REHABILITATION OF AN ANTHRACITE-BURNING POWER PLANT IN UKRAINE WITH INTRODUCTION OF COAL PREPARATION

John Ruether[1]
Brian Schimmoller[2]
Richard Killmeyer[1]
Sai Gollakota[3]

U.S. Department of Energy
Pittsburgh Energy Technology Center
Box 10940
Pittsburgh, PA 15236

[1] U.S. Department of Energy
[2] Science Applications International Corporation
[3] Burns and Roe Services Corporation

ABSTRACT

A study is being carried out jointly by the United States Department of Energy and the Ukrainian Ministry of Power and Electrification for rehabilitation of an anthracite-burning power station in the Donbass region of eastern Ukraine. The power station, named Luganskaya GRES, is laboring under deteriorating coal quality (the ash level is ranging towards 40% compared to the design value of 18%) and the physical plant is in need of repair. Approaches under consideration for the rehabilitation include upgrading the existing 200-MWe (gross) wall-fired boilers, repowering with circulating fluidized bed combustors, and the use of coal preparation. Coal washability tests conducted as part of the study indicate the coal is amenable to washing. The paper describes approaches to coal preparation being considered that provide design value coal for wall-fired boilers while minimizing rejection of Btus and generation of solid waste.

INTRODUCTION

With funding from the United States Agency for International Development (USAID), the United States Department of Energy's Pittsburgh Energy Technology Center (USDOE/PETC) is directing a study of plant betterment (upgrade/rehabilitation) or replacement and fuel upgrading (i.e., coal cleaning) options for an existing anthracite-fired power plant in eastern Ukraine. Ukrainian partners of USDOE in the study are the Ministry of Power and Electrification (Minenergo) and the Coal Energy Technology Center, a division of the Ukrainian Academy of Sciences. The selected power plant, Luganskaya GRES, has eight 200-MW_e type TP-100 wall-fired, wet-bottom boilers that were commissioned in the 1960s. These units currently must cofire large amounts of natural gas and/or mazut (i.e., fuel oil) to stabilize combustion of high-ash coal and to accommodate coal shortages. Although the coal used at this plant is produced domestically, most natural gas and virtually all mazut must be imported. Ukrainian anthracite has been declining in quality over the past 30 years, from an average of about 20% ash, the design value for

TP-100 boilers, to 35-40% ash today (as received). The design coal lower heating value was approximately 5,700 kcal/kg (10,260 Btu/lb), but coal currently shipped to power plants is in the vicinity of 4,200 kcal/kg (7,560 Btu/lb).

Firing such poor quality coal has a number of unfavorable consequences. Oil or gas, at concentrations representing up to 25% of the boiler input calorific value, has to be used as support fuel to stabilize the flame. Ukraine would like to reduce the use of support fuel in order to cut plant operating expenses and positively impact the national balance of payments. The Luganskaya GRES boilers have been derated, partly due to the low-quality coal being burned, partly due to deteriorating equipment, such as leaky boilers that permit uncontrolled air ingress. Poor coal quality and ingress air result in low boiler efficiency and high unburned carbon levels in the ash. In addition, until the Chernobyl accident and the breakup of the former Soviet Union, greater attention had been placed on developing nuclear and gas-fired plants than in maintaining coal-burning plants. Many coal-fired plants, therefore, suffer from a lack of spare parts and frequent unplanned outages.

The objectives of the present cooperative study are to define a plant betterment project for Luganskaya GRES with the accompanying analysis and documentation that will aid the Ukrainian partners in securing funding from international development banks. One element of the study included an assessment of the present condition of the power plant and a techno-economic evaluation of cost effective upgrade (rehabilitation/replacement) options for at least two boiler/turbine units. The assessment and the techno-economic evaluation were performed by the engineering services firm, Burns & Roe. Another element was a large-scale test burn of Ukrainian anthracite in a circulating fluidized bed combustor (CFB). The CFB technology is favored by Ukrainian technologists because it will permit continued use of poor quality coal for power generation, but with improved environmental performance. The test burn was conducted at the 2.5 MW_t facility of Babcock & Wilcox. A third element of the study, which is the main focus of this paper, was an assessment of the potential for the use of coal preparation as part of the strategy for improving operations at Luganskaya GRES. This was to be done by PETC by conducting coal washability studies, developing plausible coal preparation circuits, and evaluating the combustion characteristics of a cleaned Ukrainian anthracite sample in a pulverized coal boiler.

