An Overview of Coal Water Mixture (CWM) as New Unconventional Energy Potency, and Indonesia Coal Fields for Case Studies*

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Abstract

The increasing energy demand is one of many crisis faced by numerous country in every parts of the world, including Indonesia. The dependence to fossil fuels, especially oil and gas, should be alternated because its production has been declining lately. One of the alternatives is CWM (Coal Water Mixture) from low quality coal (lignite – sub bituminous). CWM – which is coal-based fuel with fluid properties that has undergone a series of processing and upgrading – could act as an oil and gas substitute, mostly for industries with boilers, which runs on heavy oil. With complex geological condition, Indonesia holds substantial coal resources, about 105, 700, 000,000 tons. Most of these resources are classified into low-grade coals. Therefore, Indonesia is a promising market for CWM development. CWM as coal-based fuels with liquid physically can be used as fossil fuels substitute, mostly in industries that using heavy oil, it's considered from the viscosity and rheology of CWM have in common with heavy oil. For economic values purposes, formula is based from several aspects, the formula; CWM Value = (in-mine coal value) + (upgrading and processing cost) + (transport. Storage cost, etc). From this formula, CWM should be more competitive than coal in hunk (solid) form. As new venture of unconventional energy resources, CWM should be socialized intensely, especially for industries that use heavy oil.

Introduction

After the increasing of oil price caused by unbalanced oil production rate versus market demands in the world, coal began reviewed as the alternative for oil substitute. Coal Water Mixture (CWM) consisting of mixture of ground powder coal, water and small quantities of additive, is a fluid having viscosity equivalent to crude or heavy oil form offer potential as a replacement for fuel oil in oil fired facilities with only modest retrofits of existing equipment. CWM technology also offer low risk of development than the other coal conversion technology through this development consist of mixture of water and coal, CWM is free from some of major problems of solid coal, such as powder dust and spontaneous combustion during storage and transportation. Unlike solid coal, moreover, CWM does not require large handling facilities (Hashimoto, 1999).

Normally, CWM is prepared by using pulverizing bituminous coal, since the surface nature of bituminous coal is hydrophobic. However, sub-bituminous and lignite, which are commonly referred to as low-grade coal, constitute about almost 85% of the measured coal reserve of Indonesia. These low-grade coals with hydrophilic surface nature could be change to be a hydrophobic by upgrading process (Usui, et al, 1997).

What is CWM

Coal Water Mixture (CWM) is an advanced method to increase the coal's economical values. CWM is a combination of coal, water, and additive substances mixture. CWM is a fuel mixture of pulverized coal and water with the help of additives forming a homogeneous viscous suspension during storage, transportation and combustion. It has to be in a homogenous state in order to get the material in the form of fluid that can be distributed through pipes to solve transportation problems. Apart from that, it is also used as a heavy oil substitute, which is usually required in the industry such as boiler fuel.

One of the benefits of CWM is the physical properties that are similar to fuel oil. One of which is its fluidity, so that the installation of the existing oil burner can be used for combustion of CWM with slight modifications. Additionally, the use of coal in the form of CWM can be handled safely, due to the confinement or trapping of the coal in water, so that the dangers of coal dust and spontaneous ignition could be avoided (Hashimoto, et al, 2006).

CWM is usually made from bituminous coal, because coal of this type usually have low inherent moisture content and it also posses hydrophobic surface, thus the CWM produced by bituminous coal has good characteristics, which are stable, easily streamed and can be burned completely. CWM can also be made from low grade coals, but in order to so, it must undergo the process of upgrading the coal resulting the coal to have properties resembling the bituminous coal, thus consequently CWM will have a good quality too (Umar, et al, 2006), although, this paper will not discuss the upgrading process in detail.

Compared with the use of CWM in the form of powder, CWM has several advantages, namely:

- Its treatment is similar to heavy oil;
- Will not cause spontaneous combustions, explosions;
- Could be used as fuel;
- Could be used with boilers similar with the boilers commonly used by heavy oil;
- If there is fuel switching from oil to coal, start up time is shorter because it can use existing facilities, in example facilities for heavy fuel oil with a slight adjustments to the burner.

