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ASSEMBLY OF MASS BALANCE OF PULVERIZING CIRCUIT WITH FAN MILL

SESTAVENÍ MATERÁLOVÉ BILANCE MLÝNSKÉHO OKRUHU S VENTILÁTOROVÝM MLÝNEM

Abstract

This paper deals with assembling the mass balance of pulverizing circuit with fan mill and is focused on issues in measurement and assessment of some quantities.

Abstrakt

Článek popisuje sestavení materiálové bilance mlýnského okruhu s ventilátorovým mlýnem a dále se zaměřuje na problémy spojené s měřením nebo stanovením některých veličin.

1 INTRODUCTION

Making-up of fuel is essential for proper operation of a boiler because of efficiency, emissions of pollutants, slagging, auxiliaries etc. Thermal balance of mill is necessary for analysis of operation of the mill and the auxiliaries and even of the combustion process. Before assembling the thermal balance, proper assembling the mass balance is necessary.

The Department for Diagnostics, Operation of Thermal Power Engineering Facilities of VŠB-TU Ostrava (KE DEZ) is experienced in measurements, analysis and improvements of operation mills for hard coal (especially ring and ball mills). But in last few years KE DEZ has very often participated with companies such as ALSTOM POWER, VÍTKOVICE HEAVY MACHINERY, ČEZ, INTERNATIONAL POWER, etc. in measurements and analysis of boilers and pulverizing circuits for brown coal (hammer mills and especially fan mills).

Brown coal is characterized by high water content. Hence flue gases (rarely hot air) are used for drying and transportation of fuel into boiler.

2 MEASSUREMENTS AND DETERMINATION OF VALUES

All measurements mentioned below on must be carried out in steady state of the boiler and the pulverizing circuit. Values of temperatures and O_2 concentration must be measured and averaged not only by time but even by space. Ventilation of mill and concentration of pulverized coal must be measured in fine meshed matrix. Proper determination of fuel composition and water content of pulverized coal is necessary.

Some methods and instruments were specially designed or modified by VŠB-TU KE DEZ to be used for various measurements.

2.1 Mass balance

The mass balance of pulverizing circuit is assembled before assembling the thermal balance. Measurement of all inputs and outputs is ideal, but direct measurements of some values are almost impossible in practice.

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Value	Method	Instrument
composition of raw coal[1]	sampling of representative sample, raw analysis, analysis of combustible matter and granulometric analysis	
mass flow of raw coal[2]	process measurement of RPM of raw coal feeder + measurement of layer thickness or measurement of weight of raw coal per one revolution of feeder	process measurement + weighing apparatus
flow of flue gases sucked by dryer[3]	repeated matrix method + continuous point measurement	cooled velocity (cylindrical) probe + data acquisition system
flow of hot air into blowers of dryer[2]	process measurement	throttling organ or velocity probe + process measurement of temperature
flow of false air through raw coal duct[2]	repeated matrix method	velocity (cylindrical) probe
flow of false air through cold air damper[2,3]	repeated matrix method	anemometer
flow of air through hot air damper[2,3]	repeated matrix method or process measurement	velocity (Prandtl) probe or process measurement
false air leakages[3]	repeated matrix method	anemometer
concentration of O_2 in intake of dryer[1]	repeated matrix method	cooled sampling probe + O_2 analyzer
concentration of O_2 after hot air inlet through blowers into intake of dryer[1]	repeated matrix method	cooled sampling probe + O_2 analyzer
concentration of O_2 in mixture of flue gases and hot air downstream from inlet of hot air into intake of dryer[1]	repeated matrix method	cooled sampling probe + O_2 analyzer
concentration of O_2 in mixture of flue gases and hot air downstream from inlet of raw coal duct into pulverizing circuit[1]	repeated matrix method	cooled sampling probe + O_2 analyzer
concentration of O_2 in mixture of flue gases and hot air upstream and downstream from inlet of hot or false air into pulverizing circuit[1]	repeated matrix method	cooled sampling probe + O_2 analyzer

[1] It is necessary for next calculations.

[2] For verification.

[3] Measurement of the value is too complicated or uncertainty of measurement is too big, so the calculation of the value is more accurate.

