Literature Review on Study of Coal Slurry Fuel Combustion and Methods of Combustion

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Abstract— The conventional energy fuels are going to extinct some or the other day. There is need for alternative. This paper deals with the research involved in alternative fuels specially the combination of pulverised coal and liquid fuels for example methanol/water/oil. The research has been found in countries like Japan, China and United States of America. Several different methodologies involved in coal slurry fuels research. Few of them and mentioned below with experimental results.

Key words: Coal Slurry Fuel, Combustion

I. Introduction

Conventional fuel coal used in coal fired power plants for electricity generation. Coal and oil both are conventional fuels and due to increase demand and increasing cost alternate energy source are necessary. After many investigation and research it has been found coal slurry fuels can be used instead of oil fuels. In this connection, slurry fuels of pulverized coal such as COM (coal-oil mixture), CWM (coal-water slurry/mixture), CMM (coal methanol mixture/slurry)and others have been investigated as alternative fuels because not only is their fuel cost moderate but also pipeline transportation and handling are convenient and economical. The investigation and development of coal slurry fuels, especially COM, have been carried out in several countries. International symposia on COM combustion have also been held in the USA since 1978.

Coal-liquid mixtures consist of finely ground suspended in liquid, such as oil or water, together with small additives to improve stability and other physical properties. The primary purpose of coal-liquid mixtures is to make solid coal behave as an essentially liquid fuel that can be transported, stored, and burned in a manner similar to heavy fuel oil. The most mature coal-liquid mixture technologies are those using coal-oil and coal-water mixtures. Several of these technologies already have been offered commercially. Since coal-liquid mixtures re intended as a substitute for oil, their market penetration is heavily dependent on oil prices.

II. Process and Methodology

Depending on research these are the methods to coal slurry mixture suspension of drop in hot air, suspension of drop in fluidised bed and Mixture Droplet on a Hot Surface. Each method has its own definition, apparatus and reasons. Firstly to study the droplets in centre of the combustion chamber this suspension method helps to figure out the process. The drop is ideal in the air with high surrounding temperature, further study is carried out. In next study method, coal slurry drop in placed on fluidised bed combustion. The purpose is to study coal slurry behaviour on the fluidised bed. Similar to it is the next method of mixture droplet on hot surface. The purpose of both the methods is same to study rheological behaviour of coal mixture

A. *Combustion of coal–water suspensions – (a)*

Combustion technologies used is coal–water suspensions in Circulating Fluidised bed combustion. Different types of coal with different particle size and constant water content in slurry experimented. Coal water suspension drops undergo three stages first evaporation second heating and carbonisation and lastly non homogeneous combustion. The basic aim of the study was to identify the moistness of the suspension, temperature in the combustion chamber, gas velocity, granulation and mass of the suspension at the time of combustion of the suspension fuel in air and the fluidised bed. Mathematical model for both case air combustion and fluidised bed combustion has been generated. Comparison of ignition delay and ignition temperature between combustion in air stream and fluidised bed showed in graphical from with respect to moisture content. Among many conclusions few are mentioned i) Water from the coal–water suspension clearly intensifies the combustion process, causing the lowering of ignition temperature ii) The highest combustion temperature has the suspension made of coal dust of the lower type, and its combustion time is the lowest. The motivation of the study was to determine the suspension fuel properties, in figure1. relation to the moisture content and degree of coal granulation. It was found that both particle distribution and coal concentration in the suspension determined the stickiness and rheology of the coal–water suspension. Small affinity of coal to water enables high concentration long-lasting suspension fuels. Optimal graining distribution should guarantee the best coal particle packing in the suspension.[3]

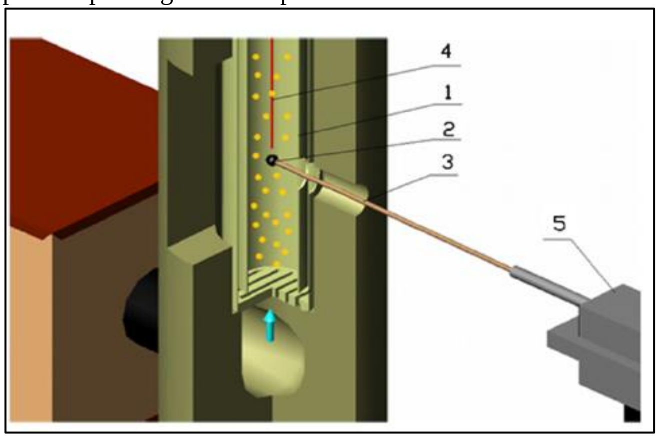


Fig. 1:

