Slagging of Coal Blends: Comparison Between Pre-Blended and in Furnace Blend

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Abstract. Coal blending technique in electric generating power plant has been widely used to reduce coal consumption cost. However, due to various coals from different places blended together, it had caused problems. Slagging formed during the operations can reduced boiler efficiency, resulting high costs for maintenance caused by blockage, corrosion and erosion. Many empirical indices and predictive method have been developed to minimize these problems but most are unreliable for coals from different places and many predictive methods are carried out in different environment. In this research, the method starts from fabricating the pre-blended and in furnace blend techniques at a local coal pulverized power plant. After feeding the coal blends for coal trial burn, the resulting ash deposition are collected at the burner where slagging usually occurs. The raw coals in used and the slagging samples are then characterized and determine their crystalline phase and compositions by using X-Ray Diffraction (XRD) and Scanning Electron Microscope Energy Dispersive Xray (SEM/EDX). From XRD analysis, compounds such as quartz, cristobalite low and manganosite were found as main species in ash deposition at all location of collected slagging. However, there are also some compound exist at specific location with specific technique being used. In the burner area for pre blended technique, compound Al2SiO5, Mg2AlSi4, KNO2 and FeO was found, whereas in furnace blend K2Mn2(SO4)3 was found. At bottom part of the furnace, pre-blended graphite was presence and in furnace yield MnO2 and Al2SiO5. At top part where superheater reside, the existence of mullite, Al2(Al2.5Si1.5)9.75 was found for pre-blended technique and microcline, KAlSiO3O8 is observed from in furnace blend technique. From the EDX analysis, in furnace technique shows more complete combustion and feasible for less slagging inside the furnace compared to pre-blended technique.

1. Introduction
Global carbon dioxide emission in the atmosphere is not just escalating nowadays, it's accelerating, and another potent greenhouse gases, like methane, flourinated gases and nitrous oxide showed a huge spike over the years. The vast increment going utterly in the erroneous direction, with no sign that the planet has the problem under control.

The increasing emissions of CO2 was mainly contributed by electricity and heat production. As the demand of electricity generation increased with the increased in world population, the burning of coal, natural gas and oil is very much in need to satisfy the demand [1-2]. Coal-fired power plant shows the most CO2 emission per electric generating capacity and it is believed that there is no other sources that
will outpace the coal, to generate electricity until the year 2035 [3]. In order to reduce the CO$_2$ emission, an effective measure needs to be taken. One of the way is by increasing the efficiency of electricity generation. Based on the Carnot’s theorem, thermodynamically the efficiency of the electrical generation can be increased by bringing up the operating temperature of the boiler inside the power plant. Researchers are determined and aiming for higher temperature to attain higher efficiency. The efficiency can be risen up to 47% if the working temperature of the boiler is maintain at 1033 K. Although the solution has been found, there are still some concern that need to be taken care of before it can be implemented. The ferritic alloy used as the boiler tube are very susceptible to accelerated oxidation at high temperature in water vapour environment. The augmented in the rate of oxidation is due to the presence of water vapour. This phenomenon has been one of the limiting factors to upturn the efficiency of a coal fired power plant and in fact, the long term effect will cause more harm in terms of structural integrity and requires regular maintenance.

It was reported that the oxide scale formed when exposed to high temperature of about 870-970 K in dry environment is a thin compact layer. It is very useful to protect the alloy from oxidation. However, when the alloy is exposed to wet and high temperature environment, the oxide scale formed different with the oxide scale formed in dry environment. The oxide scales are thick and multilayered with high porosity and voids in each layer [4]. This thick, pore-rich oxide scale will only increase the susceptibility towards oxidation at high temperature. F. F. Alia et. al. has shows that chromizing boiler tube is a good alternative to slow down the oxidation in wet condition [10].

