Use of Refuse as Fuel in an Existing Utility Boiler

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ABSTRACT

The City of St. Louis, Missouri and the Union Electric Co. are collaborating in a full scale test of the feasibility of burning prepared refuse as supplementary fuel in an existing pulverized coal-fired boiler. Raw municipal refuse is milled to small particles, magnetic metals removed and the remainder fired pneumatically to a 125 mw boiler unit. The refuse comprises only a small percentage of the total fuel requirement of the boiler.

(At the time this paper was written, the project was not yet in operation. It was anticipated that preliminary operating data would be available for presentation by the date of the Conference.)

BACKGROUND

Early this year, construction was completed for facilities to prepare, transport and fire mixed municipal refuse as supplementary fuel to an existing utility boiler. The project, constructed as a cooperative effort between the City of St. Louis and the Union Electric Co., is partially funded by the Office of Solid Waste Management Programs and the Office of Air Programs of the Environmental Protection Agency.

The St. Louis project was conceived under the premise that if domestic refuse were properly prepared, and if it were to replace only a small percentage of the fuel fired to coal-fired boilers, the effects upon the boilers would be little, if any, different than if the fuel were entirely coal. Although coal-fired boilers are not without operating problems of their own, a comprehensive study of these problems, with the close cooperation of the Union Electric Co., which serves the greater part of the St. Louis Metropolitan Area, concluded that such problems would not be significantly increased, if increased at all, by burning prepared refuse in small percentages. The concept was found to be attractive enough for the Union Electric Co. to offer the use of one of its major boiler units for a full-scale test, and to contribute a substantial sum toward the installation of facilities required for the test.

In brief, the St. Louis project provides for the milling of domestic refuse to particle sizes of less than 1½ in., the removal of magnetic metal, and the firing of the remaining milled refuse to a power plant boiler in quantities on the order of 10 percent of the heat requirement of the boiler. Provisions are made to increase the refuse firing rate up to 20 percent of the boiler’s heat requirement, if it appears appropriate to do so. No provision has been made to remove glass, ceramics or similar materials from the refuse before firing. Should this be found necessary, air-gravity separators, or similar equipment, could be installed to remove at least a portion of the undesirable materials.

TEST BOILER

The boiler to be used for the test in the St. Louis project is shown on Fig. 1. This boiler is small when compared to the newer units in the Union Electric Co. system, but it is of modern, reheat design, and the test results from this unit should be applicable to numerous other existing similar units in service in many parts of the country. Built by Combustion Engineering, Inc., who cooperated fully in the original study, the unit has a
nominal rating of 125 megawatts, and will burn about 56.5 tons/h of Illinois bituminous coal at rated load. The unit is tangentially-fired, with four pulverized coal burners in each corner. It also is fitted to burn natural gas. The furnace is about 28 ft by 38 ft in cross section, with a total inside height of about 100 ft.

At full load, the quantity of refuse equivalent in heating value to 10 percent of the coal will be about 12.5 tons/h, or 300 tons/24-h day. It is intended to fire the refuse 24 h/day, but only 5 days per week, since St Louis refuse collections are scheduled on a five-day per week basis. No difficulty in boiler operation accruing from
this interrupted refuse firing schedule is anticipated.

Other than installing a refuse burning port in each corner of the furnace, no modifications to the test boiler were contemplated. The refuse burning ports were installed between the two middle coal burners. No alterations to the pressure parts of the boiler were necessary. The milled refuse is burned in suspension, in the same flame pattern as the pulverized coal or gas. Non-burnable particles, or burnable particles with sufficient mass to prevent them from being consumed in suspension, therefore will fall to the bottom ash hopper.

The prepared refuse is fired at a constant rate. The existing boiler combustion controls vary the rate of firing of the pulverized coal or gas to accommodate the heat requirements of the boiler. Should the boiler trip and go out of service suddenly, for any reason, an electrical interlock will immediately stop the feeding of refuse, although the pneumatic blowers will continue to function to clear the pipe lines of any refuse remaining in them.

No modifications were made to either the electrostatic precipitators or the bottom ash handling system. Although a significant increase in the quantities of ash were anticipated, particularly in bottom ash, the existing ash handling facilities were regarded as adequate.