Process of CWM

On its implementations, CWM manufacturing uses bituminous coal. This is based on the condition that CWM process can only occur on hydrophobic coal. Numerous studies on CWM manufacturing and burning have been conducted by tekMIRA's research center using low-grade

coal and bituminous coal. The result shows that CWM with low-grade coal possesses worse characteristics in comparison to the CWM with bituminous coal. Table 1 shows the differences between CWM with low-grade coal and CWM with bituminous coal as its raw materials (Umar, et al, 1997, 1998). From Table 1 it could be concluded that CWM with bituminous coal possesses a much higher content compared to the CWM, which are manufactured from low-grade coal in order to produce the same viscosity (800 cP). Because of its higher coal content, CWM has higher calorie level so it burns much efficiently.

Based on that, CWM-making experiments performed through firstly coal-upgrading process. In this case, the coal results from the pilot plant process Palimanan UBC, West Java, Indonesia and are called Upgraded Brown Coal Water Mixture. The characteristics of coal as raw material for UBCWM can be seen in Table 1 and UBCWM's manufacturing process flow chart is shown in Figure 1.

The main purpose in UBCWM's manufacturing is:

- To produce higher coal content
- Static stability and high dynamics
- Low viscosity
- Combusts well

Principally, UBCWM's manufacturing process is quite simple (Figure 2). However, due to the differences in their density, coal tends to segregate to form a sedimentary deposit in water. To prevent this, it is necessary to add an additive that is usually in the form of chemicals in relatively small amounts (Usui, et al., 1999). Therefore, further research on how to obtain the ideal additive substances needs to be done.

Eighty percent of coal's grain size is 75μm or 200 mesh (Umar, et al., 2001). The concentration of coal within the UBCWM is estimated to be as high as it could be, although still within a certain viscosity level, exactly 1 Pa-s on a 100/s shear rate (Saeki, et al, 1999), to enable the UBCWM to flow easily through pipes during transportation and combustion. The determination of the optimum coal concentration within the UBCWM is done by manufacturing UBCWM in low coal concentration, then the process continued until the maximum concentration limit (viscosity > 1 Pa-s). The experiment is done using three types of additives, which are naphthalene sulfuric acid (NSF), polystyrene sulfonic acid (PSS) and poly (meth) acrylate (PMA) as much as 0.3% each to determine which type of additive is the most ideal to produce maximum coal concentration in UBCWM. As a stabilizer, carboxyl methyl cellulose (CMC) is used as much as 0.05%.

UBCWM combustion is done by spraying the UBCWM using pumps into a previously heated furnace (injection system). The combustion's efficiency depends on the degrees of atomization and the atomisator used in the process (Wall. T. F, 1987), whereas the combustion perfection depends on the amount of coal contained in the water, UBCWM's flow velocity, the speed of the combustion airflow, and the temperature of combustion (Figure 3).

Initial combustion is done by heating the coal up to the minimum heat required to burn CWM, which is 600°C (Umar, et al, 1997). The amount of the coal weighed is the same with the amount of UBCWM that flowed and measured by flow meter. The increase and decrease in temperature, which occurred during the combustion process, is also observed.

How's the CWM Potency Implementation in Indonesia

Indonesia has unique and complex geological sequences. This results in the existence of numerous coal seams with economic values. Based on the governmental regulations, the usage of bituminous coal are strictly limited only for trading. This erases the possibility of a promising market for low-grade coal. This also triggered tekMIRA as the country's research foundation to conceptualize a method, which could maximize the abundance of low-grade coal potential, especially in Indonesia. Based on the data from tekMIRA, CWM potential coal reserve lies mostly in Sumatera (Figure 4). Sumatera has low-grade coal reserve that needs to undergo upgrading process before it could be manufactured as CWM. The coal reserve in Sumatra is considered highly economical (Umar, 2012).

Conclusion

1. CWM is the mixing between slight coal and water. Have a similar rheological condition as fossil fuels.
2. CWM is more applicable for power plant and steam power plant, cement industries and another industries that using boiler.
3. CWF making processes generated without heating and pressuring. CWM from upgraded coal has a better rheological characteristic than low rank coal.
4. Minimum capacity for CWF for commercially scale around 1 million tons/year CWF or around 2,500 tons/day, with range of investment around USD 250 – 300 million.

