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Technical Publication

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INTRODUCTION:

With the advent of wide use of low sulphur subbituminous and lignite coals, the Electric Utility Industry has concurrently experienced significant increases in the occurrences of pulverizer fires and explosions.

This paper is intended to present one method of reducing such occurrences by reducing one of the essential items of spontaneous combustion in pulverizers and conveying systems, namely temperature. Utilization of the flash-drying process results in dramatic lowering of primary air temperature prior to entrance into the pulverizer as shown in fig. 1.

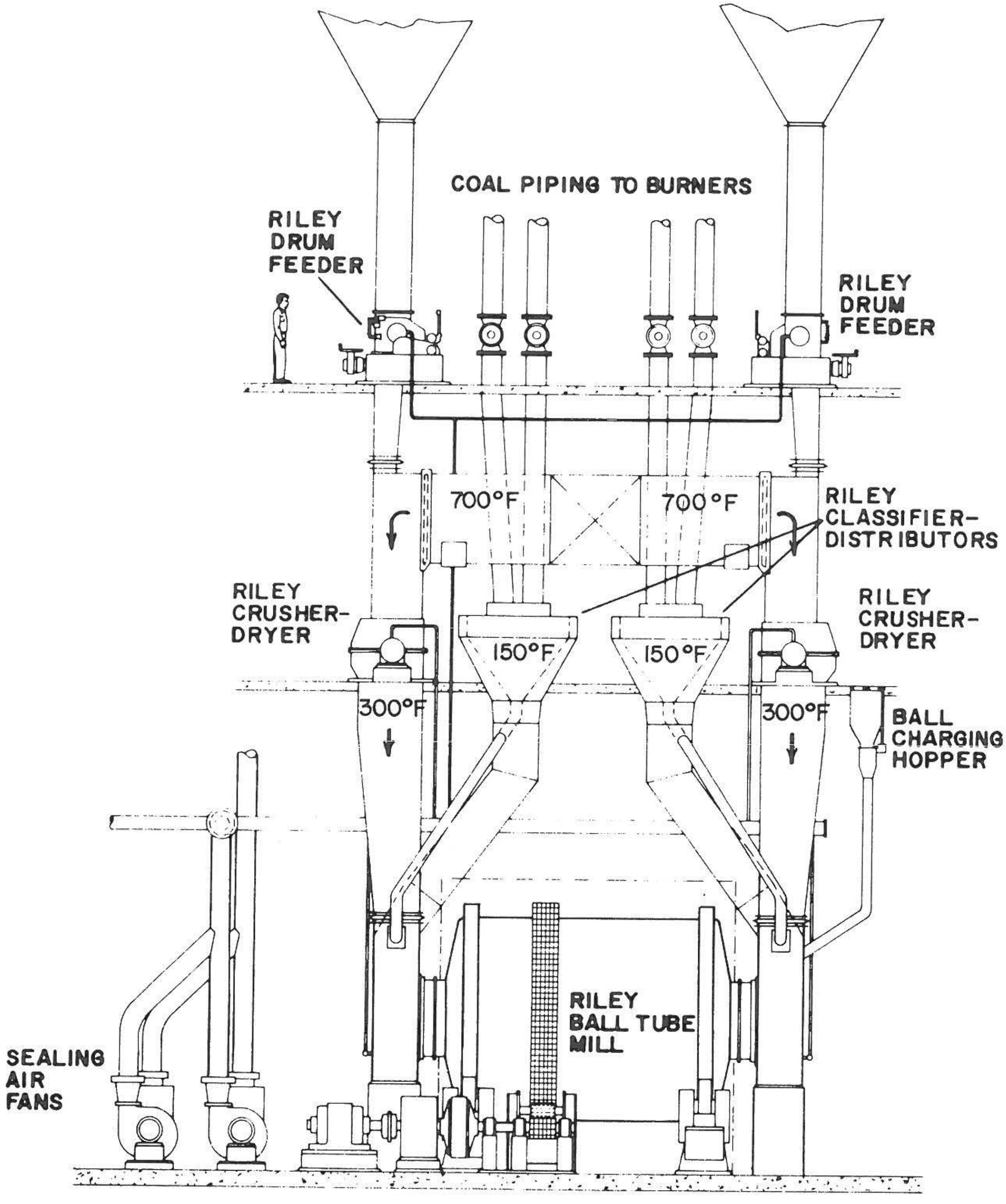

Figure 1. Typical Coal Pulverizing System

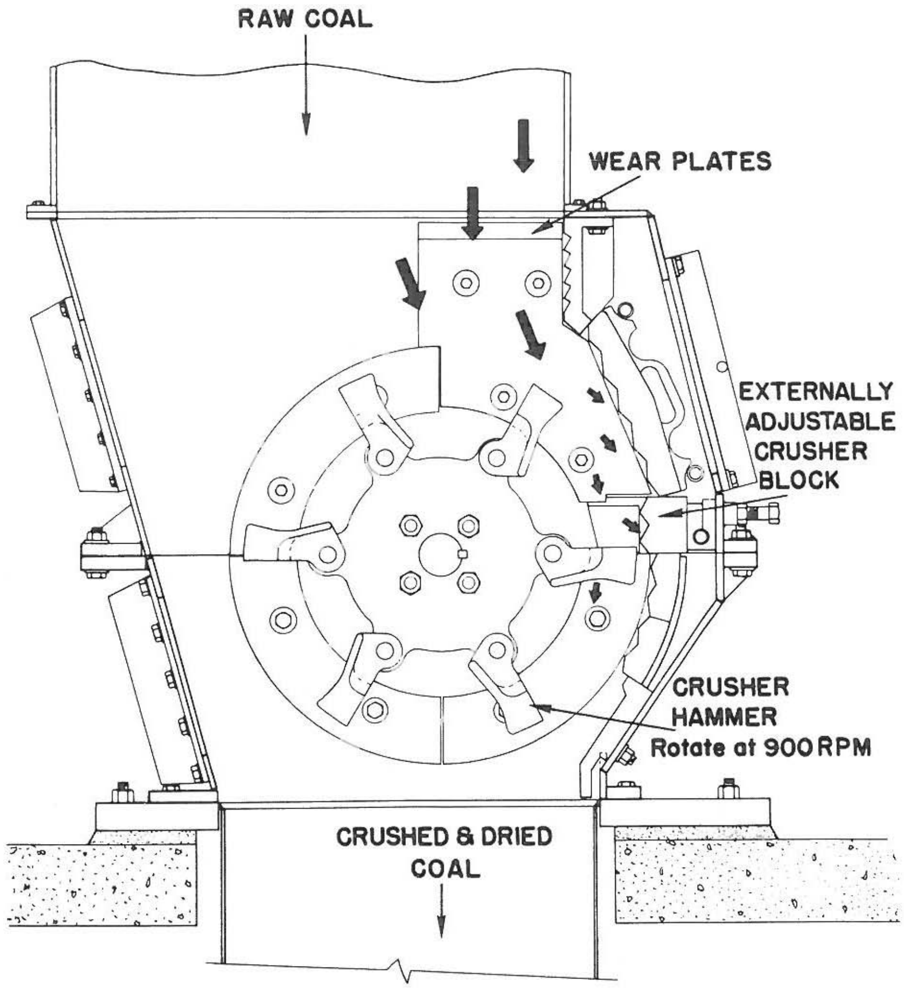

Figure 2. Crusher Dryer

HISTORY:

Riley Stoker Corporation recognized the need for pre-drying of coal a number of years ago in two areas of application:

1. Coals with high equilibrium and/or surface moisture.
