Impact of alternate fuel application on the characteristics of clinker from cement

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Abstract: Globally, every company is trying to switch to recycled or alternate fuel to reduce their cost and optimize production. Internationally, most of the alternate fuel are being used by many different companies. But in cement industry, ash of the alternate fuel mix in the raw material and effect the clinker chemistry. Hence, without analyzing the change in chemistry and changing the parameters according to the requirement of the clinker for strength and other properties is not recommended. In this paper, company using coal as their main fuel has been treated with other alternate fuels like Rice husk and dried sludge. Also chemistry of both of alternate fuel has been analyzed. Similarly, effect of using rice husk and dried sludge has been analyzed on clinker when ash of these alternate fuel added in the raw meal. Experimentally, after using rice husk, clinker LSF decreased because of decrease in C_3S. Similarly, increase in silica module is witnessed because of increase in C_2S. Increase in C_2S is because of increase in percentage of ash as compare to coal as well as SiO_2 rich rice husk ash. When dried sludge was used, the results was almost similar and percentage of clinker composition was almost same with slight change in Alumina module.

Keywords: *Clinker, Rice Husk Ash, Alternate fuel, Coal, Dried Sludge, Ash*

1 Introduction

Clinker is main part of cement industry, related every chemistry is very important to analyze for clinker production. Whole world is trying to reduce cost or experimenting different methods to optimize production or production with less cost. Rice husk and dried sludge are one of the most impactful alternate fuel that can be used along with other fuels to reduce cost of fuel. But in cement industry, the chemistry of cement is disturbed with small changes in raw meal or fuel. In this paper, characterization of raw and alternate fuels will be done along with qualitative analysis of clinker by using raw coal and raw coal with alternate fuel.

2 Importance of fuel ash in clinker composition.

After raw meal enter into calciner, calcination process start, for that fuel is required to reach temperature at 900C. The remaining ash gets mixed with raw meal and enter into kiln. Furthermore, for complete burning of raw meal into clinker, again fuel is needed to reach up to 1400C and that fuel again mix with clinker. Fuel is used in good quantity and as per its ash content it can change chemistry of clinker. Ash is rich in SiO_2 which can increase Silica Module and reduce lime saturation factor. To control that LSF is increased in raw meal and SM is fixed.

3 Alternate fuels

Most natural and waste materials are dumbed which have different levels of energy which upon burning can produce energy. These products are essential for cement industries for thermal energy requirement. Since years different cement industries are experimenting different alternate fuels in order to produce similar amount in less cost and with environmental friendly material. [1]

Normally, priorities of most of the industries are to choose AF which is cheap in prices and availability of AF is not a big issue in future. After these above concerns, calorific value, composition, ash content, volatile matters and moisture are the important parameters for selecting AF.

4 Criteria for selecting alternate fuel.

Although criteria for selecting is not a rule of thumb, but most of things are considered before replacing the main fuel. Alternate fuel are mostly considered different by products or waste products of crops or waste. Other than these it must stand on requirement of environmental protection agencies. Following are the few important parameters which are analyzed.[1]

- Physical state
- Content of Sodium, Potassium, Chloride and sulphur.
- Volatile matters
- Content of Ash and its composition
- Calorific Value
- Density and Size
- Moisture Content
- Emission released
- Impact on LSF and SM

5 Related Work

In this paper, rice husk was 20% replaced by total weight. The results which were analyzed was cement strength to bear compression, emission of CO_2 and other factors. The paper further suggested reduction in weight by RHA in overall concrete weight and reduction in settling time. Also

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it concluded with 15% usage of rice husk efficient and durable.[2]

Author worked on using rice husk as substitute against natural gas partially. The replacement caused reduction in LSF and C_3S and increase in C_2S and Silica Module. As rice husk ash is found highly concentrated with SiO_2 which is causing it to be termed as high belite OPC. Increasing SM can cause various problems which can be managed by providing Pyrite sand, rich in iron sulphide. [3]