Coal Preparation in Ukraine

Both bituminous and anthracite coals are mined in Ukraine and used for power generation. In 1993 total coal production in the country was 135 million tonnes, of which 120 million tonnes derived from the Donbass region of eastern Ukraine. Much of the anthracite is cleaned at a number of preparation plants throughout the region. Typically the initial step at these preparation plants is dry screening. The coal passing through 6 mm or 13 mm openings, called *shtib*, represents the principal fuel for power plants and is usually not cleaned further. Coarser coal retained on the screen is cleaned and sold for higher value use, such as residential heating and steel manufacturing. Another anthracite product made available to power plants are the fine silts recovered from tailings ponds. This material is called *schlamm* and derives from the tailings streams of fine coal cleaning equipment. While attractive because of its low cost, schlamm has high moisture levels and is difficult to handle. To burn it, power plants must cofire with large quantities of oil or gas.

Earlier studies of coal-fired power generation in Ukraine by Western engineering firms (preceding the present study) had identified the use of better quality coal as the starting point for improving power plant operations. However, these studies have had little or no impact on existing or planned operation. Because of the separate and independent organizational structure of the coal mining, coal preparation, and power production sectors in Ukraine during the communist era, there are few advocates of coal

preparation within the power generation sector. A reputation had grown within the power sector that anthracite shtib was so difficult to clean as to make it infeasible. To gain a better understanding of the potential of coal preparation for upgrading anthracite shtib, two samples were shipped to the U.S. and subjected to various analytical analyses, including washability (float/sink) testing. One of the samples was part of a 160-tonne shipment that was used for CFB and PC combustion testing.

Sample Characterization

Table 1
Characteristics of Ukrainian Shtib Sample

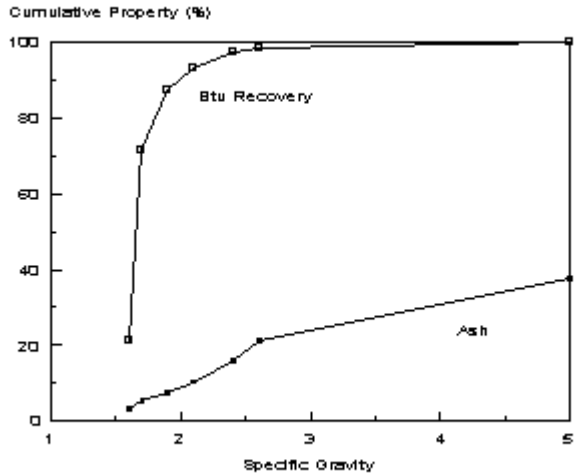
	As Received (%)
Proximate Analysis	
Moisture	2.78
Ash	34.77
Volatile Matter	7.76
Fixed Carbon	54.69
Sulfur Forms	
Pyritic Sulfur	2.26
Organic Sulfur	0.65
Sulfate Sulfur	0.02
Particle Size Distribution	
Plus ⅛ inch	30.79
⅛ inch x 28 mesh	41.86
Minus 28 mesh	27.35

Table 1 shows the proximate analysis, sulfur forms analysis, and particle size distribution of the shtib sample received from Ukraine. The high ash content (35%) is typical of the shtib product delivered to Ukrainian power plants. The as-received higher heating value (not shown) is particularly low, at under 5,000 kcal/kg (9,000 Btu/lb), but on a dry ash-free basis, rises to nearly 8,000 kcal/kg (14,400 Btu/lb), hinting at the quality gains possible with coal preparation. The pyritic sulfur content, as a percentage of total sulfur, is high compared to American coals, indicating that this coal may be amenable to significant sulfur reduction via physical coal cleaning. The size distribution is fairly uniform, with about equal percentages of material divided among the three size fractions listed and no indicated propensity for fines generation.