2. Coals to be slurried and de-watered at plant site.

Conventional coal drying techniques are slow, requiring large equipment to adequately dry coals for pulverizer application.

An improved process which is faster and more effective is flash drying in a high speed pre-crusher stage. In this process, air of sufficient temperature and mass is provided for the evaporative process and considerable surface area of the coal is exposed to hot drying primary air (fig. 2)[1].

The process provides not only the capability of drying all the surface moisture present, but significant amounts of equilibrium moisture can also be removed.[2]

Something which was thought to be of secondary benefit but which is proving to be of tremendous significance, is the extremely low temperatures which enter the pulverizer downstream thus dramatically reducing fire potential.

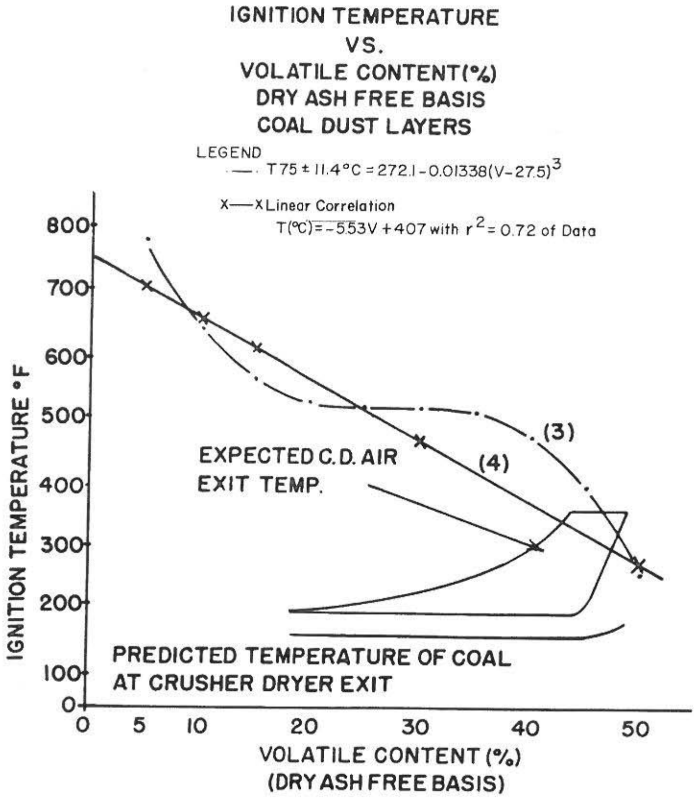

Figure 3. Ignition Temperature vs.
Volatile Content (%)
Dry Ash Free Basis
Coal Dust Layers

