REPLACING FUEL OIL BURNER IN A ZINC BATH KETTLE FOR GALVANIZATION PROCESS BY COAL CYCLONE ONE

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ABSTRACT

Most galvanizing industries use fuel oil to maintain a zinc bath temperature within the 440 – 455°C range. The oil burner is used in a heating chamber and the flue gas is then passed into the heating space under a zinc bath kettle at a temperature of 600°C. In this works one of the oil burner would be replaced by a coal burner. The kettle dimension is 12 x 1.5 x 1.8 m for its inner length, width and depth respectively. The heating space under the kettle is divided into two sections, each section is heated by a single oil burner of 50 - 80 litres/hour burning capacity. As there is no access into the heating space to remove the accumulated ash, the employed coal combustion technique should not transfer the ash into this chamber. For this purpose a vertical cyclone coal burner is used in a section with combustion capacity of 100 - 200 kg coal/hour. To minimize ash accumulation, a cyclone dust separator is connected after the cyclone burner, thus a cleaner flue gas enters the heating chamber. The coal used is a low ash sub-bituminous type of 5,500 kcal/kg at with particle sizes less than 30 mesh. Observation of temperature fluctuation in oil heated and coal heated sections during galvanization process showed that the fluctuation in both sections are in balance, indicating that the coal heating matches fuel oil heating in this system. The fuel used are 124 kg/hour for coal and 60 l/hour for fuel oil. To maintain zinc bath temperature around 430 – 455°C within 7 days galvanizing time operation it is found that fuel consumption is 20,300 kg of coal in the coal heated section and 10,080 l fuel oil in the oil heated section. It means that 1 l fuel oil is equivalent to 2 kg of coal or coal efficiency is 18.2% lower than the oil one in this system. The ash produced by the combustion of coal which trapped by both cyclones is 80% which is accumulated in the burner and 20% in the cyclone dust separator. The energy efficiency of coal is lower than that of the fuel oil since the use of fuel oil is directly burned within heating chamber, otherwise the coal is combusted in a cyclone burner and the flue gas enters the heating chamber after a longer journey through a cyclone dust separator.

Key words : galvanization, zinc bath kettle, fuel oil burner, coal cyclone burner.

1. INTRODUCTION

As the result of long time subsidized fuel oil, most industries in Indonesia use fuel oil for their heating processes. Unfortunately, due to drastic increase of fuel oil price, many industries face serious drop in their revenue and some of them might be collapsed with serious financial problem, therefore they can not afford to buy new coal fuelled equipment.

R & D Centre for Mineral and Coal Technology has currently developed a cyclone coal combustor, which is a modification of standard cyclone furnace combusting coarse coal particles of low melting point ash (Elliot, 1981; H.M.S.O, 1963). The developed burner can combust higher melting point ash by reducing the coal particles into -30 mesh. The cyclone burner has some characteristics resembled to those of oil burner, namely producing long flame coal burning. The fire can be directed and the coal feed rate can be adjusted within a wide range stable coal combustion, as well as the intensity may match the oil combustor (Sumaryono, 1999).

Cyclone coal burner may replace the position of oil burner in many industries. The industries do not need to invest new coal facility to substitute their fuel from oil into coal. They just to remove the oil burner and then attaching the appropriate coal cyclone burner to the previous position of the oil burner.

The replacement of oil burner by cyclone coal burner has been implemented in some industries such as lime calcination, aluminium and tin smelter, zinc galvanization, steam boiler, oil heater and air heater (Sumaryono, 2005).

2. METHODOLOGY

The object that will be heated is a kettle containing molten zinc bath. The kettle's inner dimension is 6 m long, 1.5 m wide and 1.8 m depth, which is heated to maintain bath temperature in the range of 430 - 450°C. The heating space is divided into two sections. One is heated by oil burner in the heating chamber and the other one is heated by the flue gas from coal combustion in a cyclone furnace. As there is no access to extract the accumulating ash or dust in the heating space, the flue gas entering this space should be free of dust and ash. For this purpose the work proposed are :

- constructing a vertical coal cyclone burner that is capable to trap more ash;
- constructing a cyclone dust separator positioned between cyclone and heating chambers;
- operating the heating with coal in one section and evaluate the temperature fluctuation as well as the relative energy efficiency.

Layout of these facilities is shown in Figure 1.