On increasing pollution by cement industries, this research was done to reduce emission and make cement industry as per environmental protection units. To reduce pollution, author replaced 20% of the coal with rice husk. Rice husk ash increased compressive strength when used 10% but decreasing on augmenting rice husk percentage. Although CO_2 emission is decreasing.[4]

In this research, dried sludge obtained by drying sewage sludge can be utilized with coal or other main fuel. Author showing slight increase in belite content, reducing free lime content, although increase SO_3 content in cement.[5]

In this comparative analysis by author, sewage sludge is analyzed at lower temperatures to find its ignition temperature and calorific values. And found that although energy is lower than coal but have better combustion over coal. And more advantages.[6]

In this research, author has created a kiln environment in order to perform experimentally impact of using rice husk with coal. Author experimentally used raw mix with coal and rice husk and co fired it by producing 1500 centigrade. He observed that clinker produced has higher SM than when only used coal and lower LSF than before.[7]

Author in this paper has used dried sludge dried by using lime precipitation method. Author experimentally used dried sludge at different feeding points and came on result that the compressive strength and burning ability is similar when using 9% when mixed with raw meal and 6% when used at High temperature zones. Although he suggested that when using at RM, the emissions are lower than using at HTZ.[8]

It is comparative study of different research work done by others. In this work, author has worked on different properties of waste and municipal disposed waste. Also provided links with fuels, power and heat generation.[9]

This research work was analyzed to know different fuel ignition temperature of sewage sludge as well as calorific value. Also in this paper, advantages of sewage sludge over coal were observed.[10]

6 Research Methodology

The research is done by working on previously practiced production of clinker on coal. Initially, all data gathered from company over production through using South African coal. In case I, all system data is mentioned. Although in Case II, Rice husk is partially replacing coal and factors and weight replacing are mentioned. Similarly, in Case III, dried sludge is replaced partially coal, with its analysis done in case III.

4.1. Case I: System data on production using coal.

Table 1 Target points for clinker

Set Points	Set Points ratio
Lime Saturation Factor	0.99
Silica Module/Ratio	2.45
Alumina Module/Ratio	1.25

Table 2 Raw meal composition

Components	**Mixed Raw %**
LOI	34.03
SiO_2	13.05
AL_2O_3	2.96
Fe_2O_3	2.37
CaO	46.68
MgO	0.35
K_2O	0.32
Na_2O	0.10
SO_3	0.10

Table 3. Qualitative analysis of Coal

Component	Raw Coal Data	Coal Ash Data (pulverized coal)
ASH	19%	
LOI	2.03	0.72
SiO_2	49.06	42.34
Al_2O_3	21.36	13.40
Fe_2O_3	6.80	4.40
CaO	9.23	25.18
MgO	6.20	7.10
SO_3	4.66	6.28

Table 4. Calorific Value of Coal

Description	Calories/Gram
Gross Calorific Value	6200
Net Calorific Value	5750

4.2. Case II. Production using rice husk partially

Rice husk is replacing coal partially from 3% to 10%. The calorific value of Rice husk is 2500(NCV).

Table 5. Qualitative analysis of Rice Husk Ash

Components	RHA Composition, %
ASH	65%
LOI	0.78
SiO_2	78.76
AL_2O_3	3.00
Fe_2O3	1.60
CaO	10.56
MgO	2.20
K_2O	2.09
Na_2O	0.14
SO_3	2.57

Table 6. Rice husk weight replacement.

Rice Husk Percentage Replacing Coal	Coal Weight, ton/hr	Coal Factor, %	Rice Husk Weight Ton/hr	Rice husk factor, %
0%	10.34348	13.7913	0	0
3%	10.03317	13.37757	0.7137	0.9516
5%	9.826304	13.10174	1.1895	1.586
10%	9.30913	12.41217	2.379	3.172

4.3. Case III. Production using Dried Sludge partially.

Dried sludge is partially replacing coal from 3% to 10%. The calorific value of dried sludge is found as 3550. Qualitative and weight percentage analysis is as under.