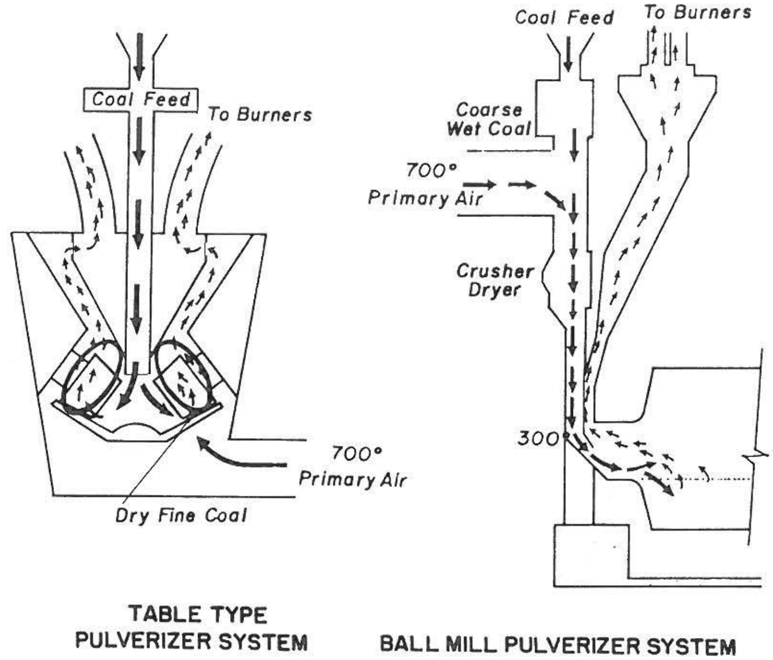

Figure 4. Typical Pulverizer Systems

REACTIVITY OF HIGH VOLATILE COALS:

Figure 3 depicts the ignition temperature of coals for various volatile contents. These curves serve as good explanation of the relatively low temperatures required to ignite pulverized fuel with high volatile content. These curves indicate that high volatile subbituminous coals with volatile content on the order of 50% on a dry, ash free basis, result in ignition temperatures in the order of 300 to 400°F. Little wonder that systems which utilize 600-700°F inlet temperatures experience high incident rates of pulverizer fires. The greatest fire potential exists when an operating pulverizer is removed from service while fully charged with coal.[5] A high pulverizer inlet temperature provides high conductive heat transfer sufficient for spontaneous combustion. When pulverized coal is allowed to remain in a high temperature environment, fire potential exists.

Figure 4 compares a conventional vertical table type pulverizer with a ball tube mill pulverizing system with crusher dryer. The table type pulverizer allows high temperature air to reach the coal charge. The ball mill system with crusher dryer normally reduces the inlet temperature to less than the auto ignition point of the coal charge.

SLURRY COAL DRYING TESTS
CRUSHER-DRYER & MILL COMBINATION

<table>
<tr><th rowspan="2">TEST NO.</th><th colspan="2">CRUSHER DRYER</th><th rowspan="2">MILL OUTLET TEMP. °F</th><th colspan="2">COAL H_2O</th><th rowspan="2">KWH/TON RAW COAL CRUSHER DRYER</th></tr>
<tr><th>INLET TEMP. °F</th><th>OUTLET TEMP. °F</th><th>RAW %</th><th>MILL PRODUCT %</th></tr>
<tr><td>b</td><td>530</td><td>280</td><td>220</td><td>17.1</td><td rowspan="7">LESS THAN 1%</td><td>5.63</td></tr>
<tr><td>c</td><td>525</td><td>325</td><td>250</td><td>17.0</td><td>5.38</td></tr>
<tr><td>d</td><td>970</td><td>375</td><td>245</td><td>17.0</td><td>2.91</td></tr>
<tr><td>e</td><td>965</td><td>300</td><td>215</td><td>17.6</td><td>2.73</td></tr>
<tr><td>f</td><td>1015</td><td>335</td><td>235</td><td>15.7</td><td>2.74</td></tr>
<tr><td>g</td><td>1070</td><td>305</td><td>215</td><td>17.2</td><td>2.46</td></tr>
<tr><td>h</td><td>1080</td><td>310</td><td>205</td><td>17.0</td><td>2.45</td></tr>
</table>