The differences in the development of oxide scale and mass gain of the ferritic alloy in dry (absence of water vapour) or wet (presence of water vapour) environments are extensively studied. The phenomena are evidence for the amplified in the oxidation rate of these alloys in such environments. However, the mechanism of the occurrence is still unidentified. It is vital to comprehend the failure of the 9 to 12% of main alloying element Cr to form protective oxide scale in water vapour containing environment despite this type of alloy are specially designed for a long term service environment. Mohd Hanafi B. A. et. al. has discovered that the water vapor might allow hydrogen to dissolve in the ferritic alloy thus enhancing the oxygen permeability and hindering the development of protective external scale by means reducing the lifetime of the boiler tube [5].

This paper aims to study the effect of dissolved hydrogen towards the Schottky Barrier of the Fe/Cr$_2$O$_3$ heterojunction to further understand the oxygen transport during oxidation process. It will explain the mechanism of accelerated oxidation of ferritic alloy in wet condition by the formation of space charge layer at the interface of metal/metal oxide heterojunction.

2. Methodology

2.1 Materials

Materials used in this study were two type of coals, imported from Indonesia and used in Tanjung Bin Power Plant namely as PCO coal (bituminous ) and MPP coal (subbituminous) respectively and will also be called as coal A and B throughout this article. method.

2.2 Sample Preparation

Both two sets of coals were blended in ratio 60:40, which set one was used pre-blended technique, a technique which both types of coal were blended using some machining process before going into the furnace feed. The second set used the in-furnace blend technique, which mean a technique was applied by simultaneously injecting both coals through the feed into the pre-heated furnace.

The method of preparing the pre-blended coal of sample A and B starts at respective coals yard in stacking and reclaiming process. In this process, coals are dug out from the coal yard and then was put on top of a moving conveyor belt. Coals from both samples’ coal yard simultaneously moving on top of the conveyor belt but at a different speed, where sample A conveyor belt moving at 60% of speed and the sample B conveyor belt moving at 40% of speed. Both the coal will then mix up at the ‘junction town’ and continue to move into 5 different coal bunkers. In each coal bunker, the ratio of coal A and B
will be 60:40 due to the different speed of the stacking and reclaiming process. Later, each blended coal from the bunker will go through coal mill where blended coal will be crushed from the size of less than 50mm to below 75μm. Then, coals from 5 bunkers are fed through the burners into the furnace. 

Same as pre blended technique, sample for in-furnace blend has same movement structure of coal from the coal yard to the furnace. However, to get the 60:40 ratio in the furnace, slight change has been made to the operation. The sample A and B coal from the coal yard go from the coal yard through conveyor belt – junction town – coal bunker by one type of coal at a time. This mean, five of coal bunkers will be filled with one type of coal whereby sample A coal filled three out of the five bunkers and sample B coal filled out the rest. After proceed to coal mill to reduce the size, the coals from each bunker are fed simultaneously into the furnace through the burners.

After coal trial burn process completed, the power plant was stopped to allow collection of slagging samples. Samples were collected at several locations such as near the burners, at the bottom ash, near the superheater and after exiting the furnace (fly ash). Samples name are given according to the place it was taken. For example, A1 is the slagging taken at the A burner and BA6 is the slagging taken between burner B and A. The number 1 until 6 indicate the location of the slagging, where 1 is closer and 6 is farther to and from the burner. For XRD and SEM- EDX analysis, sample were prepared in powder form where all the samples were ground to 10-50μm.

2.3 Coal Blends Analysis

One the aim in this study is to find technique that produced the best ash properties so that prediction of slagging occurrence and cleaning can be done efficiently. Therefore it is crucial to find the compound and composition existing in the slagging samples. In order to find that, XRD was used to identify the phase of crystalline material in each individual coal of sample A coal, sample B coal and the slagging samples. While EDX was used to quantify its existing element or composition within all the samples at the define locations. The result of both characterization process will assist in determine the best technique to be implemented in the power plant industries which yield less ash deposition and slagging that are more and easily to be removed.

The XRD used in this study is Rigaku Ultima IV, with voltage and current set at 40kV, 40mA. While scan speed is set to be at 10°/min. This characterization process was done on the sample A and B coal before coal trial burn and collected slagging after coal trial burn process.

