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COAL-WATER FUEL DEVELOPMENTS IN EASTERN CANADA: THE CHATHAM AND CHARLOTTETOWN DEMONSTRATION AND BEYOND

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ABSTRACT

Under a cooperative agreement between Energy, Mines and Resources Canada, the New Brunswick Electric Power Commission and the Cape Breton Development Corporation, a 4 t/h preparation facility has been built to produce a coal-water fuel for testing in two small utility boilers located at Chatham, N.B. The formal Chatham project is now completed and this paper presents the results from CWF burner and boiler performance testing in the two units at Chatham, N.B.

Under a similar cooperative agreement between Energy, Mines and Resources Canada, Maritime Electric Company Ltd., New Brunswick Electric Power Commission and Cape Breton Development Corporation, funding has been provided to develop burners for testing on unit No. 10 at the MECL Generating Station at Charlottetown, Prince Edward Island, Canada.

This unit is a 20 MW(e) Babcock and Wilcox front-wall fired unit designed for No. 6 fuel oil and is extremely compact in design. Details will be given of the status of the unit test program, and modifications, burner selection and pollution control measures being taken in order to be able to operate the unit on CWF during late 1985.

MISE AU POINT D'UN COMBUSTIBLE À BASE DE CHARBON ET D'EAU DANS L'EST CANADIEN DÉMONSTRATIONS AUX INSTALLATIONS DE CHATHAM ET DE CHARLOTTETOWN ET AUTRES ASPECTS

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RÉSUMÉ

En vertu d'une entente de coopération entre Énergie, Mines et Ressources Canada, la Commission d'énergie électrique du Nouveau-Brunswick et la Société de développement du Cap-Breton, une installation de préparation d'une capacité de 4 t/h a été construite en vue de permettre la production d'un combustible à base de charbon et d'eau. Le projet conventionnel de Chatham est à présent complété et ce rapport présente les résultats de la performance du brûleur CCE et des chaudières des deux installations de Chatham, Nouveau-Brunswick.

En vertu d'une entente de coopération de même nature entre Énergie, Mines et Ressources Canada, la Maritime Electric Company Ltd., la Commission d'énergie électrique du Nouveau-Brunswick et la Société de développement du Cap-Breton, des fonds ont été alloués pour la mise au point de brûleurs devant servir aux essais à l'installation n° 10 de la Centrale MECL de Charlottetown, Île-du-Prince-Edouard, Canada.

L'installation à alimentation frontale, une unité Babcock et Wilcox d'une capacité de 20 MW(e) conçue pour la préparation de mazout n° 6 est de faible encombrement. Le rapport présente des détails sur l'état actuel du programme d'essais en installations, les modifications apportées, le choix des brûleurs ainsi que sur les mesures qui ont été prises pour le contrôle de la pollution de façon à permettre l'exploitation de l'installation CCE vers la fin de l'année 1985.

INTRODUCTION

The first stage of the Canadian CLM program has brought the development of coal-liquid fuel technologies well beyond laboratory scale but they are still not ready for widespread commercial application. The aim of the next phase of the program is to define equipment performance, fuel and combustor specifications, and capital and operational costs for the manufacture and delivery of CWF and for the conversion of boilers originally designed to burn oil. This information will enable potential CWF producers, transporters and users to determine where, and the circumstances under which its use would be commercially attractive. The work of the next phase includes a demonstration of the combustion of CWF in a 20 MW(e) boiler designed to burn oil in a compact space and definitive, site-specific, cost estimates for a CWF manufacturing plant and for the conversion from oil to CWF of an electric utility boiler in the 100-150 MW(e) range.