Fig. 2 shows the course of combustion of the coal–water suspension drops, made from different coal dust. In the first combustion stage of the coal–water suspension, evaporation of moisture occurs and results in a drop in the suspension fuel. It was noticed that after the evaporation, the shape and size of the agglomerate drops remained the same. After the evaporation stage there is heating and carbonisation of the coal particle agglomerate, which leads to thermal decomposition and expansion. The final stage is the non-homogeneous combustion of the agglomerate, which is characterised by the absence of flame occurring during volatile combustion. The completion of the process is signalled by the sudden fall of the char product temperature. The char agglomerate combustion period is definitely longer than the ignition time and volatile combustion. It was observed that during intensive volatile combustion, a sudden temperature rise of the coal–water suspension drop occurs. The coal–water suspension made of anthracite dust slowly burns without flaming, opposite to that of fuels of lower coal content. The fuel, which constitutes the coal mule flurry, burns violently because of volatiles situated at the suspension drop surface. [3]

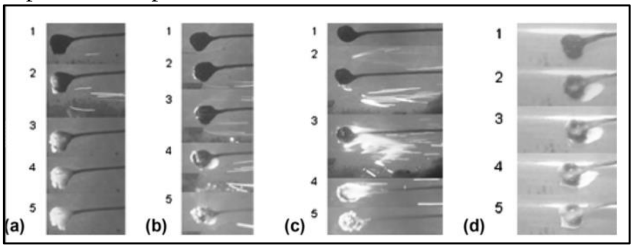
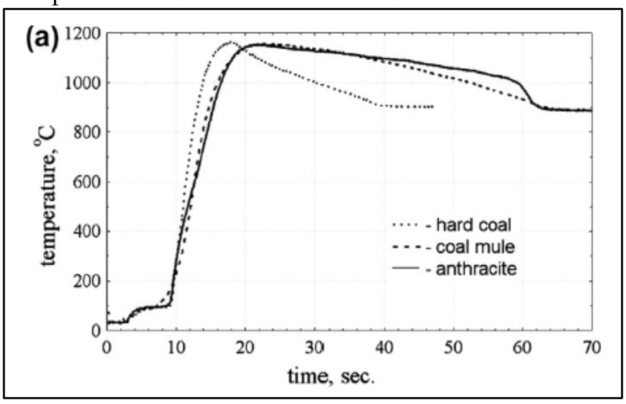
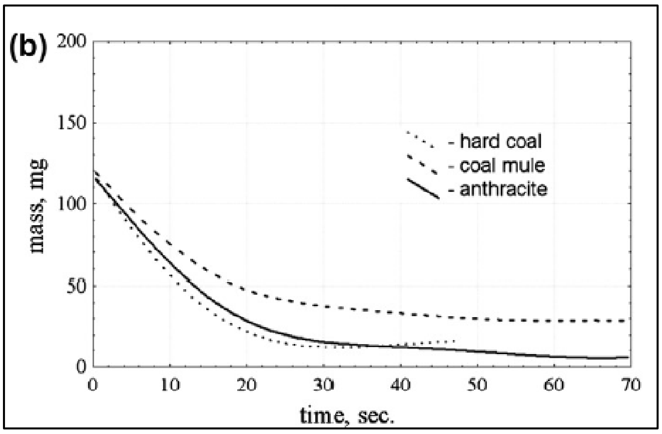


Fig. 2:

Fig. 3.a presents the course of changes of temperature and mass of slurries from different types of coal. After ignition of the vaporised fuel, an intensive suspension temperature increase to its maximum value was observed. It was noticed that the suspension made of the low type of (big content of volatiles) coal dusts had the highest combustion temperature, and its combustion time was the shortest. The increase of moisture content in the suspension leads to the lowering of fuel ignition temperature – an abrupt change of fuel temperature.

An example of: figure3 (a) the temperatures changes of coal–water suspension during its combustion in air (moistness of suspension: 35%); mean particle size: brown coal – 145 lm, hard coal – 135 lm, coal-mule – 125 lm, (b) mass loss changes of coal–water suspension during its combustion in air (moistness of suspension: 35%); mean particle size: brown coal – 145 lm, hard coal – 135 lm, coal-mule – 125 lm, (c) influence of slurry moistness on the ignition temperature (sudden rise of slurry temperature); mean particle size: hard coal – 135 lm.