The composition of each elements inside each samples of coal A, coal B and slagging for both techniques were done using SEM/EDX. The test was conducted by taking six different spots for each sample. All results will be tabulated in follow section by averaging the six spots considered.

3. Results and Discussion

3.1 Characterization of raw coals

XRD test is applied to raw coals of sample A and B coal to determine their phase identification and crystal structure. Figure 1 shows the XRD pattern of coal A and Coal B before coal trial burn, where coal A shows several peaks which indicate crystalline structure within the coal. While, coal B does not have definite peak which shows that the structure of the coal is amorphous, and it contains lot of moisture. XRD pattern of coal A shows the presence of quartz alpha, kaolinite and cristobalite beta HP [6-8].
Figure 1. XRD patterns of PCO coal and MPP coal

Figure 2 are the SEM/EDX images of sample of coals used in this experiment. Table 1 shows the tabulated data of both samples. Coal A has higher carbon content of 60wt% as compared to coal B of 46.7%. This directly translated that coal A is bituminous and coal B is sub-bituminous coal (“What are the different types of coal?” 2019). Other elemental composition for both coals before coal trial burnt process are tabulated in table 1.

Figure 2. SEM images of coal A (a) and coal B (b), where both coal are taken from six different spots
Table 1: Average elemental composition of coal A and B

| Elements | Coal A (wt%) | Coal B (wt%) |
|----------|-------------|-------------|
| C        | 60          | 46.7        |
| N        | 0.8         | 1.3         |
| O        | 25.3        | 36.6        |
| Na       | 0.4         | 0.2         |
| Mg       | 0.1         | 1.4         |
| Al       | 0.2         | 4           |
| Si       | 0.4         | 6.2         |
| Mo       | 0.1         | 0           |
| S        | 3.2         | 0.1         |
| K        | 1.1         | 0.1         |
| Ca       | 3.6         | 2.5         |
| Mn       | 2.4         | 0.1         |
| Fe       | 2.4         | 0.9         |
| **TOTAL** | **100.00** | **100.00** |

3.2 XRD analysis of pre-blended and in furnace blend technique samples

A set of samples for pre blended technique (set 1) were consist of 12 samples taken from A1, A6, B1, BA4, BA6, C6, D6, E1, E6, Super Heater (SH), Fly Ash and Bottom Ash. Figure 3, the XRD patterns for samples of Set 1 from different location which are bottom, middle and top of the furnace. At bottom of furnace slagging that are accumulated on the burner will fall to the bottom of the furnace due to its weight. Such slagging often consists of graphite, C. The highest peak in the pattern shows the existence of cristobalite alpha high, SiO$_2$ which is a crystalline at diffraction angle of 2θ = 21.81º. At middle of furnace, slagging at all 9 locations has highest peak in the form of crystalline silica, which is quartz, SiO$_2$ at diffraction angle of 2θ = 26.60º except at C6, E1 and E6 [9-11]. Those three locations have indialite, cristobalite low, SiO$_2$ at the highest peak. Apart from that, E1 and E6 have the peak of dialuminium silicon oxide HP, Al$_2$SiO$_5$. At C6, exist peak of potassium nitrate, KNO at diffraction angle of 2θ = 35.94º. At B1 and D6 exist wustite, FeO and sillimanite high dialuminium silicate oxide Al$_2$(SiO$_7$)$_4$O respectively. As the part with the highest temperature of 1200-1400°C, slagging that exist at this site are usually ceramics that can withstand higher temperature than the designated temperature. At top of furnace, at the super heater, there are several crystalline that can be observed shown by the peaks which are cristobalite low, SiO$_2$ quartz, mullite, tridymite and dialuminium silicon oxide HP [12-14]. At the fly ash, only light material that pass along the flue gas will arrived at the collection part. The compound found in the fly ash are quartz and mullite which signified by the XRD peak of diffraction angle of 2θ = 26.70º and 2θ = 33.46º respectively. Only light material can reach the superheater carried by the flue gas and cooled down at the surface of the super heater in the form of fouling [15-17].
In comparison, an in-furnace blended technique samples consist of 8 samples were taken from A6, B1, BA6, C1, D6, E1, Super Heater (SH) and Bottom Ash. Figure 4 show the XRD patterns for all the samples of Set 2 at three different location which are the bottom, middle and top of the furnace. At bottom of the furnace, most slagging that appear at the bottom of the furnace are either when the slagging is accumulated and fell due to gravity or when the compound is heavy [18-20]. There are several peak patterns that shows that there are many types of crystalline structure at the bottom ash. There is quartz, cristobalite low, ramsdellite and sillimanite, and at the bottom ash. At top of the furnace, the point of focus is the slagging that occurred at super heater or also known as fouling. The three distinguished peaks exist in the XRD pattern are cristobalite low, quartz and microcline, $K\alpha SiO_2O_6$ at diffraction angle of $2\theta = 21.81^\circ$, $26.74^\circ$ and $35.86^\circ$ respectively. At the middle of furnace, all location has highest peak of quartz at diffraction angle $2\theta = 26.73^\circ$ except for A6 and D6 where it has highest peak at diffraction angle $2\theta = 21.80^\circ$ which yield cristobalite low, SiO$_2$. A6 also yield the peak pattern of dipotassium dimanganese sulfate at diffraction angle of $2\theta = 27.98^\circ$. All XRD pattern also show the existence of manganosite and sillimanite high dialuminium silicate oxide. However, E1 pattern shows high noise and only several distinguished peak at diffraction angle $2\theta = 50.34^\circ$ which give the indication of tridymite, SiO$_2$ [21].