**PROCESSING FACILITIES**

Refuse processing, for the 300 tons/day processing rate, will be accomplished during one 8-h shift. Two-shift operation will be required for the 20 percent firing rate, which still would permit the third shift to be devoted to routine maintenance of hammermill hammers and other equipment. The processing facilities have been designed to have a nominal capacity of 45 tons/h of raw refuse, which, after magnetic metal is removed, should be equivalent to about 40-42 tons of supplementary fuel per hour. Fig. 2 shows diagramatically the elements of the refuse processing facilities.

Raw refuse is discharged from packer-type trucks to the floor of the raw refuse receiving building. Front end loaders are used to push the raw refuse to a receiving conveyor. This method of handling raw refuse was selected over the pit and crane method principally because of the limitations in production rates imposed by pit and crane operation as well as the relative economy. From the receiving conveyor, the raw refuse is transferred to an inclined belt conveyor, which in turn discharges to a vibrating conveyor, which feeds the hammermill directly.

The hammermill is a conventional mill with a horizontal shaft, with a hammer circle of about 60 in., and an interior rotor length of about 80 in. At the time the design of the mill was agreed upon, there was no evidence that any other type of mill could either provide the production rates required, or the control over particle sizes desired for purposes of this process. The mill is powered by a direct-connected 1,250 hp, 900 rpm motor. Single stage milling was deemed appropriate for purposes of the prototype installation, although two-stage milling normally is advocated for this type of operation. The mill has a grate cage which provides openings of about 2 in. by 3 in. Tests run on a similar, but smaller mill, indicated that essentially all milled particles would be less than 1/2 in. in size, that 96-98 percent by weight of...
the particles would be less than 1 in. in size, and that about 50 percent of the particles would be less than 3/8 in. in size. Uncompacted bulk density of the milled material, depending upon moisture content and composition, was found to be variable, as low as 4 lb/ft³ in some cases, and as high as 12 lb/ft³ in others. This variation in density poses problems in equipment design and selection, since some equipment is designed on a gravimetric basis and others on a volumetric basis.

From the hammermill, the milled material is discharged to another vibrating conveyor, feeding an inclined belt conveyor leading to a storage bin. Magnetic separation is effected at the head pulley of this belt conveyor, with the magnetic materials discharged to trucks for disposal.

The storage of milled refuse poses problems requiring special attention. For the prototype installation, since a convenient alternate means of refuse disposal was available, and since the interruption of refuse firing to the boiler would not cause significant operating problems, it was concluded that only minimum storage volume for the milled material was necessary. The storage volume provided therefore is only sufficient to permit a relatively even flow of supplementary fuel to the boiler. Milled refuse, having laminar characteristics, has a bridging tendency, and storage bin design should be such that bridging will be minimized. The most effective means of preventing bridging appears to be the construction of bins with a greater cross section at the bottom than at the top. It also is necessary to provide a bin unloading device which will remove material from all parts of the bin bottom without resorting to the use of hoppers, in which the material almost certainly would bridge.

From the storage bin, the supplementary fuel is conveyed to a stationary packer for loading into self-unloading trucks for transport to the power plant. In the prototype project, the power plant is about 18 miles from the processing plant. At the nominal 300 ton/day firing rate, only one 25-ton load of supplementary fuel will be delivered to the power plant every 2h. If it were feasible to locate the processing facilities near the power plant, it would be possible to eliminate truck transport by pneumatically conveying the supplementary fuel directly to the boiler from the storage bin.

**RECEIVING AND FIRING FACILITIES**

Fig. 3 is a diagram of the facilities at the power plant. The self-unloading mechanisms of the transport trailers discharge the supplementary fuel to a receiving bin, from which the material is conveyed to a pneumatic feeder for transfer to a surge bin. The surge bin is equipped with four drag chain unloading conveyors, each of which feeds a pneumatic feeder. Each of these four pneumatic feeders conveys the supplementary fuel through a separate pipe line directly to a firing port in each corner of the boiler furnace. The pipe lines are about 700 ft long.

The pneumatic systems are of the high pressure type, in which the material to be conveyed is introduced by a rotary air lock feeder into a pressurized pipe line. The air velocities are on the order of 80 to 90 ft/sec. The velocities of the conveyed particles, depending upon their mass, are expected to be about 50 to 70 ft/sec. The initial pressures in the pipe lines depends upon their length as well as the quantity of material to be conveyed, and will be several psi, normally in the range of 2 to 3 psi.

