Validation of PEPSE® Pulverizer Model

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VALIDATION OF PEPSE PULVERIZER MODEL

Abstract

The process of validating a PEPSE pulverizer model to the current operating conditions can reveal several interesting facts about the pulverizer system. The most significant of these was the amount of air inleakage above the design value that was occurring around the seals and along the journal base plate. The reduction of the leakage by 70% would increase the mill outlet temperature by 35 DEGF, thus reducing the total mill power consumption by 8.75%, 0.21MW, and increasing the boiler efficiency by 0.25%. This paper describes the experience of validating the model to the current operating conditions and the identification of the air inleakage.

Introduction

A primary air duct heater study was initiated at the J C Weadock Plant at Consumers Power Company during January, 1991. The purpose of the study was to determine the heat requirements of an auxiliary duct heater necessary to raise the primary air temperature to the pulverizers when burning western coal. The pulverizers are the suction type and are currently grinding a blend of eastern and western coal with a mill outlet temperature of 140 DEGF. The duct heaters would allow higher mill outlet temperatures, thus reducing power consumption, improving capacity, and improving boiler efficiency.

During the process of validating the PEPSE model to the current operating conditions, a significant amount of air inleakage above the design value was determined in order to match the current operating conditions. The design air inleakage is approximately 0.2 lb air/lb coal, or 7800 lb/hr. This occurs mainly around the seal on the journal shaft and in the pyrite hopper discharge chute. To match the current operating conditions, an additional 13000 lb/hr of tempering air, or leakage, was necessary. The amount of tempering air appeared unreasonable since the tempering air dampers were closed. This paper describes the experience of validating the model by checking each PEPSE input parameter to the actual parameter and the identification of the air inleakage.

PEPSE Pulverizer Model

The PEPSE pulverizer model, shown in Figure 1, consists primarily of four sources, a general heater, and the pulverizer component. For this part of the study the heater component was not activated. The tempering air flow was determined by a series of operations involving the air/fuel ratio, coal flow, primary air flow, and pulverizer air inleakage. The model input file, shown in Appendix I, is the benchmark case used to determine the tempering air flow for the actual pulverizer operating conditions.