Acknowledgement

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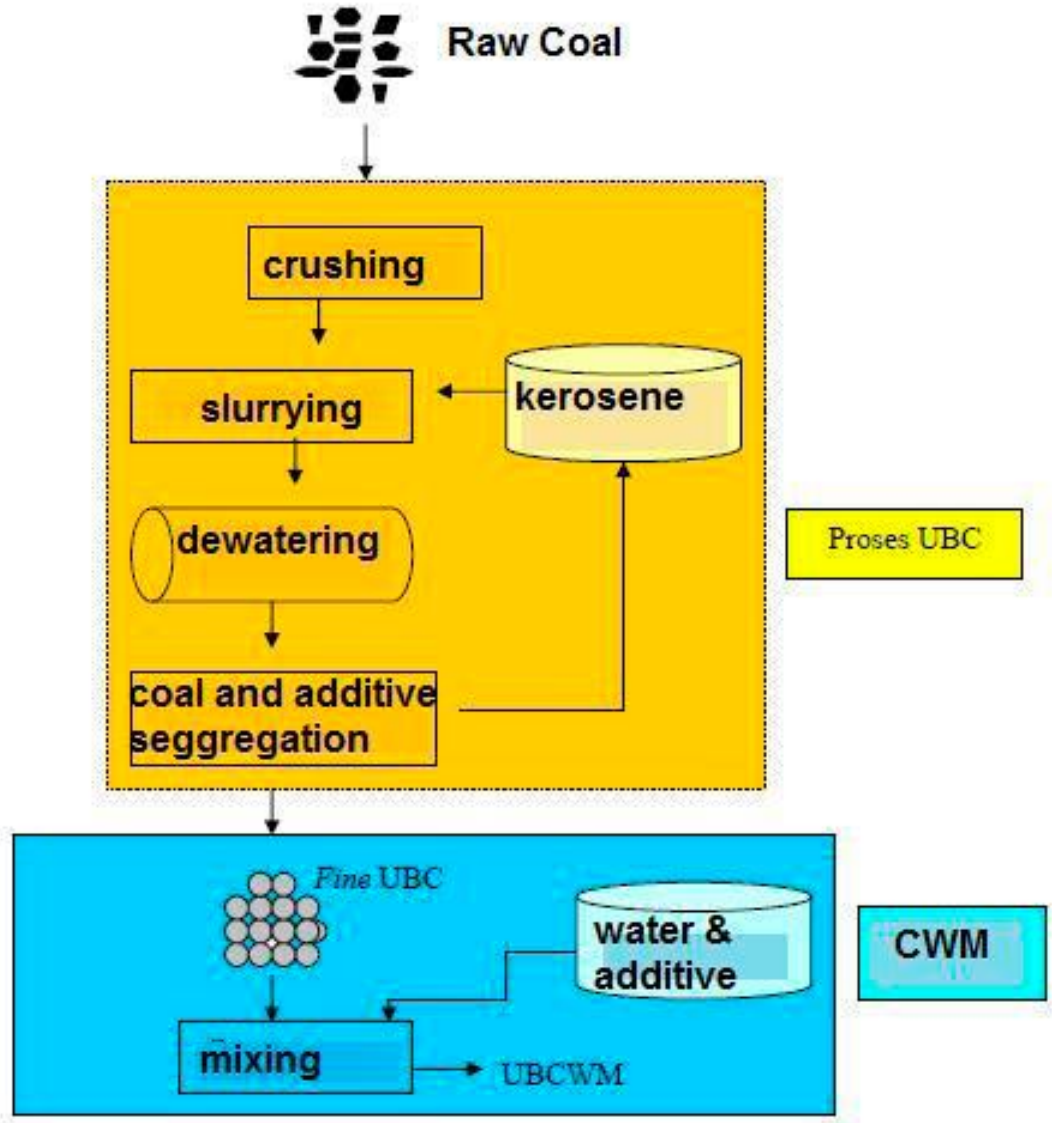

Figure 1. Step in CWM making process by upgrading low rank coal first.