CHATHAM DEMONSTRATION PROJECT

The major tasks in the project were (a) the construction, startup and operation of a continuous pilot production plant for the manufacture of CWF, (b) the rail transportation of the CWF to the Chatham Thermal Electric Generating Station, approximately 700 km from the production plant and (c) the demonstration of burners using the CWF in both a front wall-fired boiler and a tangentially-fired boiler.

a) Manufacture

The design, erection and commissioning of the coal-water production plant, which was undertaken by CBDC and assisted by their licensor AB Carbogel of Sweden, was completed in mid- 1983. The pilot production plant site was chosen adjacent to CBDC's Victoria Junction coal preparation plant because this site provided access to a variety of services. The basic process flow sheet, material balances and equipment refinement and specifications were developed with the assistance of AB Carbogel. Details of the pilot production plant were given at an earlier symposium[1)].

The beneficiation in the pilot plant achieved levels of ash and sulphur in the fuel which have the potential to be attractive to users, particularly where the fuel application requires a very clean product.

b) Transportation

The Chatham Generating Station is located near the mouth of the Mirimichi River in northeastern New Brunswick. The station is served by two major highways, the Canadian National Railway system, and is accessible throughout the year. A wharf is located on NBEPC property, adjacent to the plant.

A study was undertaken to investigate the most economical and suitable method of transporting the required 6000 tonnes of CWF from Sydney to Chatham. Road transportation seemed to be convenient; however it proved to be less flexible and more costly for this type of project. Investigation of water transportation indicated that, to be economical, major storage was required both at the pilot plant and at the Chatham station. The most economical method of transportation of the CWF was determined to be rail.

Twelve rail cars, operating in four groups of three, were required for CWF transportation. A weight restriction on the rail line to the Chatham station limited the amount of fuel each car could carry to 70 tonnes. The rail cars were also used as storage to act as a buffer against interruptions either in production of fuel or testing at Chatham.

Normally, delivery of fuel from Victoria Junction, Sydney, to the Chatham plant took about one week. Although some shipments took much longer, minimal problems were encountered with the fuel transportation or unloading.

Uninsulated tank cars were used initially because the burner demonstration was scheduled to be completed prior to the onset of cold weather. However, the project was extended into the winter months and the uninsulated rail cars presented some problems in handling because of freezing, especially on the outside shell of the tank and the tank outlet. As a result one insulated rail car was added to the fleet. This rail car was able to move fuel from Sydney to Chatham over approximately a two week period in mid-winter, without problems in freezing of the fuel or in unloading.

Temporary receiving and unloading facilities were constructed at the Chatham plant to accommodate shipments of fuel. This involved placing temporary pipelines adjacent to the rail siding with three unloading points. The pipelines carried compressed air for pressurizing the rail cars to assist unloading and water for prewetting the fuel lines prior to use and to flush the lines out. In addition, a 100 mm diameter line was used to move fuel from the rail cars to the in-plant storage. As cold weather approached, a steam line was added to the facilities, to provide heat for thawing of the rail cars and outlets and to keep the fuel lines from freezing during winter operation. All pipes were then wrapped in a bundle inside a blanket-type insulation.

In general, no unexpected problems were encountered when handling fuel in below freezing temperatures. It was found that, if the fuel was loaded at the plant in Sydney at a relatively warm temperature (25°C) and the outlet valves were thawed, the fuel could be discharged at Chatham without problems.

Air lances were used to agitate the fuel in the tank cars, with limited success. Internal heating coils in several of the cars interfered with the removal of all of the fuel from the cars and made the cleaning of the interior of the cars much more difficult.

Through a series of delays, which aggravated cold-weather problems, several rail cars ended up with varying quantities of settled fuel in them. The problems of removing this settled fuel from the rail cars and, even worse, disposing of it in an environmentally acceptable manner, proved to be much greater than originally anticipated. The very fine coal, which is used to manufacture CWF, was found not to settle easily and therefore care had to be taken to provide adequate settling time. The settling time was not adequate in the ash ponds normally used and ultimately a hydraulic process was utilized. Water was pumped from a coal wash plant tailing pond at high pressures (of the order of 1.2 MPa) and the discharge routed back to the pond. This, combined with agitation at first and finally with scraping, enabled the rail cars to be cleaned effectively.

c) Burner demonstration

The only suitable location within the Chatham plant for a fuel storage facility was a coal bunker. This bunker was suitably modified for storage of the CWF. In addition, connections were installed in the bunker to provide a means of agitating the fuel by means of compressed air. Experience at Chatham indicated that this type of storage is not the most suitable configuration for CWF. The shape of the bunker proved to be a disadvantage in that it induced the fuel to channel from fuel delivery point, or the recirculating line discharge, to the inlet to the burner fuel pumps.