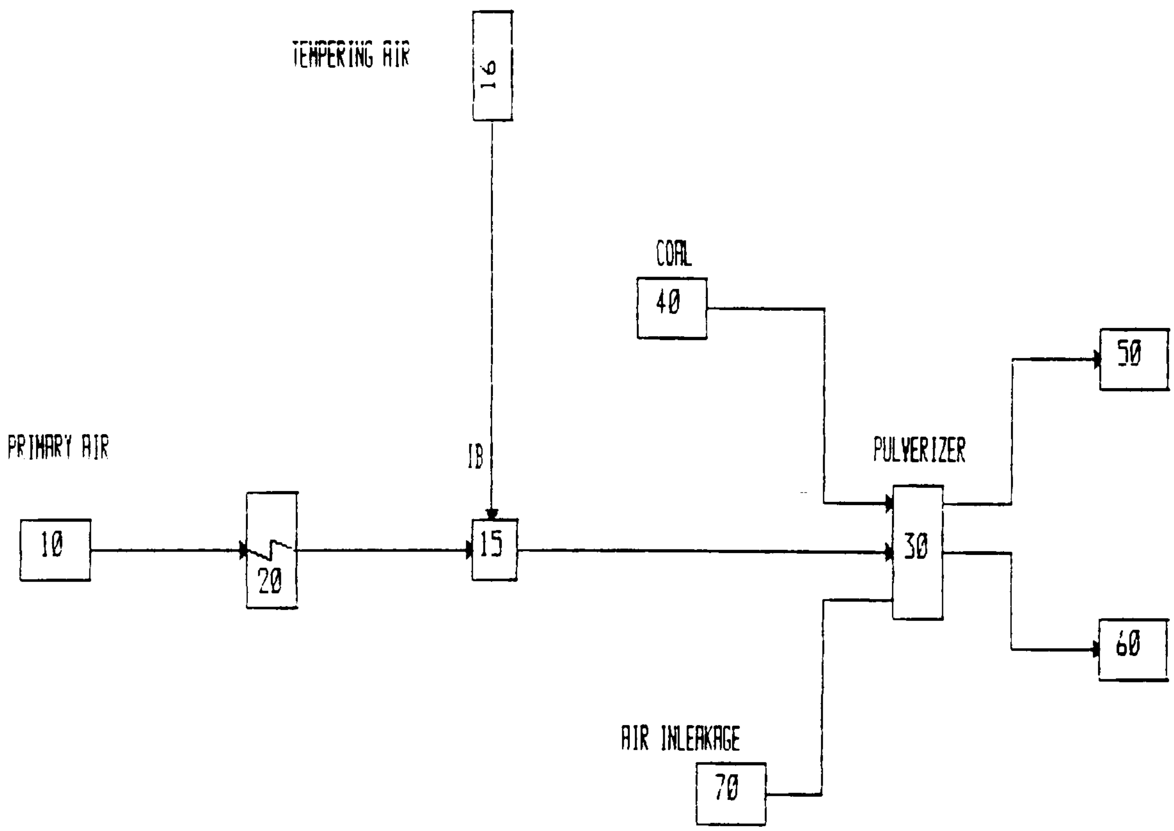

Figure 1

PEPSE Pulverized Model

Validation Process

The PEPSE pulverizer component was first calibrated against a vendor heat balance calculation. Discrepancies occurred in the outlet temperature and flow. The air flow leaving the pulverizer was within 1947 lb/hr, or 3.03%, and the temperature was within 0.7 DEGF. See Table 1.

TABLE 1

Verification of Vendor Heat Balance

Coal flow, lb/hr	35000	
Air flow in, lb/hr	51972	
Air in temperature, DEGF	540	
Air inleakage, #air/#coal	0.2	
Specific heat of coal, BTU/#/F	0.3	
Coal inlet moisture, %	13	
Coal outlet moisture, %	4	
Air/fuel ratio	1.684919	
Grinding heat input, BTU/HR	833409	
Radiation heat loss, %	10.44	
	Vendor	PEPSE
Air Flow out, lb/hr	64200	62253
Air temperature out, DEGF	180	180.7

From this analysis, grinding heat input, specific heat of the coal, and the radiation heat loss were applied to the current model. The initial runs of the model to the first set of operating conditions did not give a good correlation. Since it was known that the tempering air damper was closed, an error in the pulverizer input parameters was suspected. For example, based on a vendor curve, coal entering a mill with 12% moisture and 500 DEGF primary air temperature generally leaves with a residual moisture of 4%. However, the residual moisture is an important factor when performing a heat balance calculation and can affect the tempering air flow greatly. Therefore, another set of operating data was obtained in which each input was verified for accuracy. See Table 2.

TABLE 2

Validating to Current Operating Conditions

Coal flow, lb/hr	39016
Air in temperature, DEGF	500
Air inleakage, #air/#coal	0.2
Specific heat of coal, BTU/#/F	0.3
Coal inlet moisture, %	12.07
Coal outlet moisture, %	5.3
Coal-air outlet temperature, DEGF	141
Air/fuel ratio	1.58
Grinding heat input, BTU/HR	833409
Radiation heat loss, %	10
PEPSE Calculated Values:	
Primary air flow, lb/hr	40731
Tempering air flow, lb/hr	13111
Design air inleakage, lb/hr	7803

Since the primary air temperature is measured at the air heater outlet for the station recorders, the air temperature entering the pulverizer was verified by inserting a thermocouple through a valved connection on the air duct at the mill base. The temperatures agreed within 3 DEGF.

The coal moistures entering the leaving the pulverizer were verified by obtaining samples of the raw coal entering and pulverized coal leaving and determining the total moisture. The coal moisture changed from 12.07% to 5.3%, or 6.77%.

The coal flow and air/fuel ratio were obtained from the best available plant information. Since the pulverizers were operated at full capacity, it seemed reasonable to use the vendor values for radiation heat loss and grinding heat input for the model.

With the new set of operating data, another PEPSE run was done. The tempering air flow of approximately 13000 lb/hr was required to obtain the proper heat balance around the mill. This was in addition to the design air inleakage of 7800 lb/hr. Since the tempering air damper was verified to be closed through a visual inspection and smoke test, the presence of tempering air raised some concern. The assumption of using the vendor's information for grinding heat input and radiation heat loss may not have been valid. The energy gain and loss from these parameters will affect the energy balance in the pulverizer and, therefore, the calculation of the tempering air flow. However, a sensitivity analysis showed that the magnitude of error in the tempering air flow could not be accounted for from these parameters. Consequently, another physical inspection of the pulverizer was performed to look for air inleakage other than the known location of the tempering air damper.