Figure 3. XRD pattern from samples Set 1(pre-blend) at (a) top (b) bottom and bottom (c) of the furnace
Figure 4. XRD pattern from samples Set 2 (in furnace - blend) at (a) top (b) bottom and bottom (c) of the furnace

In summary, bottom ash for both techniques yield quartz low, $\text{SiO}_2$. As for the middle of the furnace, both techniques give quartz, cristobalite low, manganosite & sillimanite, high dialuminium silicate oxide, $\text{Al}_2(\text{SiO}_3)O$. Finally, for the top of the furnace, both techniques give XRD peak of quartz & cristobalite low. Table 2 below gives the detail comparison of compound that differ between two techniques use for coal trial burn. Four main compounds that become will be focused are indialite, mullite, dipotassium dimanganese sulfate and microcline.

Table 2: Comparison between different compound found of different coal blend technique used at specific location

| Technique & Location | Pre Blend | In-Furnace Blend |
|---------------------|-----------|------------------|
| Top                 | - Dialuminium Silicone Oxide sillimanite HP, $\text{Al}_2\text{SiO}_3$  
                      - Mullite, $\text{Al}_2(\text{Al}_2.5\text{Si}_1.5)_{0.75}$  
                      - Microline, KAl SiO$_3$O$_8$ | - Dipotassium dimanganese Sulfate, KMn$_2$(SO$_4$)$_3$ |
| Middle              | - Dialuminium Silicone Oxide sillimanite HP, $\text{Al}_2\text{SiO}_3$  
                      - Indialite, Mg$_2\text{Al}_5\text{Si}_5$  
                      - Potassium Nitrate, KNO$_2$  
                      - Wustite, FeO |  |
| Bottom              | - Graphite | - Ramsdellite, MnO$_2$  
                      - Dialuminium Silicone Oxide sillimanite HP, $\text{Al}_2\text{SiO}_3$ |  |
3.3 SEM/EDX analysis of pre-blended and in furnace blend technique samples