Tab. 1 Measured inputs for assembling the mass balance

2.1.1 Measured inputs

Inputs for determination of the mass balance, methods and instruments of measurements are summarized in **Tab. 1.**

Measurement of the flue gases velocity in one point (for determination of trends and relative changes of flow) in inlet of dryer simultaneously with repeated matrix measurement can improve an accuracy of the mass balance and makes possible the deeper analysis of pulverizing circuit operation.

Measurements of false air flow through raw coal duct, through tempering air damper and other leakages into pulverizing circuit is not necessary if measurements of O_2 in proper measuring cross sections are possible.

2.1.2 Measured outputs

Outputs for determination of the mass balance, methods and instruments of measurements are summarized in **Tab. 2.**

Measurement of velocity of primary mixture in one point (for determination of trends and relative changes of flow) in outlet of classifier simultaneously with repeated matrix measurement can improve the accuracy of the mass balance and makes possible deeper analysis of the pulverizing circuit operation.

Value	Method	Instrument
flow of primary mixture in outlet of the mill[1]	repeated matrix method + continuos point measurement	velocity (Prandtl) probe+ micromanometer with current or voltage output + data acquisition system
concentration an mass flow of pulverized coal[1]	repeated matrix isokinetic method	modified isokinetic apparatus
water content of pulverized coal[1]	repeated matrix isokinetic method	modified isokinetic apparatus + analysis of water content
granulometry of pulverized coal[1]	repeated matrix isokinetic method	modified isokinetic apparatus + granulometric analysis
concentration of O_2 in outlet of mill[1]	repeated matrix method	cooled sampling probe + O_2 analyzer

[1] It is necessary for next calculations.

[2] For verification.

[3] Measurement of the value is too complicated or uncertainty of measurement is too big, so the calculation of the value is more accurate.

Tab. 2 Measured outputs for assembling the mass balance

2.1.3 Assembly of the mass balance

Fig. 2 illustrates the algorithm for assembling the mass balance of pulverizing circuit shown in **Fig. 1** are drawn typical measurement cross sections. This typical set of measurements in cross sections shown in **Fig. 1** is sufficient for assembling the mass balance, but for the thermal balance it is necessary to know the ratio of false (cold) air and preheated air sucked to pulverizing circuit from measuring cross section no. 1 to section 2. Hence two of three significant values must be measured: flow of false air through raw coal duct, flow of preheated air through hot damper and false air through cold damper.

Proper determination of the primary mixture flow in outlet of classifier is fundamental for proper assembling the mass balance, because all other flows (flue gases, blowing air, leakages, false air through raw coal duct, hot and cold air through control dampers and even mass flow of pulverized and raw coal) result from this value and are computed on the basis of measured concentrations of O_2 in mixture of flue gases, hot and false air. Flow of primary mixture is measured by Prandtl probe. Velocities determined from these measurements are function of density of primary mixture in measurement cross section. Density depends on temperature, pressure and composition of mixture. Density of flue gases in inlet of dryer is computed from stoichiometry and concentration of O_2 measured in the inlet of dryer (this is the reason why proper sampling of raw coal and subsequent analysis of raw coal are so important). Downstream from inlet of dryer are flue gases mixed with hot and cold moist air. Raw coal is pulverized and dried in mill. Thereby a large amount of water is evaporated. Moisture in air and especially water evaporated from coal fundamentally affects density. Analyzers of O_2 concentrations on the basis of principle of operation work with dry gas (gas is dried before entering analyzers). Thereby all measured concentrations of O_2 means concentration in dry gas. It is problem to measure water content in the primary mixture directly, hence amount of water in the primary mixture is calculated from the difference between water content in raw and pulverized coal and mass flow of raw coal. Mass flow of raw coal is determined from the difference of water content between raw and pulverized coal, concentration of pulverized coal in primary mixture and volume flow of primary mixture. Volume flow of primary mixture is (as mentioned above) function of density. It is reason why mathematical model using iterations (as shown in **Fig. 2**) is necessary for proper assembling the mass balance.