Table 7. Dried sludge ash composition

Components	Dried Sludge Composition, %
ASH	19%
LOI	1.82
SiO_2	16.36
AL_2O_3	36.70
Fe_2O_3	2.80
CaO	8.97
MgO	6.30
SO_3	12.07

Table 8. Dried sludge weight percentage

Dried Sludge Percentage Replacing Coal	Coal Weight, ton/hr	Coal Factor, %	Dried Sludge Weight Ton/hr	Dried Sludge factor, %
0%	10.34348	13.7913	0	0
3%	10.03317	13.37757	0.502606	0.670141
5%	9.826304	13.10174	0.837676	1.116901
10%	9.30913	12.41217	1.675352	2.233803

7 Results and Discussion

4.4. Case I. Clinker production using coal.

Following are the clinker component produced after using only coal.

Table 9. Clinker components using coal

Clinker Component	Clinker Composition
3 $CaO.SiO_2$	64.45
2 $CaO.SiO_2$	14.75
3 $CaO.Al_2O_3$	6.84
4 $CaO.Al_2O_3.Fe_2O_3$	11.98

Table 10. Clinker Targeted set points.

Set Points	Set Points ratio
Lime Saturation Factor	0.95
Silica Module/Ratio	2.45
Alumina Module/Ratio	1.29

Table 11. Liquid index, burnability factor and coating

Set Points	Set Points ratio
Liquid Index	25.32
Coating tendency	29.64
Burnability Factor	3.43

4.5. Case II. Production using rice husk partially.

Above graph showing reduction in C_3S from 64.45 to 54.86. That showing reduction in early strength. Similarly

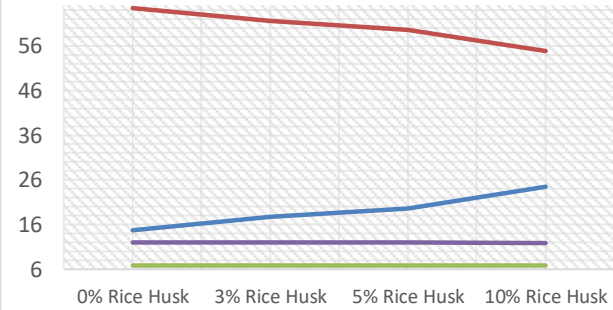

Figure 2 Comparison of Clinker component using rice husk

increase in C_2S which will directly effect on Silica Module. Small deflection in C_4AF and Stable C_3A.

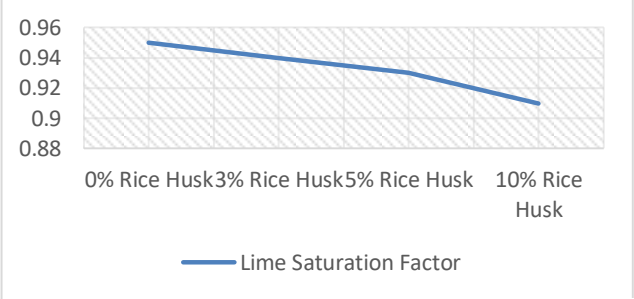

Figure 1 LSF change after using rice husk

Above graph showing reduction in Lime saturation Factor, because of reduction in C_3S. Lime saturation factor is reduced from 0.95 to 0.91 in fraction. Although LSF up to 0.90 is acceptable but it shows higher Silica content and lower strength material.

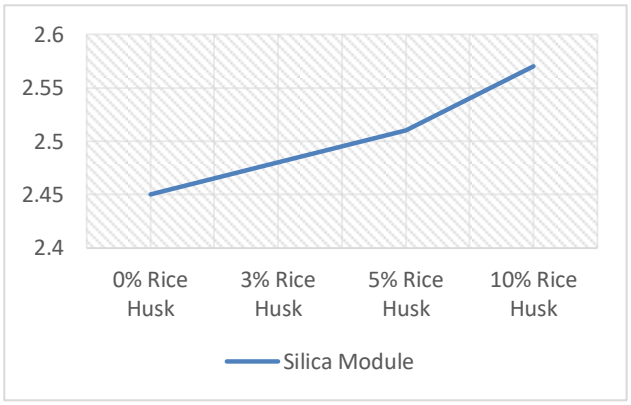

Figure 4 Change in SM after using rice husk

Above graph showing increase in Silica module from 2.45 to 2.57. SM above 2.5 can reduce liquid formation and make Kiln dusty although it can effect on kiln lining. Increase in SM will make burning hard simultaneously it will increase fuel.