Future CWF storage should be designed in such a manner that the fuel within the storage vessel can be agitated in a very slow and thorough manner with paddle mixers. Channeling in the storage bunker tended to magnify small variations in consistency between the different rail cars of fuel. This showed up as unpredictable changes in the quality of the flame at the burners.

As the particular CWF used is very sensitive to overheating, it was difficult to warm the fuel in the rail cars prior to unloading, since the only source of heat available was steam. In future installations, care should be taken to ensure that a heating medium is available at an unloading station which will provide heat for the fuel, within the temperature limits established by the fuel manufacturer.

The fuel was unloaded from the rail cars through a progressive cavity transfer pump located in the basement of the power house. From there it was pumped directly to the storage tank. The fuel was pumped from the storage tank to the burner front of either boiler by a second progressive cavity pump. The input side of this pump was always under static pressure from the fuel in the storage bunker. The pumps were sized for 125% of maximum required flow so that some fuel could always be recirculated.

The flow to the burners was controlled by a valve station located downstream from the burner front. This valve station controlled the fuel pressure at the burner front to the level desired and allowed a fraction of the fuel to be recirculated back to the storage system. Pipelines were generally carbon steel run in straight lines with right angle bends. No bends or curved pipe were used. Flexible braided lines were used from the main headers to the burners. In general, very few problems were experienced with the fuel lines.

The fuel pressure for the front wall-fired unit was controlled by a pinch valve. These valves worked extremely well, where the fuel was required at a pressure of less than 700 kPa.

On the tangentially-fired unit the fuel was required at a higher pressure of approximately 1 MPa. For this pressure, the pinch valve was not suitable and therefore the system was modified to include a variable speed drive on the fuel pump as well as a pressure control valve. In general, the fuel systems were operated in a similar manner to a bunker oil system on a large utility boiler. One of the main design criteria for the delivery system was to minimize dead-end lines and to keep the fuel moving through the system.

Contracts were awarded for the development, design and supply of burners for each of the two boilers in the Chatham plant. One contract was awarded to Foster Wheeler Canada Limited, for the supply of burners for the No. 1 unit. This unit is a front wall-fired Foster Wheeler balanced draft boiler, designed with a capacity of 12.5 MW(e) when burning New Brunswick coal. It was converted to No. 6 oil in the early sixties.

A detailed inspection was conducted on the No. 1 boiler to identify potential problems. No attempt was made to bring the unit to a new condition, but emphasis was placed on being able to obtain reproducible results during the extended period of testing on oil and CWF. The boiler and air heater gas passages were cleaned, the soot blowers were examined but were not operational and were not used in the tests, due to problems in obtaining replacement parts.

Four independent burner wind-box assemblies were supplied and installed on the boiler. Modifications were required to both the front wall and combustion air duct. Five front wall tubes were replaced to accommodate the larger burner throats. Brick work and refractory around the throats were modified and the combustion air ducts were changed to fit the deeper burner wind boxes. Balancing dampers were removed from the duct work and incorporated in the sleeve type damper burner registers. The new burners were each rated at 40 GJ/h thermal output. Ignition and support energy to each burner was provided by two light oil pilots, each rated at 6 GJ/h. Each burner was provided with controls to allow precise adjustment of air or fuel flow, as was necessary to optimize burner performance.