TABLE I

SLURRY COAL DRYING TEST
CRUSHER DRYER ONLY

TEST NO.	CRUSHER DRYER INLET TEMP. °F	CRUSHER DRYER OUTLET TEMP. °F	COAL H_2O RAW %	COAL H_2O CRUSHER DRYER PRODUCT %	KWH/TON RAW COAL CRUSHER DRYER
k	870	370	15.7	1.8	2.70
m	930	330	15.7	1.8	2.72

TABLE 2

Riley Stoker laboratory experiments demonstrated the capability to remove substantial surface moisture from slurried coal. Tables 1 and 2 illustrate the results of a laboratory size crusher dryer test. Figures 5 and 6 illustrate the apparatus utilized. Surface moisture on the order of 17% was removed in the flash drying process. Variations in inlet temperature and air to fuel ratio illustrate the dependency of the drying process on both temperature and air quantity used for drying. High moisture coals required greater quantities of air for drying than do low moisture coals.

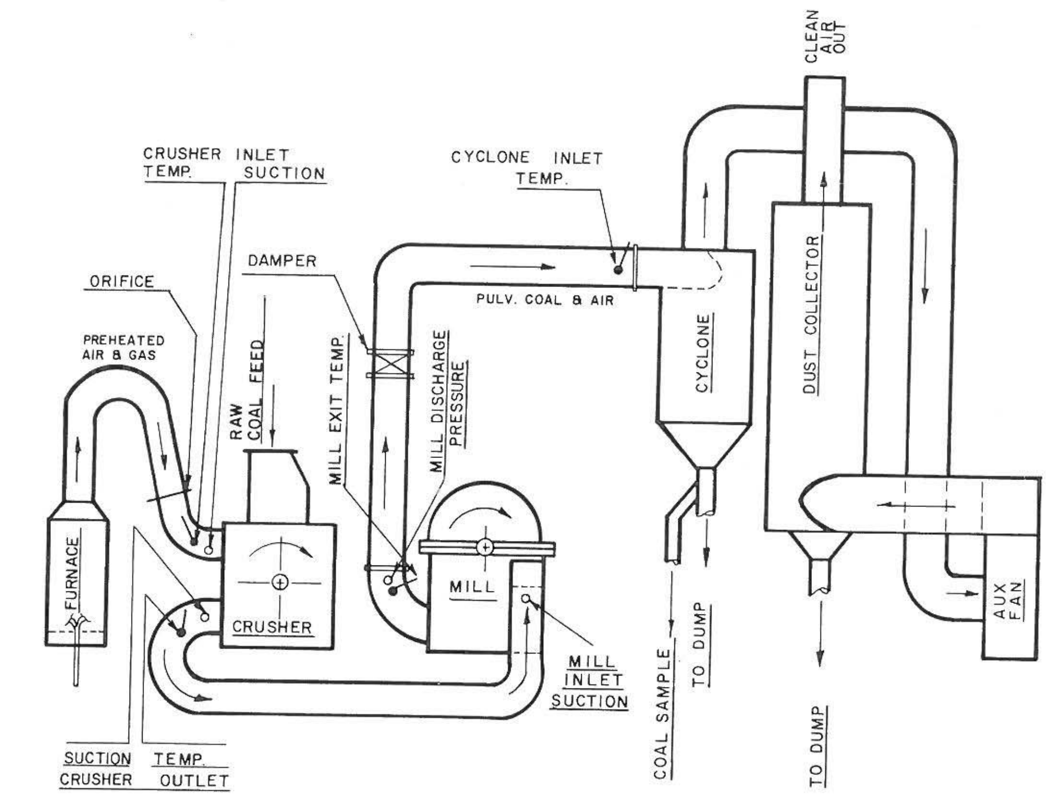

Figure 5. Crusher-Mill Test Equipment

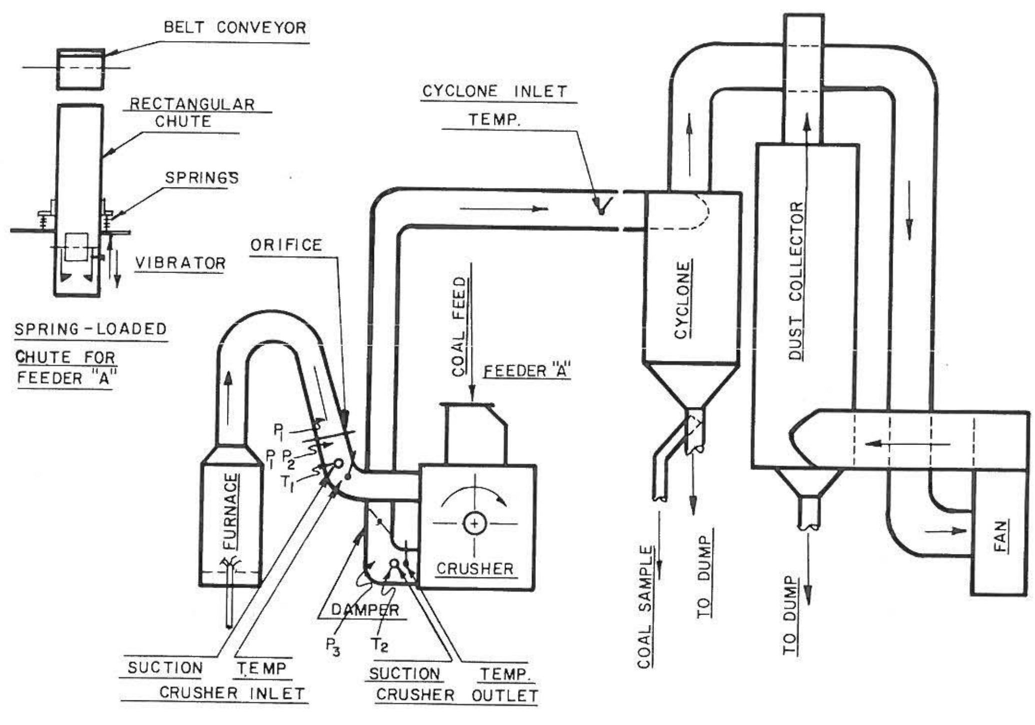

Figure 6. Crusher Test Equipment

CRUSHER DRYER & MILL COMBINATION — MIDWESTERN COAL

TEST NO.	CRUSHER DRYER INLET TEMP. °F	CRUSHER DRYER OUTLET TEMP. °F	B.T. MILL OUTLET TEMP. °F	RAW COAL H_2O INHERENT %	RAW COAL H_2O SURFACE %*	RAW COAL H_2O TOTAL %	COAL H_2O CRUSHER DRYER PRODUCT %