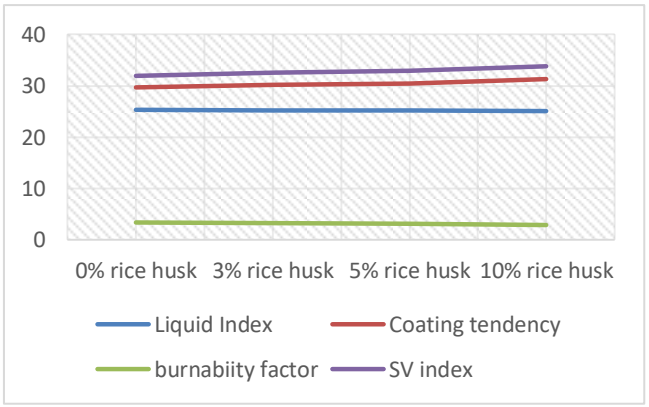

Figure 3 KILN parameters after using RH

Above graph is showing no or least change. Only SV index is showing small increase which showing coating can be better and grains will form. But the change is very slightly to see the difference.

Case III. Production by using Dried Sludge partially.

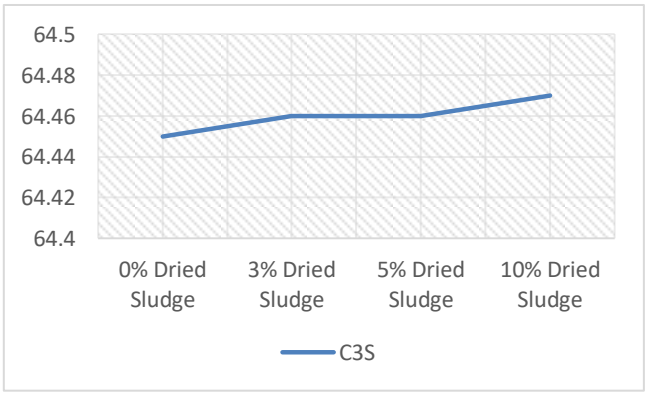

Figure 6 C3S after using Dried Sludge

Above graph showing slight increase in C_3S from 64.45 to 64.47 which is very small to put any effect. So C_3S is unchanged.

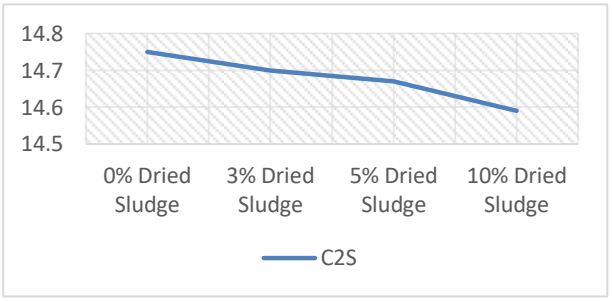

Figure 7 Change in C2S by adding Dried Sludge

Unlike C_2S in case II, C_2S is decreased from 14.75 to 14.59. Although change is very small, but reduction up to 12 is acceptable and good for clinker.