The same burner gun was used to fire heavy oil, by changing the fuel gun tip and position of the primary air damper. No other modifications were necessary. The changeover normally took less than fifteen minutes per burner, while the unit was on line. The boiler was operated manually by operators, located directly in front of the burners. No burner management system or flame supervisory system was provided, other than viewing ports at each burner.

All burner valves and controls are manual and were arranged for ease of changeover from CWF to No. 6 oil and vice-versa. The fuel flow was controlled by manual pinch valve on a recirculation line from the burner front. A second small valve in parallel to the main control valve was used to adjust the flow of fuel according to minor changes in boiler load. Recirculated fuel returns to the main storage.

The initial test program was developed by NBEPC in consultation with the burner supplier[2)]. This program included an oil base-line test and performance test while firing CWF. An initial test program was established to select materials for the CWF burner atomizer. This test program involved a series of tests on seven different materials for periods up to about 125 h. The materials tested included hardened tool steel, tungsten carbide spray coating, boron heat treatment on tool steel, cemented tungsten carbide and three different ceramic materials. The initial wear tests indicated a service-life of about 1000 h. The components of the atomizer utilized for the performance testing of the unit were a combination of cemented tungsten carbide and hardened tool steel.

A series of performance tests was conducted by NBEPC on the front wall-fired unit using No. 6 oil and CWF. In summary, as shown in Table 1, the unit was shown to operate on CWF with an average efficiency performance of 78% and a maximum efficiency performance of 81%; the boiler was shown to operate on No. 6 oil with an average efficiency performance of 84%.

Table 1 - SUMMARY
CHATHAM NO. 1 BOILER EFFICIENCY
OIL AND CWF FIRING

FIRING MODE	TEST DATE	UNIT MW LOAD	PERCENTAGE LOSSES						TOTAL BOILER EFFY, %
			DRY GAS	MOISTURE* IN FUEL	UNBURNT COMB.	MOISTURE IN AIR	RADIATION	UNMEAS	
No. 6 oil	83.07.19	9.8	7.94	6.15	0.36	0.26	0.50	1.00	83.80
	83.07.19	7.4	8.70	6.15	0.36	0.20	0.65	1.00	82.94
	83.07.18	5.0	6.07	6.02	0.36	0.20	0.85	1.00	85.51
CWF	84.01.19	9.8	7.75	6.95	4.10	0.19	0.55	1.50	78.97
	84.07.16	9.7	6.68	8.00	2.11	0.20	0.50	1.50	81.00
	84.01.19	7.7	9.00	7.23	2.81	0.23	0.60	1.50	78.64
	84.06.27	7.5	6.93	7.34	10.87	0.21	0.55	1.50	72.60
	84.01.20	5.4	8.81	6.81	3.78	0.21	0.75	1.50	78.14
	84.06.27	5.2	8.52	7.37	14.68	0.19	0.80	1.50	66.94
	84.07.17	5.4	10.55	7.51	3.91	0.26	0.70	1.50	75.56

*Total loss from moisture in fuel plus H_2O from combustion of H_2

REMARKS:

Performance calculated by NBEPC, using ASME standard procedures.

Normal operation of the boiler included: light-off with No. 2 oil; warm the boiler up; switch to No. 6 oil to bring the boiler to operating load; and, switch (while on load) one burner at a time to CWF.

The switching of the unit from CWF to No. 6 oil and back, while on load, proved to be a very routine operation.

Light-off also proved to be straightforward and although two 6 GJ/h igniters were provided on each burner, in practice it was found that only one was required. It was also possible to light-off the unit using CWF without the preliminary warming step, using No. 6 fuel oil. Normal procedures, used by the operators when starting up the unit with bunker oil, were also followed for CWF. Although performance tests were not conducted with CWF at a large variety of viscosities, the unit operated quite successfully with CWF of viscosities between 500 and 1200 centipoise (Brookfield). The burners were designed for air atomization at less than 800 kPa air pressure and although atomizing with steam was attempted, it proved unsuccessful when firing CWF.

