Consiglio Nazionale delle Ricerche
Istituto di Ricerche sulla Combustione CNR - Napoli

Short Term Mobility 2009

Report of the activity carried out by
Prof. Farouk Mohamed Okasha Elsayed
Dep. of Mechanical Engineering, Mansoura University, Egitto

July, 22-31 2009

Studio teorico-sperimentale sulla gassificazione in letto fluido di miscele acqua/biomassa/carbone

Characterization of Solid Fuel slurries for feeding fluidized bed gasifiers

Introduction

Atmospheric fluidized bed gasification is a promising technology for power generation from biomass and wastes. Nevertheless, relevant issues have still to be addressed by the scientific community, namely the purification with regard to tar and particulate matter, the achievement of a high conversion rates and gas heating value, the maximization of hydrogen content, and CO removal from the syngas [1]. The adoption of wet fuels (waste/biomass/coal slurry) is another intriguing possibility, since it represents an effective and simple way to provide steam for the gasification process [2]. The addition of coal up to 30% by weight to valuable biomass sludge strongly increases the thermal input, allowing the steady operation of the gasifier.

The research on wet fuels is of particular interest for application at small scale as well as to provide alternative to conventional disposal for residues and slurries from agriculture, zootechnics and food industry [3].

Results and discussion

Different materials are required to be fed into the gasifier including solid fuels and water vapour. Using fuel-water slurry, like coal-biomass-water-slurry, has some advantages in this respect. Among different favorable aspects, their ability to be pumped into reactors may remarkably simplify solid fuel feeding systems of atmospheric fluidized bed and, in particular, pressurized units. The use of fuels-water slurries in a single pumping system reduces the number of feeding

systems and could overcome some technological restrictions. Using fuel-water slurry sounds more attractive when related to coal transportation as coal-water slurries, the recovery of coal benefaction by-products in the mining industry and different organic effluents by-products of many industries. In fact, it may be convenient to turn these later into CWS to be directly fed without additional drying costs.

During this short visit, different characteristics of fuel slurries have been investigated including transport and thermodynamics properties. A feeding system has been conceived to study the transport properties of the slurries, according to the scheme reported in Fig. 1. Enhancement of slurries properties using special additives has been also considered.

Slurries consisting of coal, biomass and water are expected to give rise to some difficulties and operation problems. Producing these kinds of slurries leads to decreasing heating values of such fuels. Moreover, hydrophilic brown (sub-bituminous) coals and wood/herbaceous biomass absorb the free water inside their own particles and the slurries are problematic for longer storing and pump feeding. The slurries made of black coal are found better from the point of view of calorific value and rheological behaviour (sedimentation, stability, and apparent viscosity). Thus, for coal-water slurries rather the bituminous, black coal with hydrophobic properties and higher calorific values are recommended.

In the frame of the FLEXGAS project coordinated by IRC-CNR, a bimodal particle size distribution of German lignite coal for slurries has been prepared by one of the partners [4] with about 70 % of the coal size fraction below 80 μm and 30 % of 180 – 315 μm, mass basis. Such bimodal distribution is recognized to be advantageous for slurry viscosity properties at higher concentrations. The slurries of the German coal with water, water-glycerin 1 : 1 and suspensions with addition of starch (after starch gelatinization). The suspensions of coal with only water were found to be unstable. Addition of glycerine results in better stability of the suspensions (with lower tendency to coal sedimentation). Better results have been attained with addition of starch and gelatinization. On the basis of preliminary experiments 1 % of starch, mass basis, seems to be enough to change properties of liquid – particularly pure water. The mixtures of water-glycerin and starch have advantage in suppression of surface denser gel formation (longer stability).

The coal slurries with water and 1 % starch or water-glycerine with 1 % starch, mass basis, can be prepared with coal concentrations as high as about 45 %, mass basis. The suspensions are relatively stable with viscosity that slightly decreases with increasing temperature. Another possibility is to prepare vegetable or mineral oil-coal slurry. A vegetable (rape seed) oil-coal slurry has been tried. The maximum concentration of bimodal coal particles in the oil for pumping consideration can be as high as 50 %, mass basis. The coal suspensions (slurries) can be pumped by a spindle-screw

pump. Feeding the slurries by such pumps into pressurized reactors under mild pressurized conditions (pressures below 1.5 MPa) is technically feasible.