1	461	193	140	5.45	5.43	10.88	6.86
2	460	200	145	5.42	5.82	11.24	5.16
3	725	250	150	4.93	14.22	19.15	5.72
4	830	235	150	5.03	11.50	16.53	5.19
AVERAGE				5.2			5.7

*Obtained by air-drying samples to constant weight at room temperature and appr. 50% R.H., and finding the loss in weight. The so-called inherent moisture is that remaining in the sample after air drying and is determined by measuring weight loss in oven-drying to constant weight @ 105 °C.

TABLE 3

CRUSHER DRYER & MILL COMBINATION
MID-WESTERN & WESTERN COALS

TEST NO.	CRUSHER DRYER INLET TEMP. °F	CRUSHER DRYER OUTLET TEMP. °F	CLASSIFIER OUTLET TEMP. °F	COAL H_2O RAW %	COAL H_2O MILL PRODUCT %	KWH/TON RAW COAL CRUSHER DRYER
2	580	313	145	18.0	6.95	0.824
3	625	383	151	30.3	14.5	1.066
4	722	443	145	30.9	20.35	0.795
5	703	365	147	30.8	19.85	0.901

TABLE 4

Tables 3 and 4 illustrate the results of application of the flash drying process to full scale utility power plant applications utilizing low sulphur western subbituminous coal with high equilibrium moisture. Virtually all of the surface moisture, and a substantial portion of the equilibrium moisture was removed from the coal. System diagrams are shown on Figures 7 and 8.