The ash that formed in the No. 1 unit, when the burners were atomizing the fuel properly, tended to be a very light fluffy ash, which did not deposit in the cyclones or in the furnace bottom.

Although the burners worked well with fuels at different viscosities, they were found to be extremely sensitive to primary and secondary air adjustments and to minor fluctuations in fuel characteristics.

A second contract was awarded by NBEPC to Combustion Engineering Canada for the development, testing and supply of burners for the No. 2 Unit. This unit is a 22 MW(e) tangentially fired Combustion Engineering balanced draft unit. It was originally designed to burn New Brunswick coal and subsequently was converted to burn No. 6 fuel oil.

The CWF burner gun initially developed by the burner manufacturer, required high pressure fuel and atomizing air. These pressures were considered too high for application in utility boilers and the burner manufacturer was provided with maximum pressure limits for both atomizing media and fuel, which were in the range of 825 to 1035 kPa. Subsequent development of an atomizer, meeting these requirements, in the manufacturer's test facilities indicated good fuel atomization quality with both air and steam[3)].

Since the maximum wind box air pressure on the Chatham unit was only 0.5 kPa, a booster fan was installed. New burners were supplied and installed on the unit by October 1984. At each burner location there is a supply of purge water, compressed air for atomizing and purging, steam for atomizing No. 2 fuel oil for ignition, No. 6 fuel oil and CWF. Unit No. 2 is operated manually by the operators located adjacent to the boiler. There is no burner management system or flame supervisory system other than viewing ports and a television camera, which views all four burners from above. All burner valves and controls are manual and arranged for ease of switching from CWF to No. 6 fuel oil.

The fuel is controlled by a manual valve on the recirculation line from the burner front. A second manual valve, in parallel with the main control valve, is used to adjust the fuel flow according to minor changes in load. In addition, a manually operated variable speed drive was installed on the fuel pump to minimize the amount of fuel passing through the bypass valves and to provide better fuel flow control. Several performance tests were conducted by NBEPC on the unit. The preliminary boiler test results for unit No. 2 are summarized in Table 2.

Remarks:

These are the preliminary results of the performance tests conducted by NBEPC using ASME procedures and do not include data from Combustion Engineering at the time of writing (March 1985).

Achievements on unit No. 2 were as follows:

The unit was operated at loads from 50% to full capacity with all four burners using CWF and with no support ignition required.

It was possible to switch at full load from No. 6 fuel oil to CWF. The fuel switching took approximately 20 minutes per burner because of the weight and size of the burner guns. It is expected that future coal-water burners will weigh less and be less cumbersome and the switching will then take much less time, as was the case on unit No. 1.

Table 2 shows that the unit operated at about 85% boiler efficiency(ASME indirect method) compared with from 68% to 72% when using CWF (based on NBEPC data).

A notable achievement with respect to these burners is that it was possible to operate using steam as an atomizing medium. The results with steam atomization were significantly better than with air. It must be noted however that in general the burners appear to be very sensitive to minor variations in CWF properties.

The atomizers were of T design with tungsten carbide inserts and showed negligible indications of wear during the cumulative burner operation on unit No. 2.

Boiler startups were straight forward; the unit was warmed up on light oil, then switched to No. 6 fuel oil until the furnace was hot. When adequate steam pressures and temperatures were reached, the burners were switched to CWF individually and adjusted until the flame stabilized.

Table 2 - SUMMARY
CHATHAM NO. 2 BOILER EFFICIENCY
OIL AND CWF FIRING

FIRING MODE	TEST DATE	UNIT MW LOAD	PERCENTAGE LOSSES						TOTAL BOILER EFFY, %
			DRY GAS	MOISTURE* IN FUEL	UNBURNT COMB.	MOISTURE IN AIR	RADIATION	UNMEAS.	
No. 6 oil	83.10.27	20.3	6.74	6.18	0.45	0.13	0.40	1.00	85.10
CWF**	83.11.07	18.2	11.08	7.47	7.47	0.17	0.45	1.50	71.86
	83.11.08	19.6	11.88	7.37	10.71	0.16	0.40	1.50	67.99
***	84.11.09	20.2	13.34	7.35	7.09	0.18	0.40	1.50	70.14

* Total loss from moisture in fuel plus H_2O from combustion of hydrogen.