Results of the float/sink analysis for the Ukrainian shtib sample are shown in Figure 1. Inspection of these results shows that the coal is highly amenable to gravity-based cleaning. For instance, at a specific gravity of separation of about 2.5, an 18-20% ash product could be obtained suitable for use in the TP-100 boilers. Furthermore, little energy loss would be sustained; Btu recovery is nearly 98% at this density. Operating at specific gravities of 1.8-2.0, which are more common in the coal industry, a higher quality product could be made, with an ash content less than 10%, but still with a high level of Btu recovery (85-90%).

Simulator Results

The washability data were incorporated into a coal preparation plant simulator developed at PETC to compare several flowsheets for preparing 20% ash coal from raw shtib for use in TP-100 boilers. The simulator uses a database of partition and separation efficiency data to account for inefficiencies encountered in actual plant operation. One of the flowsheets evaluated with the simulator--simplified to the size classification and cleaning operations--is shown in Figure 2 for a 300-tph feed rate. A wet screen



is used to size the shtib feed at 14 mesh. The oversize stream is cleaned in a mineral jig or other density-based device at a relative density of 2.0. The float fraction from the mineral jig, at 9.4% ash, is mixed with the undersize stream from the wet screen, at 39.5% ash, to yield a PC boiler feed product at the target ash level of 19.4% ash. Overall yield (69.4%) and Btu recovery (93.8%) are comparable with values from U.S. plant practice, indicating that this coal preparation circuit is technically viable. The results from the simulator were then used to estimate capital and operating costs for a commercial plant. Most of the economic data were taken from the Electric Power Research Institute's Coal Cleaning Cost Model. Assumptions included a 300-tph plant capacity, 15 year plant life, 11% average cost of debt plus equity capital, and 4600 hour per year operation. Though not shown in Figure 2, equipment associated with receiving, storage, handling, dewatering, and loadout were factored into the economic analysis as well. Capital costs amounted to $12.91 million for the 300-tph plant and processing costs totaled $4.09/tonne of product ($3.71/ton), again comparable to U.S. figures.

Figure 1 Washability Data (Cumulative Basis) for Ukrainian Shtib

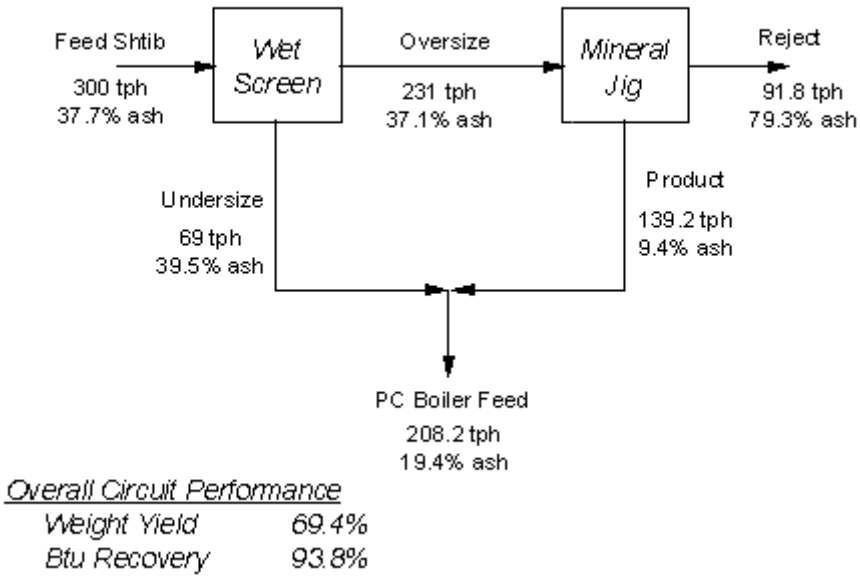
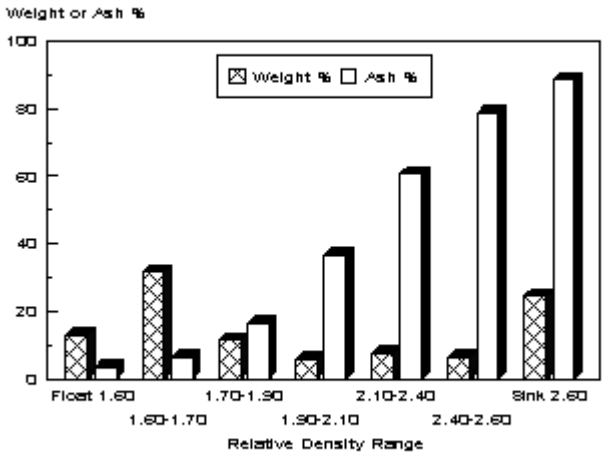