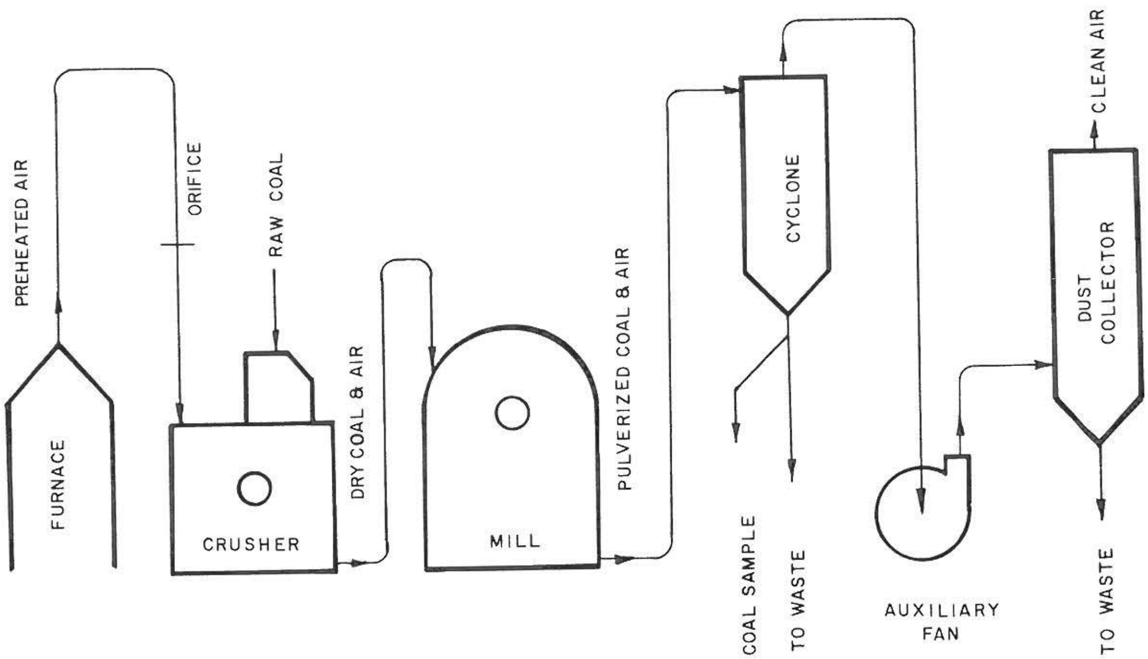

Figure 7. Test Pulverizer and Auxiliary Equipment

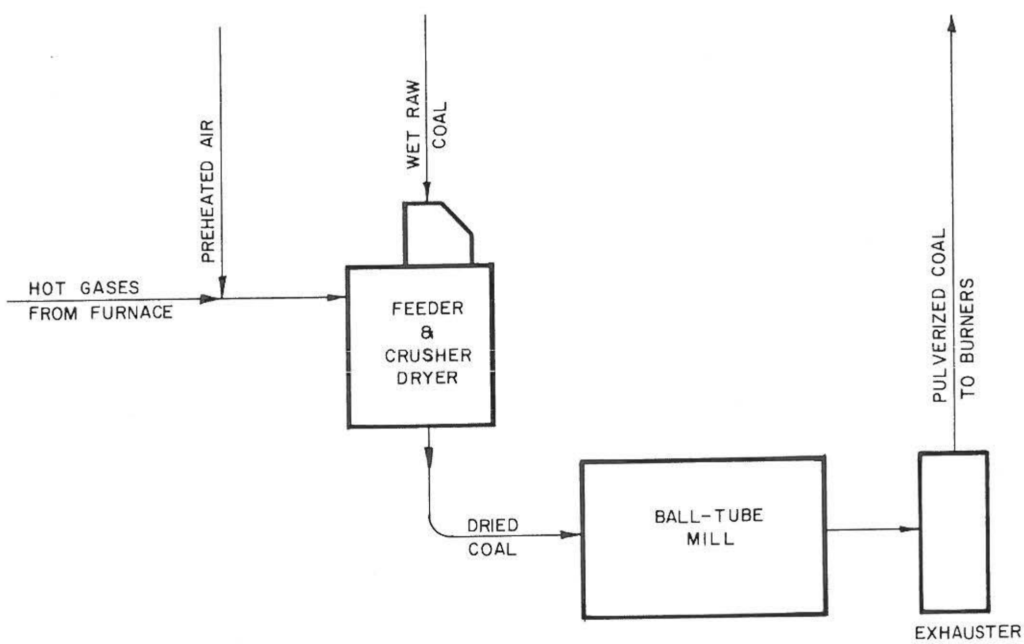

Figure 8. Crusher-Dryer Applied to a Ball-Tube Mill

TYPICAL UNITED STATES COALS

COAL AS RECEIVED	VOLATILE %	HHV BTU/LB	RAW COAL MOISTURE AIR DRIED	SURFACE	EQUILIBRIUM	TOTAL
ANTHRACITE	1.8- 6.3	12,800-13,100	0.6- 1.0	0.8- 1.5	1.0- 1.5	1.8- 3.0
EASTERN BITUMINOUS:						
a. LOW VOLATILE	14.0-21.0	12,500-13,500	0.7- 1.5	1.5- 3.0	1.5- 2.0	3.0- 5.0
b. MEDIUM VOLATILE	22.0-29.0	12,000-13,200	1.0- 2.0	2.0- 4.0	2.0- 3.0	4.0- 7.0
c. HIGH VOLATILE	30.0-45.0	10,000-13,000	2.0- 8.3	3.0-10.0	3.0- 9.0	5.0-14.0
MIDWESTERN BIT.	30.0-50.0	9,500-12,000	4.0-11.7	3.0-10.0	9.0-15.0	16.0-22.0
COLORADA BIT.	31.0-35.0	10,000-11,200	4.5- 7.6	3.0- 7.0	7.0-13.0	10.0-20.0
COLORADO SUB-BIT.	31.0-35.0	3,800-10,600	7.0-18.0	4.0- 8.0	10.0-22.0	15.0-30.0
SOUTHWESTERN SUB-BIT.	30.0-40.0	7,500- 9,000	6.0-13.0	4.0- 5.0	9.0-15.0	13.0-20.0
MONTANA SUB-BIT.	27.0-40.0	8,300- 9,000	15.0-19.0	4.0- 9.0	21.0-26.0	26.0-30.0
WYOMING SUB-BIT.	28.0-36.0	7,700- 8,200	16.0-20.0	5.0-10.0	23.0-28.0	27.0-33.0
TEXAS LIGNITE	28.0-35.0	6,100- 7,900	15.0-20.0	4.0- 8.0	24.0-28.0	28.0-34.0
N. DAKOTA LIGNITE	27.0-32.0	6,700- 8,100	15.0-22.0	5.0-10.0	30.0-35.0	34.0-45.0

