, Volume 3.

These specifications and drawings are complete to the point of major design and sufficient detailing to permit pricing. In most cases, a great deal of detailing will be required to permit fabrication which is according to the basic contract.

TASK 4

Description: Complete equipment design in a form ready for detailing.

These design drawings are included in the report as Volume 3.

Sufficient design is presented so that any contractor or equipment supplier could utilize the basic information to complete detailing to the point required for fabrication.

TASK 5

Description: Equipment details including all engineering work for equipment and equipment components other than readily available standard components.

Due to the abbreviated time period of seven months from the time of subcontract award instead of the nine months originally planned, these details were deferred to Phase II.

For the purposes of this study equipment details were not to be done except as required for greater clarity of design.

TASK 6

Description: Basic installation engineering as needed for equipment layouts and supports including civil, structure, and utility engineering.

This engineering is completed to the point required for estimation purposes as originally planned. Drawings are to be found in P.E.C. Volume 2 and Volume 3.

TASK 7

Description: Utility layout engineering incorporating piping and electrical drawings and all utility routings.

This engineering is graphically represented on the drawings included in P.E.C. Volume 2, Section and Volume 3.

The extent of the engineering is confined to the boundary of the dry coke quenching immediate area. All connections and engineering required beyond that boundary are the responsibility of National Steel to be completed when a supplier is chosen.

TASK 8

Description: Instrumentation and control engineering including P & I diagrams, instrument logic drawings, instrument location drawings, list of instruments and control panel layouts.

Those drawings required for estimating purposes and the associated specifications will be found in P.E.C. Volume 2, Section 13 and 14 and Volume 3.

The instrument logic drawings, location drawings, and control panel layouts are not deemed necessary for Phase I.

TASK 9

Description: Total capital cost estimate broken down in sufficient detail to differentiate major cost items and to also include ancilliary and support equipment defining a total installed scope of work.

Volume 1, Section 6 of the P.E.C. final report shows a breakdown of the costs of the various components of this system including estimates of the installation costs. These costs when combined with the items below total $21,742,652.

The following costs will be incurred by the Weirton Steel Division during installation:

1. Demolition of existing installation
2. Site preparations
3. Spare parts
4. Contingencies
5. Start-up costs
6. Taxes
7. Insurance
8. Escalation

The basic installed cost is $16,068,257. Estimates of items 1, 2, 3, and 5 along with 6% interest during construction will add $1,580,000 to the installed costs.

Basic cost	$16,068,257
WSX costs	1,580,000
Subtotal	$17,648,257

If escalation is assumed to average 6% per year of the installed costs, then the following must be added:

$17,648,257 x .06 = $1,058,895/year

Based on a two year construction period, this amounts to $2,117,790.

Subtotal	$17,648,257
Escalation	2,117,790
Total	$19,766,047
Contingency @ 10%	1,976,605
Grand Total	$21,742,652

TASK 10

Description: Obtain and develop estimated operating and maintenance cost including a return on investment analysis.

The P.E.C. economic evaluation is presented in Volume 1, Section 9. The total investment used does not include the additional items listed in Task 9. The P.E.C. study shows an after tax return of 7.9% of the total investment of $17,580,000.

When the additional items of cost given in Task 9 are included, the economic evaluation changes as follows:

Economic Evaluation

The following evaluation is based on the DCQ plant operating at 85% of the design capacity, i.e., at an annual coke throughput of 1,026,000 tons (dry weight).

Investment

The total plant investment is estimated to be:

Installed cost of plant	$16,068,257
Demolition	100,000
Site preparation, roads, etc.	100,000
Spare parts (2% of installed cost)	320,000
Start-up costs (labor, materials and utilities for 3 months)	100,000
Interest during construction (6% of installed cost)	960,000
Escalation and contingency	4,094,395
Total Investment	$21,742,652

Operating Costs

		$/Year
Depreciation (20 year straight line)		$1,087,133
Insurance (1% of investment)		217,427
Labor (8 men at $30,000/year - See Note 1)		240,000
Maintenance (2% of installed cost)		434,853
Power (3 kwh/ton coke at $0.025/kwh)		77,000
Water (267 gallons/ton coke at $0.25/1000 gal.)		68,000
Coke Oven Gas (38 SCF/ton coke at $1.00/1000 SCF)		50,000
Nitrogen (3 SCF/ton coke at $2.00/1000 SCF)		6,000
Chemicals		10,000
Flocculant	$3.00 /lb.	
Salt	0.03 /lb.	
HCl	0.035/lb.	
NaOH	0.035/lb.	
Sulfite	0.15 /lb.	
Calgon	0.30 /lb.	
Total Operating Cost		$2,180,413

Note: 1. Labor cost is based on basic salary of $24,000/year plus fringe benefits of 25%.

2. No allowance is made for interest on money borrowed for investment.

Income

	$/Year
Steam (417,000 tons at $9.27/ton)	$3,866,000
Coke fines (9600 tons at $50/ton)	480,000
Total Income	$4,346,000

NOTE: This does not allow for the increased coke yield with DCQ. Estimated burn-off with DCQ is 0.2%, compared with up to 2% for open wet quenching. This would represent an additional income of well in excess of $1,000,000, if coke is costed at $100/ton.