Table 3 until 5 show the results of EDX analysis of pre blended technique at the bottom, middle and top part of the furnace. The highest elemental composition at the bottom ash consist of oxygen and followed by silicon. There are also several other elements such as aluminium and ferum form oxides at the bottom ash. These oxides left as an incombustible residue known as ash. At the middle of furnace, the highest elemental composition is oxygen at 36.16wt% followed by silicon at 31.21wt%. This explain the high peak intensity of $SiO^2-$ in XRD pattern formed. Also, here, compare to bottom ash, it has cobalt, titanium and barium a small composition. This might be because the coal used is not pure and might have been mixed with some foreign elements at the coal yard [22-23]. At top of furnace, both super heater and fly ash show the average of oxygen composition at 39.44wt%, followed by silicon at 34.59wt% and aluminium at 11.37wt%. There are also several elements that constitutes less than 5% of composition such as ferum, cobalt and phosphorus. Low carbon content shows that most of it has been burnt during the coal trial burn process to provide enough heat energy for the power plant.

Table 3: Average elemental composition for bottom ash of SET 1(pre-blend)

| Element | Spot 1 (wt%) | Spot 2 (wt%) | Spot 3 (wt%) | Spot 4 (wt%) | Spot 5 (wt%) | Spot 6 (wt%) | Average (wt%) |
|---------|--------------|--------------|--------------|--------------|--------------|--------------|---------------|
| C       | 0.60         | 0.00         | 3.20         | 0.40         | 0.00         | 0.60         | 0.08          |
| N       | 0.00         | 0.00         | 0.00         | 0.10         | 0.10         | 0.30         | 0.08          |
| O       | 27.10        | 35.80        | 31.70        | 48.60        | 45.90        | 49.10        | 39.70         |
| Na      | 0.20         | 0.30         | 0.50         | 0.80         | 0.80         | 0.40         | 0.37          |
| Mg      | 0.60         | 0.60         | 0.50         | 0.80         | 1.50         | 0.90         | 0.82          |
| Al      | 10.40        | 24.20        | 11.90        | 13.50        | 12.00        | 11.40        | 13.90         |
| Si      | 33.30        | 31.60        | 35.90        | 30.60        | 28.30        | 32.20        | 31.98         |
| S       | 0.20         | 0.10         | 0.20         | 0.10         | 0.10         | 0.10         | 0.13          |
| K       | 2.00         | 0.60         | 1.20         | 0.90         | 2.10         | 0.90         | 1.15          |
| Ca      | 4.90         | 1.60         | 5.90         | 1.90         | 2.10         | 2.00         | 3.07          |
| Mn      | 3.50         | 0.00         | 0.20         | 0.00         | 0.00         | 0.00         | 0.62          |
| Fe      | 17.20        | 5.20         | 9.30         | 2.60         | 7.90         | 2.10         | 7.38          |
| TOTAL   | 100.00       | 100.00       | 100.00       | 100.00       | 100.00       | 100.00       | 100.00        |

Table 4: Average elemental composition for middle of furnace of SET 1(pre-blend)