Using a smoke pencil, significant air leakage was verified around the journal shaft and between the journal base plate and mill housing. According to the vendor, the rubber seal around the journal shaft should be tight and leakage should only occur at the joint where the two halves of the seal meet. The surface between the journal base plate and the mill housing is a machined surface and leakage should not occur. Leakage can occur in the pulverizer at the pyrite hopper discharge chute which has a gate that moves to allow debris to exit the mill. However, the mill under-bowl pressure was nearly positive so significant air inleakage could not occur there.

Using PEPSE, the extra air inleakage was reduced by 70% and the new mill outlet temperature was calculated to be 175 DEGF, or an increase of 35 DEGF. There are eight mills in the plant that all have the same conditions. If the leakage condition was eliminated on all of them and the new mill outlet temperatures were 175 DEGF, total mill power consumption would decrease by 8.75%, or 210 KWh, and the boiler efficiency would increase. This would be a significant savings to the plant. Mill power is reduced because the higher temperatures improve the grinding process by drying the coal more quickly and reducing the amount of coal recirculation within the mill. The grinding process has two components. First, there has to be sufficient force from the rolls to crush the coal and sufficient heat to dry the coal. If the coal is not dried, the rolls have difficulty in crushing the coal and mill power goes up. Therefore, the higher temperatures improve the grinding process and reduce power consumption.

Summary

Through the process of validating the PEPSE model to the current operating conditions, significant air inleakage was identified which had previously gone unnoticed. Once the leakage was identified, a cost can be associated with it an appropriate action can be taken. Alerted to the fact that the tempering air dampers were closed, the presence of tempering air in the model signified that there was a problem in the pulverizer system and an inspection was necessary.

APPENDIX I

The following input file is for the determination of the tempering air flow for the pulverizer model benchmark case.

```
*****************************************************************
*      GENERIC INPUT DATA
*****************************************************************
*
*  CYCLE FLAGS
010200    0      0      0      0      0      0      0.     0.
*
*  CYCLE CONVERGENCE DATA
012000    30     1.   300.     0.     0.     0.     0      0.
*
*  PEPSE OUTPUT SUPPRESSION CARDS
*
020000  NOPRNT
020003  PRINT
020036  PRINT
020074  PRINT
*
*  PRINTER PLOT DATA
060000   80    61
*
*
*****************************************************************
*        GEOMETRY CARDS
*****************************************************************
*
500100    10         U     15    IA
500150    15         U     20     T
500160    16         U     15    IB
500200    20         T     30    PA
500300    30        PC     50     I
500310    30        MA     60     I
500400    40         U     30    RC
500700    70         U     30    LA
*
*
*****************************************************************
*      COMPONENT DATA
*****************************************************************
*
*************** HEAT EXCHANGERS
*
*  AUX HEATER
700200   27        0.      0.     0.     0.
*
```

```
*************** SOURCES, SINKS, AND VALVES
*
*  PRIMARY AIR SOURCE
700100   31   500.  14.770001   48220.    0.    0.
700103   AIR, -0.013
*  TEMPERING AIR
700160   31    80.  14.7   10.    0.    0.
700163   AIR, -0.013
*  FUEL SOURCE
700400   33    70.  2500.   39016.    0.    0.
700403  FUEL, 11393., SSVL, 0., CO2, 0., H2O, 0.1207
700404   SO2, 0.,   O2, 0.0693,  N2, 0.0142,  CO, 0.
700405    H2, 0.0475,    C, 0.651,    S, 0.0073, ASH, 0.09
*  AIR INLEAKAGE
700700   31    80.  14.7  7803.     0.    0.
700703   AIR, -0.013
*
700500  32
*
700600  30
*
*************** MIXERS
*
*
700150   50     1     0.
*
*************** CLASS 7 COMPONENTS
*
*  JC WEADOCK 673 MILLS
700300   74     1    10     0   0.3   0.053   141.
700301  1.58    0.  23.811701   0.1
*
*
*****************************************************************
*      SPECIAL FEATURES
*****************************************************************
*
*************** CONTROLS
*
*
*  AUX HEATER
840100   BBHXGR    20   160.    0.     0.  TT   30
840108   DELETE
840109   10000.   1E+8
*
*************** OPERATIONS
*
*
880050    XRATAC      30        MUL       WWVSC      40       OPVB       10
*
880060    OPVB        10        SUB       WWVSC      10       OPVB       11
*
880070    OPVB        11        SUB       WWVSC      70       WWVSC      16
*
*
*
*
*******************************************
*   END OF BASE DECK
*******************************************
*
*
.
```