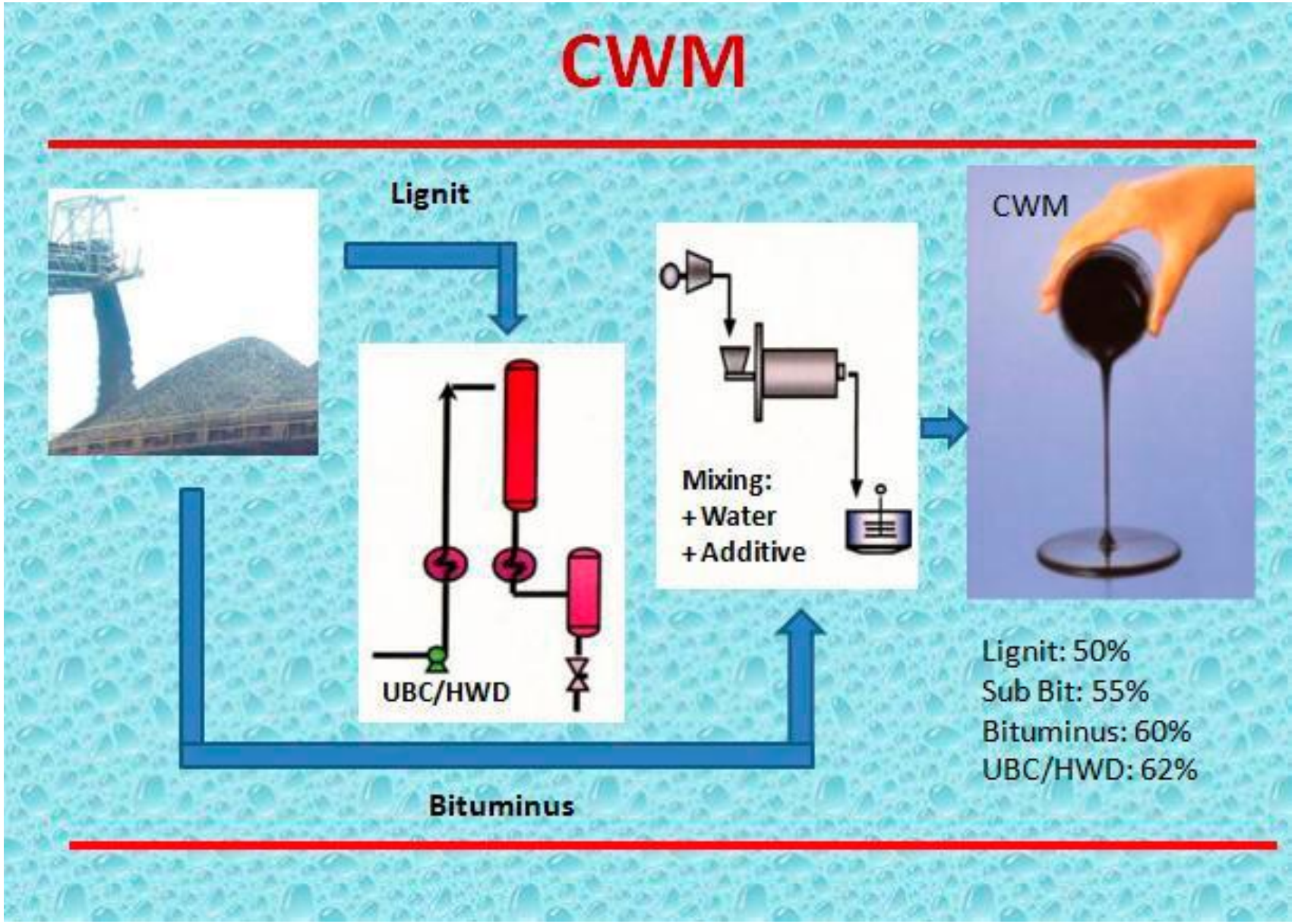

Figure 2. Illustration resume of CWM making processes from raw coal to liquid CWM.