| Element | Avg. Al (wt%) | Avg. Al6 (wt%) | Avg. Bi (wt%) | Avg. BA4 (wt%) | Avg. BA6 (wt%) | Avg. C6 (wt%) | Avg. D6 (wt%) | Avg. E1 (wt%) | Avg. E6 (wt%) | Avg.   |
|---------|---------------|----------------|--------------|----------------|---------------|--------------|--------------|---------------|---------------|---------|
| C       | 1.42          | 4.50           | 0.05         | 9.48           | 3.15          | 4.42         | 6.72         | 0.02          | 0.32          | 3.34    |
| N       | 0.03          | 0.20           | 0.03         | 0.10           | 0.27          | 0.13         | 0.15         | 0.18          | 0.12          | 0.13    |
| O       | 34.03         | 44.30          | 35.68        | 35.92          | 35.53         | 36.72        | 43.15        | 43.08         | 23.05        | 36.16   |
| Na      | 0.08          | 0.30           | 0.05         | 0.15           | 0.63          | 0.55         | 0.33         | 0.67          | 0.45          | 0.36    |
| Mg      | 0.35          | 0.50           | 0.13         | 0.20           | 0.55          | 0.92         | 0.30         | 0.87          | 0.97          | 0.51    |
| Al      | 13.03         | 10.20          | 4.18         | 7.80           | 10.47         | 7.68         | 10.73        | 11.40         | 8.86          | 9.93    |
| Si      | 32.72         | 34.90          | 44.50        | 29.73          | 21.12         | 30.00        | 33.02        | 29.60         | 25.27         | 31.21   |
| S       | 0.17          | 0.10           | 0.13         | 0.12           | 0.13          | 0.13         | 0.17         | 0.12          | 0.17          | 0.14    |
| K       | 0.97          | 0.80           | 1.23         | 1.63           | 0.90          | 1.20         | 0.88         | 1.18          | 1.72          | 1.16    |
| Ca      | 1.83          | 1.40           | 2.18         | 2.12           | 2.42          | 6.73         | 1.42         | 2.90          | 2.50          | 2.60    |
| Mn      | 4.02          | 0.40           | 3.10         | 6.07           | 7.38          | 2.88         | 0.67         | 2.78          | 9.47          | 4.08    |
| Fe      | 8.38          | 2.10           | 3.72         | 6.68           | 16.80         | 8.63         | 2.47         | 11.40         | 25.02         | 9.46    |
| Co      | 2.97          | 0.00           | 0.00         | 0.00           | 0.00          | 0.00         | 0.00         | 0.00          | 2.08          | 0.56    |
| Ti      | 0.00          | 0.00           | 0.00         | 0.00           | 0.00          | 0.00         | 0.00         | 0.00          | 0.00          | 0.06    |
| Ba      | 0.00          | 0.00           | 0.00         | 0.00           | 2.67          | 0.00         | 0.00         | 0.00          | 0.00          | 0.30    |
| TOTAL   | 100.00        | 100.00         | 100.00       | 100.00         | 100.00        | 100.00       | 100.00       | 100.00        | 100.00        | 100.00  |
Table 5: Average elemental composition for top of furnace for SET 1 (pre-blend)

| Elements | Avg. Super Heater (wt%) | Avg. Fly Ash (wt%) | Average |
|----------|-------------------------|--------------------|---------|
| C        | 0.00                    | 0.17               | 0.09    |
| N        | 0.05                    | 0.13               | 0.09    |
| O        | 41.25                   | 37.63              | 39.44   |
| Na       | 0.20                    | 0.33               | 0.27    |
| Mg       | 0.65                    | 0.42               | 0.54    |
| Al       | 13.15                   | 9.58               | 11.37   |
| Si       | 33.35                   | 35.82              | 34.59   |
| S        | 1.57                    | 0.15               | 0.86    |
| K        | 0.97                    | 1.62               | 1.30    |
| Ca       | 4.93                    | 1.88               | 3.41    |
| Mn       | 0.13                    | 3.38               | 1.76    |
| Fe       | 3.75                    | 5.30               | 4.53    |
| Co       | 0.00                    | 3.58               | 1.79    |
| TOTAL    | 100.00                  | 100.00             | 100.00  |

While, table 6 until 8 shows the elemental composition of ash deposition at three different locations namely as bottom, middle and top. At bottom of furnace, high percentage of carbon make up of overall 10.72wt% of total bottom ash that is in the form of graphite as observed in XRD analysis. The highest percentage of element at the bottom ash is oxygen with 28.48wt% followed by silicon at 27.80wt%. Aluminium and ferum which is relatively heavy also found on the bottom of the furnace with the at 11.88wt% and 11.57wt% respectively. At middle of furnace, oxygen has the highest composition of 38.53wt% followed by Si of 33.84wt%. There is small amount of titanium at burner E1 with composition of 0.82wt%. Aluminium also has major weight percentage of 11.26 at the burner area. Ferum has amount that exceed 5wt% and significant that form slagging in the burner area. At top of furnace, at the superheater part, the highest composition is oxygen at 40.47wt%. Then, silicon with 27.73wt% and aluminium at 10.97wt%. There is also existence of cobalt at spot 4 which give the average composition of 2.42wt% for that element. Ferum is also sighted with the percentage of 9.18wt%.