2.1.4 Supplemental measurements

Other supplemental measurements of parameters for complex analysis of pulverizing circuit are shown in **Tab. 3**

Value	Method	Instrument
RPM of fan mill	process measurement	
electric input of fan mill motor	process measurement	

Tab. 3 Measured supplemental values

CONCLUSIONS

- Methods and instruments mentioned above are used by VŠB-TU Ostrava KE DEZ for assembling the mass and heat balance of pulverizing circuits with fan mills. Similar methods and instruments are used for other types of pulverizing circuits.
- Some of the methods, instruments and equations have been designed, improved or expressed by members of KE DEZ.
- If the pulverizing circuit is equipped with circulation of flue gases this fact must be taken into consideration.
- The way of evaluation was successfully used in cooperation with ALSTOM POWER company to consider the influence of the grinder on the fineness of grinding of the fan mill and in cooperation with VITKOVICE HEAVY MACHINERY company for assessment of potentials of pulverizing circuit with regard to retrofit of power units.

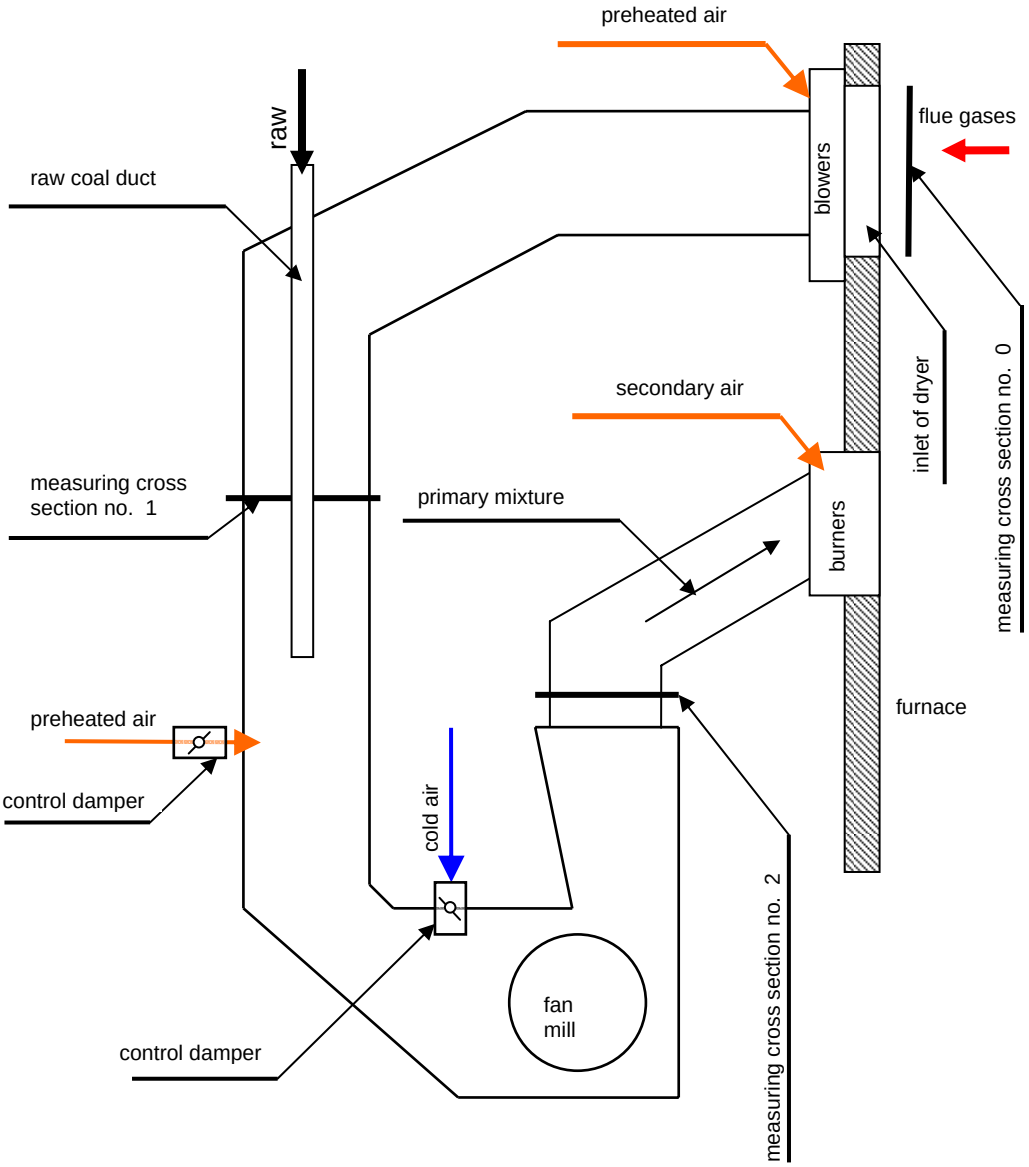

Fig. 1 Scheme of pulverizing circuit

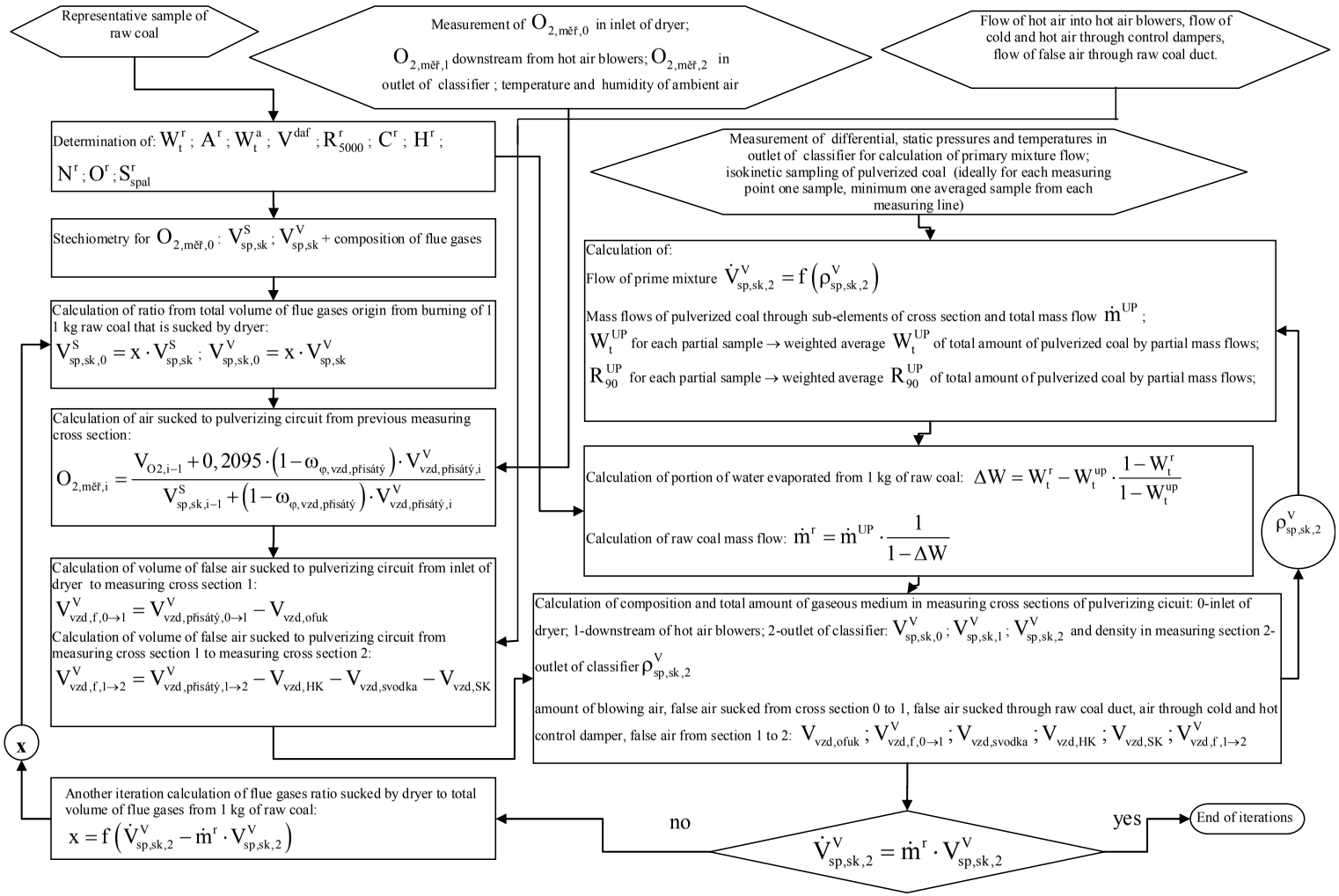

Fig. 2 Algorithm for assembling the mass balance

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