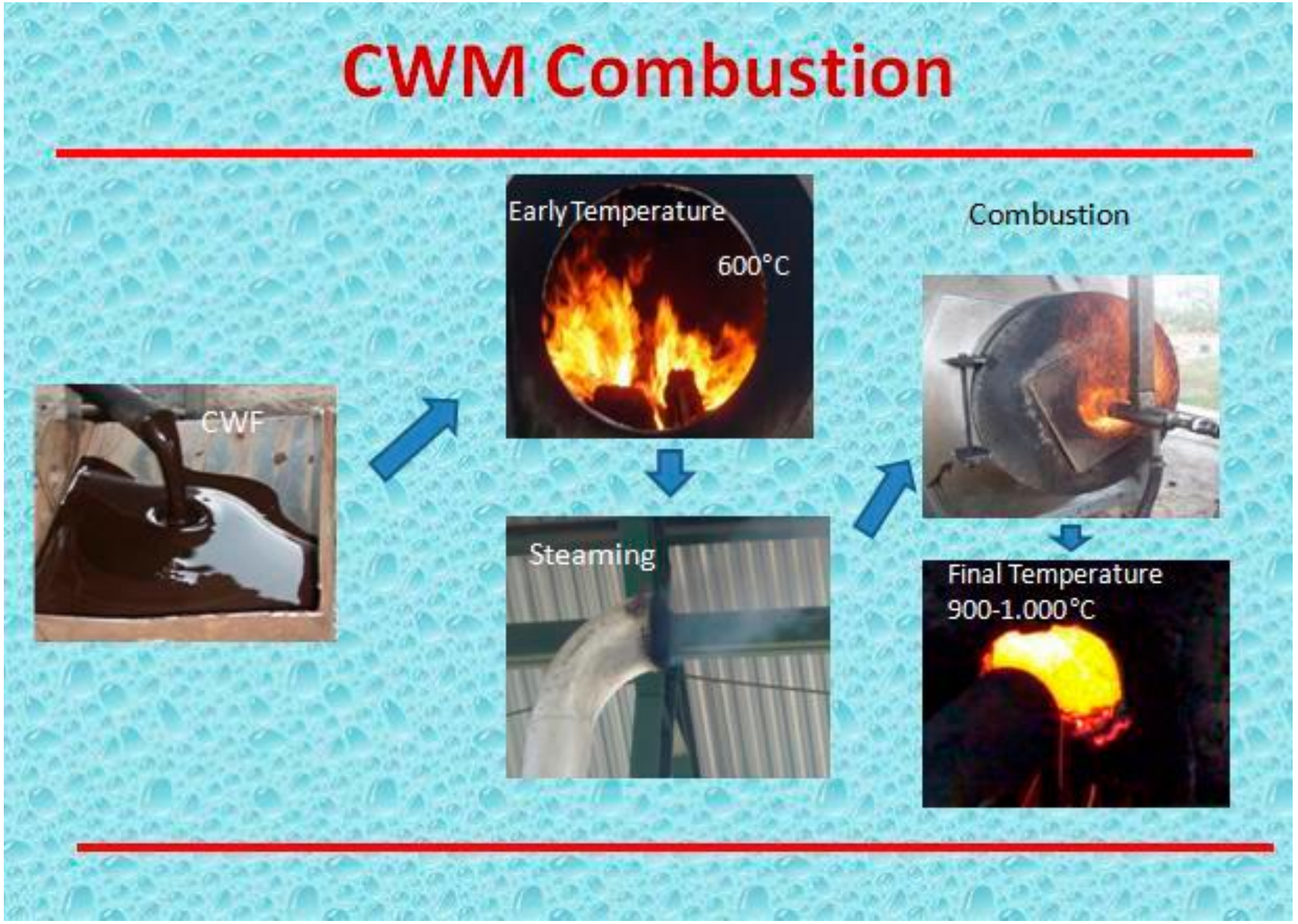

Figure 3. Illustration for CWM Combustion and the processes sprayed by sprayer to boiler.

Figure 4. Project plan for CWM Development in Sumatera, Indonesia.

	Low Rank Coal	Bituminous Coal
Coal Contain	50%	60%
Water Contain	50%	40%
Calories	2620 kal/g	3840 kal/g
Viscosity	800 cP	800 cP
Rate of Stability	6 weeks	9 weeks
Early Burning Temperature	700°C	600°C

Table 1. The differences between CWM with low-grade coal and CWM with bituminous coal as its raw materials based from laboratory measurement (after Umar, et al, 1997).