Profitability

Income	$4,346,000
Operating Costs	2,180,143
Margin	$2,165,587
Corporation Tax	1,039,482
Income After Tax	$1,126,105
Investment Tax Credit (10% of installed cost distributed over 20 year life)	80,341
Average Annual Income After Tax	$1,206,446

This represents a discounted cash flow return of 10.5%.

Using the total investment estimate of $21,742,652, the discounted cash flow return of 10.5% is marginal and would not receive favorable consideration.

TASK 11

Description: Obtain and develop estimated data for comparison to the base line return on investment in generating an equivalent amount of steam by conventional processor.

The generation and supplying of steam to the production units at a steel mill is considered a service utility such as water, compressed air, etc. The service is charged out at actual cost; thus the installation of a steam generating boiler cannot be justified by savings unless it is replacing an old, inefficient, high maintenance unit or is included in an equipment package that will increase production or generate increased profits.

A new package boiler designed to produce 100,000# of steam/hour would cost approximately $2,100,000 installed.

Assuming that the boiler and the DCQ unit generated the same amount of steam, the following information can be itemized:

	Conventional Boiler	DCQ
Capital Cost	$2,100,000	$21,742,652
Operating & Maintenance	$4.93/1000# steam	$2.61/1000# steam
Depreciation	$0.17/1000# steam	Included
Steam Generation	417,000 tons/year	417,000 tons/year

It can be seen that a capital investment will be required for the DCQ that is ten times that of the conventional boiler and that the cost of steam generation by the DCQ will only be 51% of the conventional boiler. The figure of $4.93/1000# steam is the present charging rate at Weirton Steel Division, but does not include amortization.

Using the above cost, the difference is $5.10/1000# less $2.61 or $2.49/1000# steam.

417,000 tons steam x $2.49/1000#	$2,076,660
Taxes @ 48%	996,797
Savings after taxes	$1,079,863

Based on the difference in capital cost and the savings realized, it would take over 18 years to recover the increased capital cost.

In both cases, the cost of borrowing money has not been included.

TASK 12

Description: Prepare a statement of engineering and operating feasibility elaborating on technical risks which may be encountered in the construction and operation of such a facility.

The process of dry quenching of coke has been proven to be a very successful operation in regard to the engineering and operating feasibility. The USSR and Japanese steelmakers have successfully used the dry quenching process for several years, and both are now marketing the technology.

The installation of dry quenching in the U.S. has been delayed due to the availability of cheap energy in the past and not due to any concern for technical risks which may be encountered. The process uses equipment and control that is in common use throughout the steel industry, and has been proven extremely dependable both mechanically and electrically.

It is believed that the installation of a dry coke quenching unit should present no more construction and operations problems than would be encountered with the installation of any other equipment of comparable monetary value.

TASK 13

Description: Make a recommendation as to whether such facilities should be built with adequate justification for the recommendation.

See page 2 for recommendation.

TASK 14

Description: Make an assessment of the environmental improvement effect in terms of identified particulate per hour which will occur from the Brown's Island dry coke quencher as compared to conventional processes.

In the conventional process of wet quenching, the incandescent coke is transported to a water quenching area. This area is normally enclosed with a concrete structure either with or without baffles. The coke is quenched with water using either clean water or recycled uncleaned water.

The actual testing of several wet quenching facilities has produced widely varying results. In an effort to reduce the variations and to provide a common factor, the following particulate emissions have been proposed as typical.

		Type of Wet Quench
2.2 lbs./ton of coal coked	-	Uncontrolled
1.1 lbs./ton of coal coked	-	Controlled (baffles and dirty water)
.25 lbs./ton of coal coked	-	Controlled (baffles and clean water)

In the dry coke quenching process, the following particulate loadings are predicted based on production of 2700 tons of coke per day or 3970 tons of coal coked per day:

.0008 lbs./ton coal coked	- Purge gas
.008 lbs./ton coal coked	- Extract air

Total - .0088 lbs./ton coal coked

In addition, there will be some particulate from the pressure relief valves that will release a few cu.ft. of bunker gas to the atmosphere. Assuming

the valve relieves at every coke charge (6 per hour) and discharges 100 cu.ft. of gas at each occurrence - 600 cu.ft. per hour @ 10 grains/cu.ft. = 6000 grains/hour. This represents less than 1#/hour (.857) and will discharge .005#/ton coal.

Grand Total - .0008 + .008 + .005 = .0138#/ton coal.

These numbers are predictions by P.E.C. and are not verified at any operating unit. Assuming that the predictions are 100% low, the particulate loading would still be less than the best wet quench arrangement - .0276#/ton of coal vs. .25#/ton of coal.

Transport of the coke over conveyor belts and junction houses may produce a more severe dusting problem than with wet quenched coke, but the lack of comparative data makes this difficult to assess at this time.

TASK 15

Description: Assemble a task summary report showing all drawings, designs, specifications, data and calculations necessary to fully describe the work done and a summary of results of each task in such detail so that DOE can, based on the report, contract for the recommended work of Task 13. A reproducible copy of the final report is to be provided documenting all of the work performed under the contract.

This task is completed with the submission of this report.

TASK 16

Description: Prepare a multi-media environmental assessment of dry coke quenching including projected comparisons with conventional wet quenching practice. These comparisons shall include the actual quenching operation and subsequent coke handling systems, environmental control at the blast furnace, and utilization of the steam generated by dry quenching.

This task is to be performed by the Environmental Protection Agency as agreed in a meeting with National Steel, EPA, DOE, PECOR, and Waagner-Biro on December 5, 1977.

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