** Two ignitors required for flame stability - heat input adjusted for 260 l/h, No. 2 oil.

*** Test using steam atomization - approximately 1750 kg/h steam used on 4 burners. Air atomization for previous CWF tests.

Note: Both CO_2% and CO% in flue gas estimated for oil fired tests and CO% estimated for all CWF tests.

CHARLOTTETOWN DEMONSTRATION

The 20 MW(e) boilers at the Maritime Electric Company's generating station in Charlottetown, P.E.I., have been identified as the most suitable boilers in Canada for continuation of the program to demonstrate the combustion of CWF in an electric utility boiler designed to burn oil. These boilers were identified because they are not in regular use, because their compact nature is a challenge to the new fuel which will indicate its potential for most other units designed to burn oil, because they are of an appropriate size for the demonstration and because the modifications (conversion from forced to balanced draught and addition of a bag-house) needed for demonstraton will be beneficial to station operation and to the local environment, whatever fuel may be used in the future.

The specific boiler chosen for the demonstration, unit No. 10, has the capacity to raise 24 kg of steam per second at a pressure of 6 MPa and a temperature of 480°C. The physical arrangement of this boiler is such that the distance from the first bank of boiler tubes to the burner throats is only about 5 m. The boiler was built with five burners, firing through the front wall in two horizontal rows, the lower row having three burners, the upper row having two. Bidders for CWF burner conversion were given the choice of using as many of these burner ports as they wished, provided that sufficient fuel could be burned to raise 24 kg/s of steam as a maximum and that 6 kg/s of steam could also be raised on a continuous basis, without ignition support for the CWF under either circumstance. This range was required because the boiler derating, due to the change from oil to CWF, was unknown. A further requirement was that the carbon conversion during combustion be above 98%.

Boiler derating may be caused by insufficient heat generation or by insulation of the heat generated from the water and steam in the boiler tubes. Insufficient heat may be generated because flame temperature or position may be inappropriate, because gas velocities have to be kept low enough to avoid tube erosion, or because flames have to be restricted in size to avoid impingement on furnace walls and consequent slagging. Heat transfer may be restricted by accumulation of slag on boiler water walls or by fouling of boiler tubes by ash. It may be possible to minimize the deleterious effects of fouling or slagging by the use of soot blowers. The Charlottetown demonstration is investigating all of these effects. By the end of the demonstration, 15,000 tonnes of Carbogel fuel from Cape Breton and up to 5,000 tonnes of other CWF will have given reliable indications of how these fuels behave and how operators can cope with start-up, operation at various levels and ash disposal. Knowledge of boiler performance, wear and associated economics will also be available.

The first phase of the demonstration starts with the selection, during the first four months of 1985, of burners suitable for the demonstration. Modifications to the boiler also start in early 1985 and should be complete by August, in coordination with the selection, manufacture and installation of burners. Fuel preparation continues throughout the spring and summer months of 1985 and the combustion demonstration follows this with a target of completion by the end of the year. At the end of the Charlottetown demonstration and the definitive estimates for commercial CWF production and conversion of a large electric utility unit, the following information will be known on a site-specific basis:

1. fuel specifications;
2. means of manufacturing, transporting and using CWF;
3. cost of fuel production plant;
4. operation, maintenance and feed cost for fuel production;
5. cost of fuel transportation, handling and storage;
6. derating;
7. cost of conversion from oil to CWF;
8. cost of and constraints on boiler operation using CWF;
9. possible low-cost modifications to reduce derating.