Future development

A next stage of the research should be testing the feeding of coal/biomass/water slurries into experimental gasification facilities available at IRC-CNR and the gasifier performances. These tests should also be devoted at understanding the mechanism of water evaporation as well as of pyrolysis and conversion of the fuel [5]. In fact, significant differences are expected with respect to combustion conditions, by virtue of the lower temperature, less oxidative conditions and large presence of char particles inside the bed.

References

1) Bridgewater A.V., The Technical and Economical Feasibility of Biomass Gasification for Power Generation, Fuel 74, 631-653 (1995)
2) Melodi F., Uno studio sulla gassificazione a letto fluido di reflui agro-alimentari, Tesi di Laurea, Università di Parma (1997)
3) Werther J., Sänger M., Hartg E.U., Ogada T., Siagi Z., Combustion of Agricultural Residues, Progress in Energy and Combustion Science 26 , 1-27(2000)
4) Svoboda, K., Puncochar, M., FLEXGAS project, progress report of ICPF-Prague, 2009
5) Okasha F.M., Dispersion of Coal-Water Slurry in a Bubbling Fluidized Bed Combustor, PHD thesis, Università di Napoli (1994)

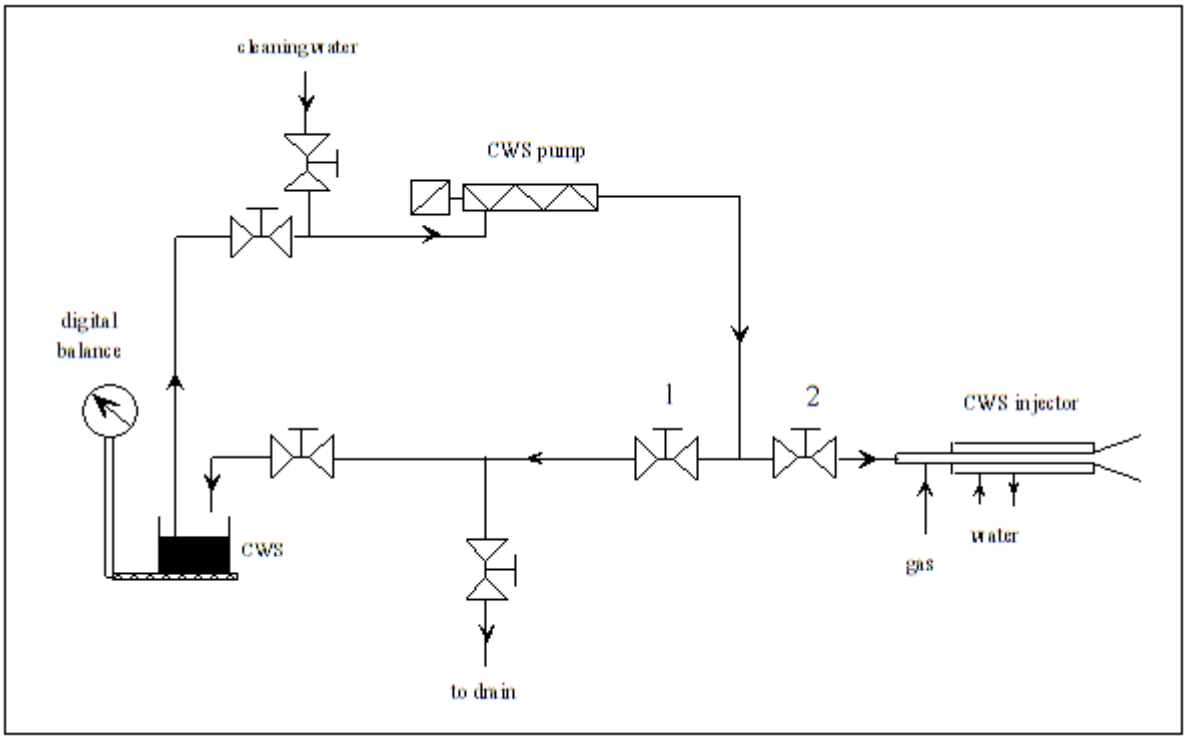

Figure 1: scheme of a feeding system for coal/biomass/water slurries into experimental fluidized bed facilities available at IRC-CNR