Table 6. Average elemental composition for bottom of furnace for SET 2 (in-furnace)

| Element | Spot 1 (wt%) | Spot 2 (wt%) | Spot 3 (wt%) | Spot 4 (wt%) | Spot 5 (wt%) | Spot 6 (wt%) | Avg.   |
|---------|--------------|--------------|--------------|--------------|--------------|--------------|--------|
| C       | 0.00         | 7.2          | 0.1          | 13.3         | 4.2          | 39.5        | 10.72  |
| N       | 0.00         | 0.00         | 0.4          | 0.00         | 0.00         | 0.00         | 0.07   |
| O       | 22.4         | 22.0         | 51.5         | 30.2         | 20.4         | 24.4        | 28.48  |
| Na      | 0.1          | 0.3          | 1.3          | 0.7          | 0.00         | 0.00         | 0.40   |
| Mg      | 0.3          | 0.2          | 1.2          | 0.7          | 0.3          | 0.00         | 0.45   |
| Al      | 17.2         | 6.7          | 11.5         | 11.0         | 17.4         | 7.5          | 11.88  |
| Si      | 42.9         | 27.7         | 28.5         | 19.9         | 25.5         | 22.3        | 27.80  |
| S       | 0.2          | 0.2          | 0.1          | 0.1          | 0.3          | 0.0          | 0.15   |
| K       | 1.5          | 1.0          | 0.5          | 2.0          | 2.6          | 0.6         | 1.37   |
| Ca      | 4.9          | 2.6          | 2.8          | 3.7          | 4.3          | 2.2         | 3.42   |
| Mn      | 0.6          | 3.9          | 0.0          | 7.3          | 10.2         | 0.2         | 3.70   |
| Fe      | 9.9          | 28.2         | 2.1          | 11.1         | 14.8         | 3.3         | 11.57  |
| TOTAL   | 100.00       | 100.00       | 100.00       | 100.00       | 100.00       | 100.00      | 100.00 |
In general, the coal composition of raw coal A and B is high before coal trial burn process. However, it decreases significantly due to combustion process. Supposedly, the oxygen content inside the slagging should also decrease to a low level because of combustion process but instead it remains high in weight percentage. This is due to the forming of several oxide layer that occur during the combustion process or better known as slagging [24-25]. Table 9 shows the comparison between pre-blended and in furnace blend technique at the boiler.
Table 9. Comparison between weight percentage of elements between pre-blended and in furnace blend

| Technique & Element | Pre Blend (wt%) | In- Furnace Blend (wt%) |
|---------------------|-----------------|------------------------|
| O                   | 36.16           | 38.53                  |
| Si                  | 31.21           | 33.83                  |
| Al                  | 9.93            | 11.26                  |
| Fe                  | 9.46            | 9.44                   |

4. Conclusions
The fabrication of pre-blended and in furnace blend has been conducted. Then, after coal trial burn the samples of ash deposits were characterized to find the compound exists and elemental composition in the samples using XRD analysis and SEM/EDX. Through XRD analysis, it is found that the main compound species are quartz, cristobalite low, manganosite and tridymite. This means that these compounds can be anywhere inside the furnace. The main concern for the cause of slagging are compound that are only present during specific technique of coal blend being used such as indialite ($Mg_2Al_5Si_5$), potassium nitrate ($KNO_2$) and dipotassium dimanganese sulfate ($K_2Mn_2(SO_4)_3$). Apart from that, the edx analysis show that the significant decrease in carbon content before and after the coal combustion process. This is expected as the carbon act as a fuel that give energy to the power plant system. However, the oxygen weight percentage also increase significantly which can be explained by the abundant of oxide compound being formed as a result of the combustion process. All in all, the objectives have been achieved which are to evaluate the effect of mineral compound on slagging and also to find the elemental composition and compound exist within slagging collected using XRD and SEM/EDX analysis.

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