TABLE 5

CHARACTERISTICS OF HIGH VOLATILE COAL:

Characteristically, low sulphur high volatile subbituminous coals exhibit high equilibrium moisture contents. Table 5 illustrates several examples in contrast to eastern bituminous coal.

It is therefore apparent that both adequate drying and fire hazard protection means are necessary to handle such coal.

DESIGNING FOR HIGH VOLATILE COALS:

In the contract engineering phase, the pulverizer system is designed for sufficient temperature and primary air flow, through the crusher dryers, to obtain necessary coal moisture reductions while simultaneously producing the lowest practicable pulverizer inlet temperatures.

Since regenerative type air heaters are practically limited to 650-700 °F, the flexibility in the pulverizer system design lies in the selection of air to coal ratios to handle the specific coal property. Figure 9 shows a typical ball tube mill arrangement including crusher dryers. Figure 10 illustrates changes in air coal ratio necessitated by different coal characteristics.

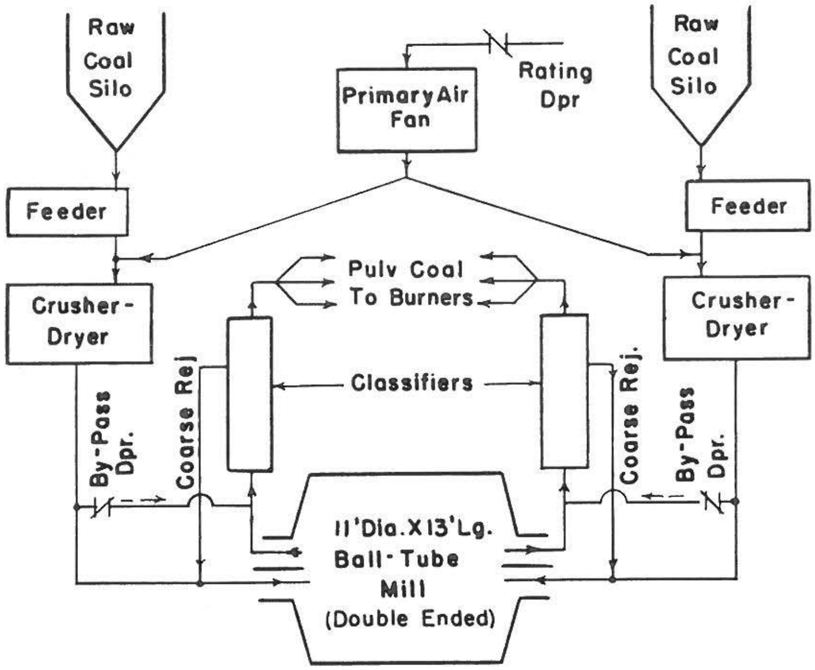

Figure 9. Mill System Components

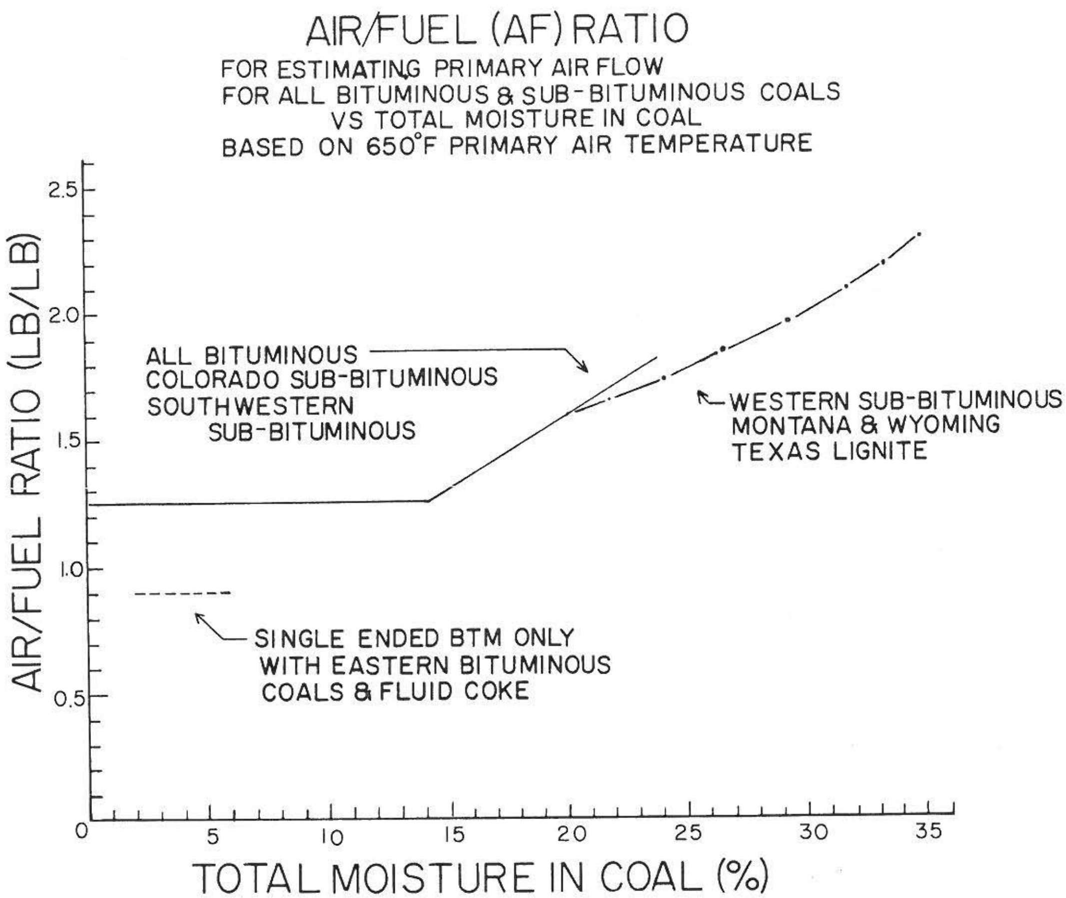

Figure 10.

WET COAL OVERRIDE:

Another feature of the Riley Ball Tube Mill System is its bypass (auxiliary) damper override control for handling extremely wet coal. Once the coal's moisture has caused the tempering air damper to close and hot air damper to come fully open, many pulverizer systems only method of handling wet coal is to slow down coal feed rate to the pulverizer resulting in loss of capacity. The Riley system causes the bypass damper to open resulting in the need to further open the rating (volume) control damper. This, in turn, adds more primary air to the crusher drier where more effective drying results. The fact that the bypass damper has opened bypassing the pulverizer, causes the crusher drier air to coal ratio to be higher than normal while the pulverizer air to coal ratio remains normal. Thus, by altering air flow, wetter coal can be effectively handled reducing the propensity for wet coal accumulations within the system. This indirectly reduces fires because wet coal deposits invariably dry out and become a potential fire source.