![Supplementary fuel receiving and firing facilities.](image-url)
The boilers are operated with balanced draft, with a slightly negative pressure in the furnaces.

The division of responsibility between the City of St. Louis and the Union Electric Co. in this case was determined to be between the receiving facility and the surge bin. The operation of the surge bin and the pneumatic boiler firing systems have been established to be the responsibility of the utility. The delivery of the supplementary fuel and its transfer to the surge bin is the City's responsibility.

Although the original project provided for only one boiler to be used for the test, the Union Electric Co. has adapted a second boiler for burning refuse. This second boiler is a twin of the first. Either one or the other of the boilers could burn refuse through four burning ports. Both boilers could burn refuse at the same time through two burning ports at each boiler. Whenever desired, changing flanged sections in the pipelines will permit one or the other boiler to be used.

**POTENTIAL BOILER OPERATING PROBLEMS**

Although the limitation of burning refuse as only a small percentage of the total fuel should tend to minimize boiler operating problems, there are several potential effects which are being given special attention in the tests. These relate to slagging, corrosion, completeness of burn-out and precipitator performance.

Some slagging can be expected in most coal burning boilers, with the degree of slagging related to coal quality and to operating procedures. Preliminary investigations indicated that the ash fusion temperatures of refuse were in the same range as those of Illinois bituminous coal. Other coals, particularly those with low sulfur contents, may have higher ash fusion temperatures. The tests will include observations of potential slagging tendencies of mixtures of refuse ash and coal ash.

An evaluation made by Combustion Engineering, Inc. during the preliminary studies, indicated the possibility of a slight increase in corrosion potential. Probes will be installed at strategic points in the boiler to assess the effects, if any, of corrosion. The removal of magnetic materials, together with the zinc, lead and tin which often will be bonded to them, is expected to have a possible beneficial effect.

Since utility boilers are not normally equipped with grates, there was some concern that larger burnable particles would not be completely consumed in suspension. The small particles achieved in the type of milling equipment provided is expected to decrease this possibility, particularly in view of the large percentage of paper in the refuse.

Some increased loading is expected upon the electrostatic precipitator, although the extent of the increase could only be estimated prior to the test program. It is anticipated that data will be obtained to indicate the relative performance of the precipitator with coal ash and with a combination of coal and refuse ash.

**APPLICABILITY OF PROCESS**

The process cannot be expected to be applicable in all metropolitan areas. Some types of fossil fuel fired boilers are not as adaptable as others. Boilers operating essentially as base load units may be more desirable for burning refuse than those operated at partial loadings. Cooperation between utilities and municipal corporations sometimes may be difficult to achieve. The quantities of supplementary fuel available may not be sufficient to be of interest to the utility. The location of the boiler plant may not always permit economical application of the process.

Of particular importance is the relative economics of the process. The basic economic elements are:

1. the total unit cost of processing, transporting and firing the refuse as supplementary fuel;
2. the cost accruing to the utility in using refuse as supplementary fuel;
3. the costs of alternate means of refuse disposal; and
4. the value of the material as fuel when compared to the value of fossil fuel.

In the case of the St. Louis prototype project, the City of St. Louis is delivering the prepared refuse to the utility at no cost for the duration of the tests. Depending upon the circumstances of a given case, this same arrangement could be mutually attractive to a city and a utility, or, a city might be willing to pay the utility a nominal fee for using the refuse, or, the utility might be willing to pay the city a nominal fee for the supplementary fuel. Each situation requires an objective appraisal to determine the appropriate basis for negotiation.

Assuming, however, that a mutually attractive financial arrangement can be worked out, and indications are that this may be probable in a number of metropolitan areas, the process shows promise of having fairly extensive application. It could provide an economical means of disposing of large quantities of refuse, effect recycling by recovering energy, conserve natural resources of fossil fuel and assist in the control of air pollution. The preliminary appraisals indicate that these potential advantages may be achieved by effecting sufficient cooperation between municipalities and utilities to permit the use of existing, large scale power plant facilities, by using commercially available equipment and by applying already tried and proven basic technology.