3. RESULTS AND DISCUSSION

3.1 Equipment Performance

Cyclone Coal Burner

Heating space is positioned below heat chamber. Therefore the chamber has positive pressure when the space is hot. During heating operation, the pressure is 3.5 cm H_2O. Consequently, coal combustion system should have positive pressure higher than that of 3.5 cm H_2O. Refractory setting should be tight that is strong enough to resist positive pressure. Each section of heating space is heated by the oil burner with 80 l/hour burning capacity. To alter the oil burner, the combustion capacity of the cyclone burner should be about 160 kg coal/hour. Vertical cyclone burner retains dimension as follows :

- 200 cm high
- 92 cm inner diameter
- 152 cm outer diameter
- 31 cm wall thickness

The will it self consists of 25 cm quartz sand, 2.5 cm castable, 2 cm ceramic wool, 0.5 cm steel plate.

The quartz sand expands slightly at high temperature, however, as the burner is continuously operated for years, it considerably does a problem. Coal of -30 mesh size is fed tangentially at the bottom of the burner. Figure 2 presents the details of the cyclone burner.

Cyclone Dust Separator

Cyclone dust separator serves for separating ash from the combustion gases that is generated the cyclone coal combustor. It operates at 950 - 1050°C, therefore, the liner has to be made from refractory brick. The brick is made from quartz

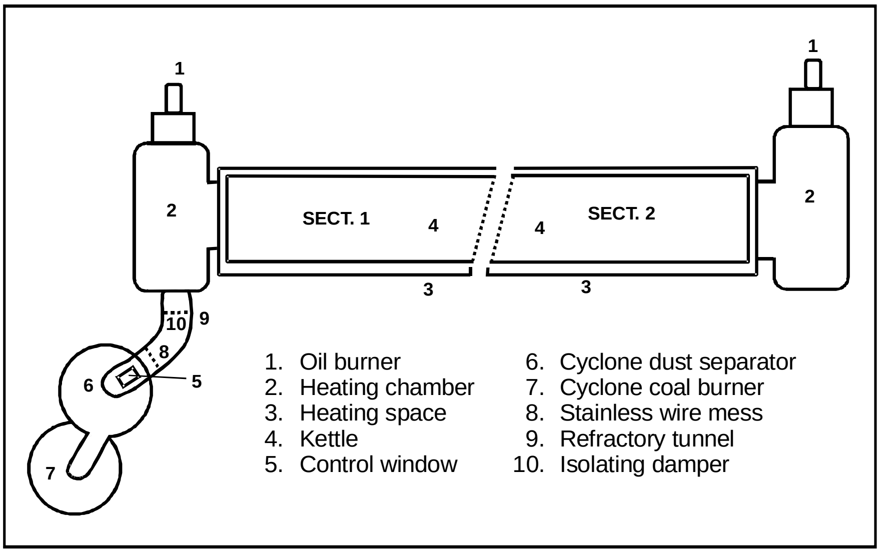

Figure 1. Layout of the galvanizing kettle

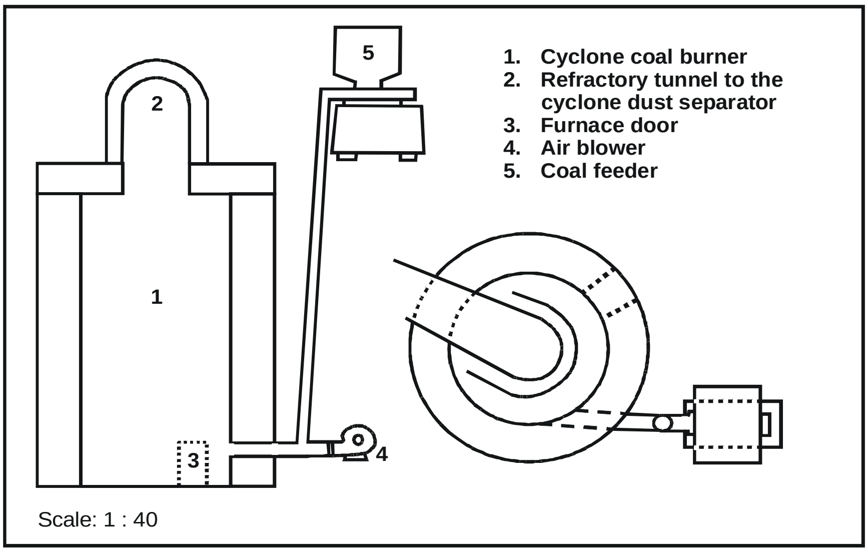

Figure 2. Cyclone coal burner

sand, that must be cemented by proper cement. At the bottom, there is a door to facilitate the removal of accumulated ash. Cyclone heigh is 145 cm retaining inner diameter of 90 cm and wall thickness of 30 cm (Figure 3).