Figure 2 Material Balance and Circuit Performance for Candidate Ukrainian Shtib Coal Preparation Flowsheet



Part of the reluctance to employ coal cleaning among power plant personnel in Ukraine is due to their strong aversion to losing any energy in the coal cleaning reject stream. Ukrainian members of the study team asked that coal cleaning schemes be considered that would produce two streams, one of 18-20% ash for use in TP-100 boilers, the other of 40-50% ash for use in CFB combustors. This was attempted, but no satisfactory flowsheet could be developed because of the natural cleanability of the shtib; only a small amount of middlings could be produced that would have an ash content suitable for CFB fuel. This is demonstrated in Figure 3, which shows the washability data for the shtib sample. The majority of the material is concentrated at low (<10%) and high (>80%) ash contents. Only about 12% of the material, between 1.9 and 2.4 relative density, could be recovered at the desired ash content for CFB firing, and this small amount of material can be added to the low-ash product to be used in PC boilers without exceeding the 18-20% ash specification. It was concluded that it is more economical to burn raw shtib or a mixture of shtib and schlamm than to use coal preparation for preparing CFB feed from shtib.

Figure 3 Washibility Data (Elementary Basis) for Ukrainian Shtib

PRF and CERF Testing

Using a portion of the 160-tonne shtib shipment from Ukraine, pilot plant testing was conducted in PETC's 1-tph Coal Preparation Process Research Facility (PRF) to 1) demonstrate that the clean coal products predicted by the washability analysis and the simulator could be obtained, and 2) produce bulk quantities of clean coal products for combustion testing in PETC's Combustion and Environmental Research Facility (CERF). The PRF was configured to simulate the flowsheet in Figure 2. The facility processed a total of 15 tons of raw shtib, generating clean coal products ranging in ash from 9% to 19%. The products were then pulverized to various size consists for PC combustion testing in the CERF. The purpose of these tests was to verify the anticipated effects of improved coal quality, improved pulverizer performance, and other variables on combustion efficiency, support fuel use, emissions, slagging, and fouling. In addition, the results could be used to quantify the benefits to be achieved from a power plant upgrade.

CONCLUSIONS

As part of a general study of plant betterment for the Luganskaya GRES station, an investigation of use of coal preparation has been conducted. Washability studies showed that the principal feed coal is amenable to cleaning to design specification for the PC boilers at the station. Simulation of a feasible design for a commercial sized coal preparation plant yielded an estimate of cleaning cost and showed that good energy recovery could be expected. Predicted separations were verified in pilot plant coal cleaning

done at PETC that also served to prepare cleaned coal for use in PC combustion tests. These tests confirmed the expected benefits of using lower ash coal in terms of reduced support fuel requirements, higher carbon burnout, and reduced emissions. Coal cleaning is an important component to improving performance of Luganskaya GRES.

REFERENCES

1. Computer Simulation of Coal Preparation Plants, USDOE Report DOE/PC/30144-T7, December, 1982.

2. Coal Cleaning Cost Model, Electric Power Research Institute, EPRI TR-101025s, Palo Alto, CA, March 1993.