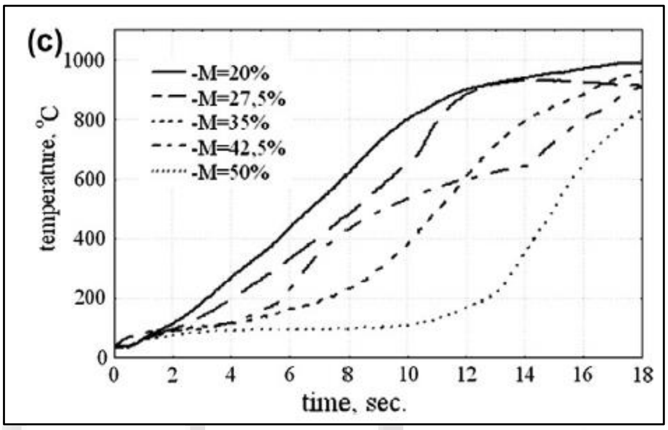


Fig. 3:

1. (b)The test fuel droplet was suspended at the tip of a fine Pt-Pt Rh thermocouple (wire diameter 0.1 ram40 mounted on the droplet carrier (6). Immediately after the droplet diameter was meas- ured, the droplet was carried to a fixed position in the middle of the combustion chamber and burned. In the case of forced ignition, the droplet was ignited when it passed through a pilot flame (20) (nozzle diameter 0.6 mm) located at the side wall entrance of the tube. The characteristic initital diameters of the droplets were between 0.9 and 1.6 mm. Ten measurements were made for each sample under the same temperature condition. The image of the burning sequence was recorded by a video camera (17) at 60 fps, from which the temporal variation of the droplet size and the burning times for each of the cornbustion periods were measured. The history of the droplet temperature was recorded by means of an oscillograph [6]

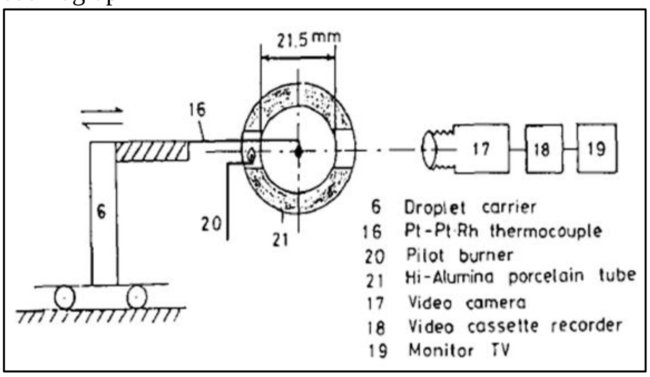


Fig. 4:

Figure 5 shows the temperature history of a spontaneously ignited COM droplet. The two stepwise lines (No. 1 and No.

2) are the signals from two digital time counters (14) which detect photocell signals at the moment of droplet insertion, ignition, and gas phase flame extinction. It is seen that as soon as the droplet entered the furnace at point a, the droplet temperature began to increase with gasification. At point b the droplet ignited and the gas-phase combustion of the volatile matter led to rapid temperature increase. The flame extinguished at point c and combustion of the residual solid immediately followed. The entire combustion process terminated at point d. Hence, in the case of spontaneous ignition, the duration's ab, bc, and cd represent the ignition delay, gas phase combustion of the volatiles, and solid combustion periods, respectively. [6]

B. Combustion of a Coal-Oil Mixture Droplet on a Hot Surface-

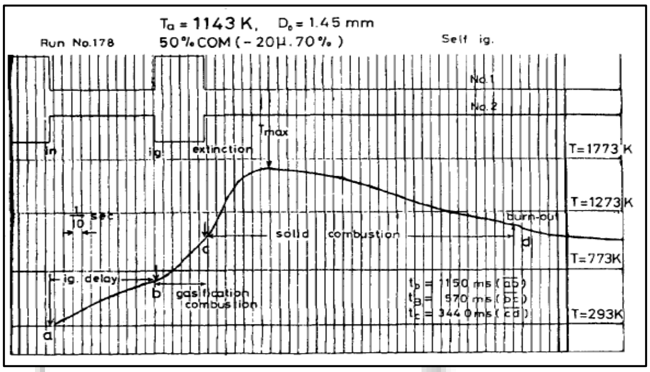


Fig.5

The experimental apparatus is shown in Fig. 5. It is almost the same as the one used before [9, 10]. The hot plate (1) made of stainless steel is 160 mm square and 30 mm thick, and its upper surface is polished to concavity (sphere radius 1400 mm) to control the position of the droplet. The surface temperature at the centre of the hot surface (tw) is determined by an extrapolation of the values measured by three Pt-Pt13%Rh ther terline of the test chamber, obtained with Pt- Pt13%Rh thermocouple(diameter 50 #m), are shown in Fig. 3. In the figure, z indicates the vertical distance from the hot surface. A droplet is dropped freely onto the hot surface from a hypodermic needle (stainless steel) [Fig. 2(7)] which is kept at constant temperature of 80"C by recirculating hot water. In order to get constant do (initial droplet diameter), three kinds of needles were used for the three kinds of fuels, i.e., 1.69, 1.45, and 1.05 mm inner diameter for 50 wt% COM, 30 wt% COM, and C fuel oil, respectively.[5]