A 100 - 200 kg/hour coal combustion proceeds in the cyclone burner. The flue gas flows out from the burner through a 40 - cm diametere hole that is availabe on the cyclone lid. Then it goes into cyclone dust separator tangentially and comes out from this cyclone through a 40 - cm diameter hole at the top. Subsequently the flue gas flows through a refractory tunnel that connects cyclone dust separator with heating chamber of galvanizing bath. In the tunnel, there is a stainless wire mesh fixed to trap remaining ash that is conveyed by the gas at 700 - 800°C.

Control Window and Damper

Refractory tunnel is facilitated by a control win-

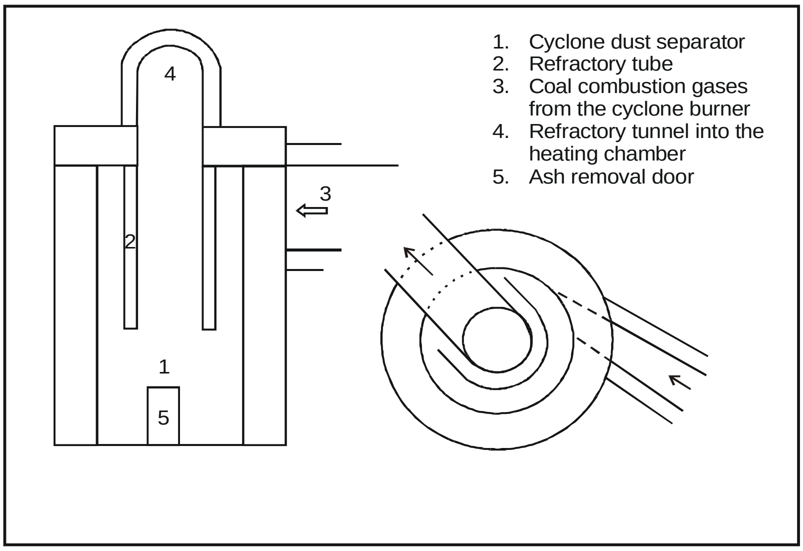

Figure 3. Cyclone dust separator

dow and a damper. The window can be opened for controling the quality of coal combustion process especially at the initial burning. The damper is positioned in the tunnel to isolate the oil and coal heating systems. When the oil burner in the heating chamber is operated, the damper must be fixed in the tunnel, otherwise the hot flue gas will escape through the cyclone dust collector and cyclone burner rather than flow down into the heating space under the kettle.

Coal Feeder

A screw feeder is capable of delivering coal 50 - 200 kg/hour and air blower should have capacity of 30 m^3 air per minute or more depending on the friction head in the system.

3.2 Coal Specification

Table 1 shows proximate analysis of coal used in this experiment; namely sub bituminous coal - with low ash content.

3.3 Procedure

As there is a positive pressure in the heating space, the isolating damper is placer closed to the space. The procedure is as follows :

- open the control window on the refractory tunnel;

Table 1. Proximate analysis of coal (air dried basis)

Inherent moisture	23%
Volatile matter	38.4%
Fixed carbon	37.4%
Ash	1.2%
Calorific value	5500 kcal/kg

- prepare the initial burning of coal; gas heating, oil heating or initial burning by firewood. If the firewood is used, firstly ignite the firewood pile. After a stable burning of the firewood is obtained, put the air blower “on” at about 50% of its capacity. Then feed the -30 mesh coal into the cyclone burner using a screw feeder at a rate of 60 - 100 kg/hour;
- some smoke may be emitted from the control window. Adjust combustion stoichiometry by adjusting rate of air blower and coal feed rate;
- increase coal combustion rate gradually until reaching 150 kg/hour. Continue to adjust the rate of air blower, until clean combustion is obtained;
- When good and efficient coal combustion is obtained, close the bottom door in the cyclone

burner and set off the air blower as well as the coal feeder. Close the control door otherwise open the isolating damper then set the air blower and coal feeder "on";

- set off the oil burner in the heating chamber. At this condition, the system is fully operated by coal heating.

3.4 Temperature Fluctuation and Relative Energy Efficiency

Capability of coal to substitute fuel oil in galvanizing system is evaluated by observing temperature fluctuation within the bath during galvanization process. Relative energy efficiency is evaluated by observing fuel consumption in both oil and coal sections at same period.