THE FUTURE UTILITY CWF PROGRAM

If the Charlottetown CWF project proves successful, then economic and environmental studies on large units are likely. Part of the Charlottetown project will be the selection of an oil-designed utility boiler in the 100-150 MW(e) range for a cost estimate and conceptual design for CWF conversion. Candidate units are the Nova Scotia Power Corporation (NSPC) Tufts Cove generating station No. 2 and 3 units and NBEPC's Dalhousie No. 1 unit and Courtenay Bay No. 3 and 4 units. Details of the major parameters that will affect performance of these units on a CWF conversion are given in Table 3.

Table 3 - COMPARISON OF DESIGN PARAMETERS OF CANDIDATE CWF CONVERSION UNITS WITH COAL-DESIGNED UNITS

UNIT	CAPACITY	EPRS 1)	PAHR 2)	FEGT 3)	TUBE SPACING (m)		
	MW(e)	(MWm^{-2})	(MWm^{-2})	(°C)	RS 4)	SSH 5)	RH 6)
Tufts Cove 2	100	0.45	5.9	1270	0.30	0.15	0.10
Tufts Cove 3	150	0.52	5.6	1290	0.30	0.15	0.10
Dalhousie 1	100	0.27	5.7	1200	0.45	0.23	0.15
Courtenay Bay 3 and 4	100	0.32	4.7	1200	0.45	0.23	0.11
Coleson Cove 1, 2 and 3	335	0.69	7.3	1200	0.45	0.23	0.11
Dalhousie 2*	200	0.21	4.8	1200	0.60	0.23	0.15
Trenton 5*	150	0.32	4.5	1010	0.91	0.22	0.11

1) Effective Projected Radiant Surface
2) Plan Area Heat Release
3) Furnace Exit Gas Temperature
4) Radiant Section
5) Secondary Superheater
6) Reheater

* pulverized coal fired

Remarks:

The Tufts Cove and Coleson Cove units were designed for heavy fuel oil with no consideration being given for future coal conversion. This is reflected in the very high heat release and absorption parameters shown in Table 3, when compared to the units currently using coal or which are coal capable. The units typically have smaller furnaces, higher furnace gas exit temperatures, closer tube spacing and flat furnace bottoms. They are typical of many units designed at this time, principally to reduce the capital, operating and maintenance investment. Conversion of these plants to CWF may require significant derating penalties, unless major modifications can be carried out on the original installations, or significant beneficiation can be carried out on the parent coal to reduce the ash content to below 2%.

It must also be recognized that for oil designed furnaces, gas velocities entering the first pass are typically of the order of 22 m/s, which, even with a beneficiated CWF may have to be reduced considerably in order to avoid excessive tube erosion problems and thereby contribute to further derating of the unit.

It should also be noted that the wider first (and some subsequent) pass tube spacings and the lower gas exit temperature of the coal-fired unit are important factors in determining the overall performance of compact oil-fired units, either by derating or by boiler modifications.

Without physical changes to the boiler design, output will probably be restricted from 50% to 70% of that achievable when firing oil, again depending on the degree of fuel beneficiation. Even for a clean CWF of about 1.5% ash, this is an order of magnitude higher in ash content than that found in heavy fuel oil.

For such a study to arrive at the most cost effective and best engineering solutions, a number of alternatives will have to be considered,

1. Convert to CWF and derate the unit output as imposed by the fuel and operating conditions.

2. Convert to CWF and consider boiler design changes that will enable full-rating to be maintained.

3. Convert to CWF but retain the capability for oil-firing. Hence full-load may only be achieved when firing oil and a derated output when firing CWF.

4. Convert to CWF but retain the capability to burn oil or CWF by boiler design changes to achieve full-load operation by either mode of firing.