NO PANACEA:

This paper describes one approach to dealing with the fire hazards attendant with high volatile coals. It is not claimed that the utilization of the system described will totally eliminate fires in pulverizers and conveying systems. However, experience to date with applications of such systems has been extremely encouraging. Although hard data on fire incidents are difficult to obtain, our experiences with applications of systems utilizing the crusher flash drying process has shown marked reduction in fire incidents when contrasted to earlier system designs which did not utilize this system component.

ALTERNATIVE:

One alternative to the method presented is to saturate the entire pulverizer and conveying systems with inert gas each time the system is removed from service with a coal charge remaining in the pulverizer. We believe this alternative to have merit, although its first cost and operating cost can be high. It is doubtful that its use will be completely effective in preventing pulverizer fires in the vicinity of hot primary air pulverizer inlets since sufficient oxygen may be available for the smoldering process to proceed. Gaseous inerting will be effective in preventing serious explosions in pulverizers. However, damage due to overheating and from spontaneous combustion of highly reactive coals can also cause deterioration and failure of pulverizer parts.

FUTURE APPLICATIONS:

The ball mill pulverizer system with crusher dryer described herein is ideal for new plants burning high volatile, high moisture coals. It can also be considered for retrofits of existing systems, particularly when a change in fuel characteristics or moisture content increases the potential for fire incidents.

REFERENCES

[1]"Mill Drying In Pulverizing High Moisture Coals," W.C. Rogers ASME 5.
[2]"Using High Moisture Western Coals in Power Boilers Designed for Pulverized Bituminous Coal Firing," R.L. Thiede et al APC 4
[3]"Reactivity of Solid Fuels," A.A. Orming I & E Chan 9-44
[4]"Explosibility of Carbonaceous Dusts," J. Nagy et al B of M 1965
[5]Communications With Numerous Utility Companies With Table and Ball Tube Type Pulverizers