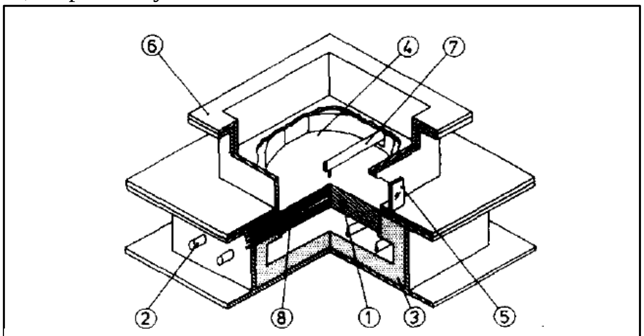


fig.6 **Experimental apparatus: 1, hot plate; 2, heater; 3, insulator; 4, test chamber; 5, Vycor windows; 6, upper lid; 7, hypodermic needle with water jacket; 8, thermocouple.**

The burning processes of a COM and a C fuel oil droplet on a hot surface are shown in Fig. 7. A COM droplet on a hot surface has a two-stage combustion process, just the same as a suspended COM droplet [3, 4, 6], i.e., a gas-phase combustion followed by a solid-surface combustion. Two-stage combustion occurs only if the heating rate (hence, the evaporation rate) is fast enough to ignite the vapour homogeneously. Very slow heating rates lead to heterogeneous ignition on the particle surface. Clearly in this study, the hot surface can supply a faster heating rate than the gas so two-stage combustion is preserved. Furthermore, a residue is formed in the case of a COM droplet, unlike the case of a C fuel oil droplet.[5]

III. CONCLUSION

In suspension method following conclusion are taken in account the coal particles of the coal–water suspension drops are located irregularly. The fluid in the suspension combines the particular coal particles into bigger agglomerates. In the case of the

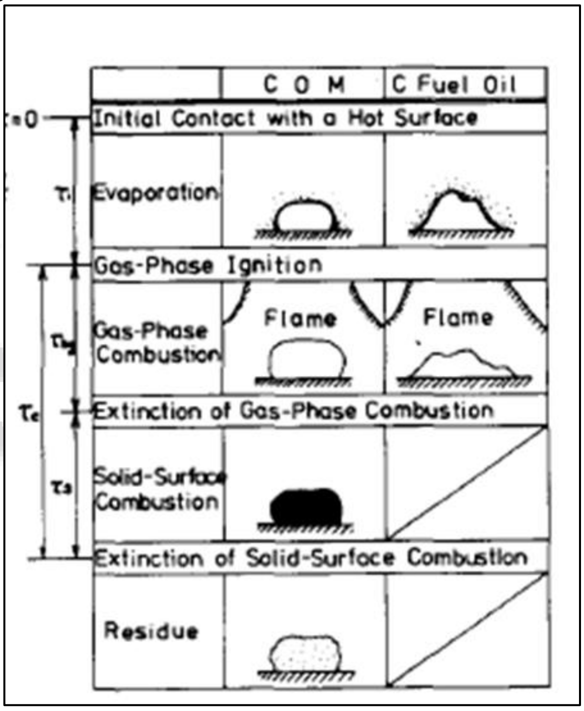


Fig. 7:

coal–water suspension made of coal particles of various sizes, the tendency was observed to form groups of larger particles inside the suspension and smaller particles flow to the drop edge. After water evaporation, located outside the agglomerate, coal particles reach the melting temperature and stick with each other, forming a shell. [5].Water from the coal–water suspension clearly intensifies the combustion process, causing the lowering of ignition temperature. The highest combustion temperature has the suspension made of coal dust of the lower type, and its combustion time is the lowest. The specificity of suspension combustion in the conditions of the fluidised bed, changes the mechanism and kinetics of the process[3]. During combustion in the conditions of the fluidised bed, one can observe the intensive fuel heating in the initial stage of the process and then the heat transfer from the coal–water suspension by the striking inert material, which leads to the lowering of the medium fuel temperature and slight lengthening of its combustion time In case of hot surface The residue formed by a coal-rich droplet (50 wt% COM) is hollow, but the one formed by a coal-lean droplet (30 wt% COM) has a spongy tissue. The residue formed on a hot surface (800°C) does not stick to the surface, but Residue formed on a cool surface (600"C) sticks closely to the surface.[6]

Current analysis of the known approaches to investigation of the ignition and combustion processes for the WCF together with analysis of their results allows making conclusion about a large groundwork of scientific society in this area of knowledge. The obtained results show essential possibilities regarding to driving of the WCF ignition and, as result, the potential of growth of the efficiency of WCF usage in energetics.

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