Temperature Fluctuation

The oil section is heated by oil burner the a burning rate of 60 l/hour. Temperature in this section is stable at 447 - 448°C. Coal burning rate in another section is adjusted close to the bath temperature in oil section. The equilibrium temperature is obtained by coal burning rate of 124 kg/hour. Temperature fluctuation is then observed during the galvanization process. The galvanized metal is part of the highway bridge material that is dipped into the zinc bath. The temperature fluctuation during two-hour process is showed in Figure 4. The figure 4 indicates that the heating by coal burner may match the heating by oil burner as showed by the fact that temperature fluctuation of coal heated bath is nearly coincides with the temperature fluctuation of oil heated bath.

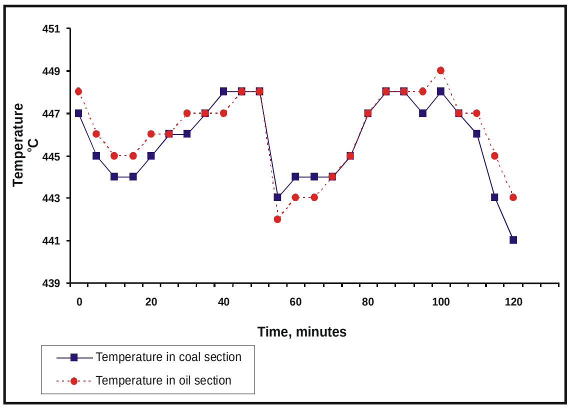

Figure 4. Temperature fluctuation during galvanizing process

Relative Energy Efficiency

Total consumption of fuel in oil heated section and coal heated section for a week (7 x 24 hours) is as follows :

- fuel oil = 10,080 l;
- coal = 20,300 kg

The energy contents of both are :

- fuel oil energy = 10,080 litres x 9,063 kcal/l;
  = 91,355,040 kcal
- coal energy = 20,300 kg x 5,500 kcal/kg
  = 111,650,000 kcal

Therefore, using coal yield more energies than using fuel oil or the energy efficiency of coal used in this system is 18.2% lower than that of fuel oil.

Ash Accumulation

After 40-hour operation, the system consumes 4.600 kg coal. Total ash accumulation is about 80% in the cyclone burner and 20% in the cyclone dust separator. Only is a very small amount of ash trapped in the stainless wire mesh. It means that the cyclone burner constructed vertically has also a function as a dust separator that removs bigger part of the ash. The cyclone dust separator collects smaller part of ash and only a minimum amount of ash is trapped by the wire mesh.

3.5 Discussion

Temperature fluctuation of the bath during galvanization process, shows that the temperature in the bath of coal heated section is nearly coincides with the temperature in the bath of oil heated section. Especially, temperature after the galvanized object is withdrawn and bath temperatures increases. It reflectsg the role of both fuels. This fact indicates that coal may match fuel oil in this system at the combustion rate of 124 kg/hour for coal and 60 l/hour for fuel oil.

The relative energy efficiency of coal is 18.2% lower than that of the energy efficiency of fuel oil. It can be understood since the fuel oil is burnt directly within heating chamber. On the contrary, coal has to be burnt far away from the heating chamber. The coal flue gas must be cleaned in the cyclone dust collector before entering heating chamber. Therefore, more energy lost occurs by coal flue gas due to its longer journey to the heating chamber.

However, coal is still attractive since its cost is lower than fuel oil cost. The cost of coal, ground into -30 mesh, is Rp 137,-/1000 kcal while the fuel oil is Rp 585,-/1000 kcal. Therefore, the energy cost of coal is less than 35% compared to the cost of fuel oil in this system. Construction of another coal cyclone burner and cyclone dust separator is underway to alter the oil burner in another section.

4. CONCLUSIONS

1. Coal combustion in a cyclone burner is a reliable mean to combust the coal in order to replace fuel oil burner in the heating process of a zinc bath kettle. It is by considered that :

   – high intensity combustion in a wide range stable combustion rate is attained by this technique;
   – the combustion rate can be adjusted easily to overcome a drastic temperature fluctuation in the zinc bath.

2. The energy efficiency of coal used is relatively lower than that of the fuel oil since coal is burnt in a cyclone furnace far away from the heating chamber. The coal flue gas has to pass a longer journey to the heating chamber through a cyclone dust separator. This results in high energy lost. On the contrary, fuel oil can be burnt directly in the heating chamber.

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