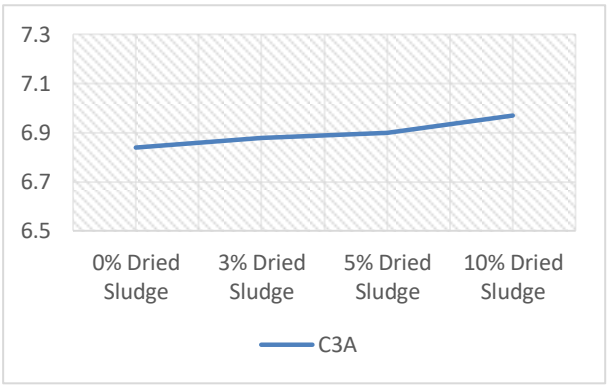

Figure 8 Change in C3A after adding Dried Sludge

C_3A is slightly increased. But change is not big to put any effect physically. Although increase in C_3A increases liquid phase and decreases burning ability of clinker.

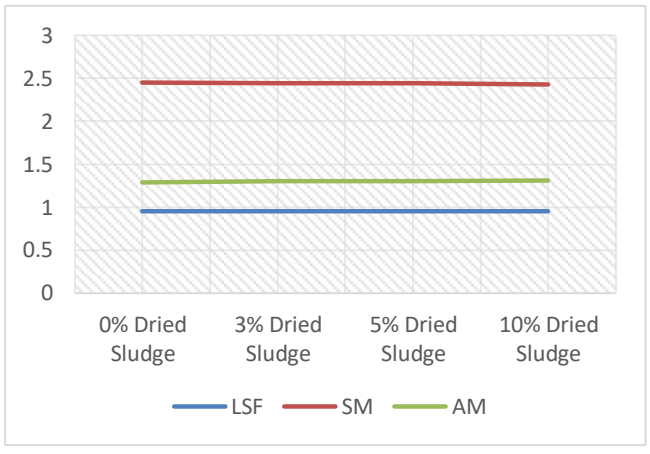

Figure 5 LSF, SM and AM comparison after adding Dried Sludge

Above graph showing very slight change in LSF, SM and AM which is not big to put any effect physically and acceptable.

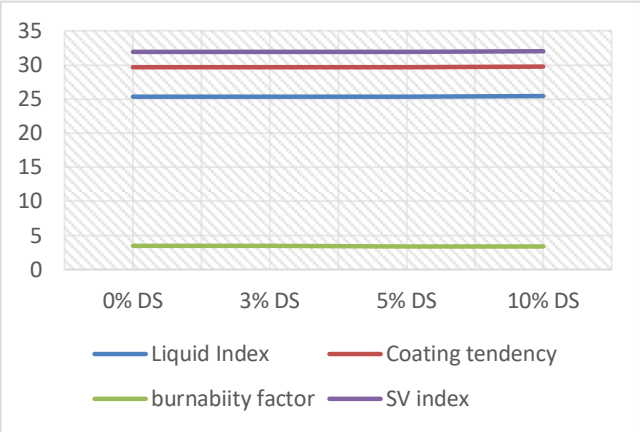

Figure 9 Kiln parameters after adding Dried Sludge

Similarly, in above graph no change is visible, which can be analyzed.

5. Conclusion

In this paper, data has been taken from cement industry in which rice husk and dried sludge are used partially replacing coal. It is found that by using rice husk replacing coal that LSF is decreased and SM is increased. Increasing SM is reducing burning ability of fuel as it is making burning hard because of reduction in liquid content. Hence kiln get dry and dusty. Similarly, higher SiO_2 can damage kiln lining. It is suitable to use rice husk between 3 to 4% as it makes LSF and SM at moderate level and will not cause any effect on compressive strength and also it will not disturb Kiln. If used more than that few changes can be done in raw meal like reducing SiO_2 rich shale and increasing Limestone to increase LSF. Similarly, rice husk of different area can be used where moderate SiO_2 can be found. When using dried sludge, it is found that there is not any impactful change in the composition of clinker. But as dried sludge is high in SO_3 which cause emissions. Although more dried sludge will result in reduction in C_2S which increased liquid content and burn ability of clinker but it will increase more free lime because of increase in LSF and also more LSF will cause more fuel for calcination. Also, dried sludge can be different from every pile as because of waste of different areas collected at one place.

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