For the Tufts Cove Generating Station units raw coal would be supplied from the CBDC coal mines, which are about 350 km from the station. Hence an integral part of the study would evolve around the best location for the CWF preparation plant from technical, environmental and economic aspects. In the case of the New Brunswick generating stations, in addition to the CBDC coal supply, coal may be obtained from the US or transported by sea from Western Canada.

If CWF is to be manufactured at the pithead, then it must be established that during transportation it will not destabilize. Also, because of the severe Maritime winters, consideration must be given to the prevention of freezing. Transportation costs will certainly consider that CWF's contain about 30% free moisture. It is expected that the site specific study of the various CWF preparation plants and the unit conversion scenarios outlined above, will be completed by late 1985. The study will then be used to determine the future direction of the utility CWF demonstration program.

ONGOING WORK

The ongoing program of demonstration of CWF in utility boilers has generated interest in Canada in the industrial sector. A 1981 survey[4)] conducted by the Montreal Engineering Company on behalf of EMR showed that industrial boilers and process combustors consume about 46 x 10^6 bbl/year compared with 15 x 10^6 bbl annual consumption of fuel oil for power generation, the latter all in Eastern Canada. Therefore it is not surprising that CWF technology development has generated interest in industry across Canada.

Canada Cement Lafarge, one of the largest cement producers in Canada, has been following the Chatham demonstration program with interest and has also been involved in a short CWF test at Sete, France by its affiliated company Lafarge. In collaboration with EMR, a program has been developed which could lead to a 38-week test project in a wet process cement kiln in Richmond, British Columbia. The program which started in late 1984 has as its main objectives:

(i) To develop and optimize on-site CWF preparation, using surplus wet process grinding capacity.
(ii) To observe the impact on the cement manufacturing process of replacing natural gas with CWF.
(iii) To develop and optimize durable burners for CWF. More information on this program is being given at another presentation at this symposium.

During 1982, the Iron Ore Company of Canada became interested in COM as an option for replacing fuel oil in its iron ore induration operations in Labrador City, Newfoundland.In order to assess the feasibility of using COM they approached EMR for financial and technical assistance to convert an oil-fired iron ore dryer located in Sept Iles, Quebec, to a coal-based fuel. The conclusions[5)] of the 50 h test burn in the dryer confirmed that the use of COM was technically feasible, but only marginally so on an economic basis.

During 1983 and 1984, the Iron Ore Company evaluated many other options for alternative fuel and finally approached EMR for technical support of a project to evauate CWF. The first phase, now completed, was a single burner test in an iron ore induration furnace. A number of CWF and burners were evaluated in this phase. The second phase is scheduled to be a full zone conversion of eight burners, four each on opposing walls of the furnace. The third phase will be a full conversion of the furnace. If, at the conclusion of phase 3, the economic and technical feasibility is attractive, then the Iron Ore Company will proceed with conversion of the entire induration operation in Labrador City to CWF.

EMR, together with the National Research Council of Canada (NRC), has been involved in the development of a wear-resistant ceramic CWF atomizer which can also burn oil[6,7)]. More details of this project will be given in another presentation at this symposium[8)].The nozzle was developed originally from a metallic annular atomizer, which showed some promise because the most susceptible wear components were protected by an atomizing medium boundary layer. Further development led to an adjustable ceramic atomizer which could be made to suit most burner and windbox configurations, and which had been shown to exhibit almost negligible wear in extensive spray and combustion tests. Since that time a comprehensive combustion characterization program has been undertaken on the atomizer in a flame tunnel[8]. Preliminary tests on a single burner in unit No. 1 boiler at the Chatham Generating Station have shown the versatility of the atomizer in being able to switch from heavy fuel oil to CWF by a simple in situ burner-gun adjustment. Most other CWF burners require their atomizers to be exchanged to allow fuel oil to be burned in the boiler. These tests have shown the potential of the NRC atomizer and EMR plans to operate unit No. 1 entirely with the atomizers and two different CWF for performance testing in the spring of 1985. It is expected that this will lead to commercialization of the atomizer.

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