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ORANGE PEEL AS ALTERNATE FUEL IN CLINKERIZATION

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ABSTRACT

The problems of agro-waste disposal and energy crisis in is increasing day-by-day. There is a pressing demand to find method for its disposal Orange peel has been used as alternate fuel in place of pet coke in the production of clinker. Various ratios of orange peel were mixed with pet coke and used as alternate fuel. It was observed that clinker produced was not affected adversely, rather sulfur contents were lower in these cases. This improves the quality of clinker and /or cement.

Key words: Alternate fuel, Agro-waste, Orange peel, Clinker.

INTRODUCTION

Our earth gave us many boons to improve our lifestyle and make it comfortable. Cement is also a wonderful boon for humanity, which nature has given to us. Any one can see from the height that the all flyovers, skyscrapers, buildings, bridges, dams all types of houses, hospitals, all factories, roads, trade centers, railways etc. which make the life easier and comfortable are having a common content i.e. cement. The most important use of cement is in the production of mortar and concrete, which is a strong bonding material used in building construction, consisting of a hard, chemically inert particulate substance, known as an aggregate and cement.

Wastes can be considered, as those materials, which are no longer required by an individual, institution or industry. They are thus by-products or end products of the production and consumption process, respectively. Solid wastes include all domestic refuse, non-hazardous wastes such as commercial and institutional wastes, street sweepings and construction debris, human wastes, ashes from incinerators, sludge, sewage and agricultural waste. If these wastes manifest hazardous characteristics, they should be treated as hazardous wastes. Degree of urbanization and industrialization, and intensity of agricultural activities make significant differences in treatment of waste and disposal problems faced by developed as well as developing countries. The main sources of wastes are municipal, industrial, agricultural, construction & demolition, animal, forestry, mining & quarry wastes etc.

Major challenges of using agricultural biomass residues include the relatively low calorific value, which can cause flame instability and availability since most of the agricultural residues are seasonal (not

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available round the year). The flame instability problems could be overcome with lower substitution rates and ability to adjust air flow and flame shape. Collection and storage of residues during the months of availability or alternatively, sourcing different residues at different times of the year could overcome the availability problem. Usually, a steady and abundant supply of biomass is there, especially which are by-products of agricultural activity. It can replace fossil fuels and also helps in reducing greenhouse gases emissions while closing the carbon cycle loop. Biomass can provide added income to farmers without compromising the production of main food and even non-food crops.

Among various agricultural wastes, rice husk is a major waste, which contains high ash silica. The ash contains above 90% silica having different important properties like high porosity, specific surface area and light weight. Rice hull ash has been applied as an amendment in many materials due to its high insulating property. It has various industrial applications, i.e. concrete and light weight building materials, refractory brick manufacturing, manufacture of insulation and flame retardants, etc.[1,2] Pitt[3] developed a fluidized bed furnace for the controlled combustion of rice husk. It was observed that highly pozzolanic rice husk ash is produced, when the temperature of burning and the residency time inside the furnace are controlled.

Saraswathy and Song[4] investigated the effect of partial replacement of cement with rice husk ash on the porosity and water absorption of concrete. Cement was replaced with 0, 5, 10, 15, 20, 25, and 30% RHA. Proportion of control (without RHA) mix was 1 : 1, 5 : 5 with w/w ratio of 0.53. It was concluded that porosity values decreased with the increase in RHA content due to small RHA particles improves the particle packing density of the blended cement, leading to a reduced volume of larger pores. Wada et al.[5] observed that RHA mortar and concrete exhibited higher compressive strength than the control mortar and concrete. Excellent strength development at the early stages even without steam curing for RHA mortar and concrete has also been reported.

Amin[6] has reported that the recycling of bagasse ash, which is a waste product of sugar industries. It is used as a cement replacement in concrete. It provides a good solution to environmental concerns, which is associated with waste management. Physical and mechanical properties of hardened concrete, including compressive strength, splitting tensile strength, chloride diffusion, and resistance to chloride ion penetration have also been investigated for use of bagasse ash content as a partial replacement of cement. Parande et al.[7] reported that the use of agricultural waste residue, apart from improving properties of concrete, main benefits were saving natural resources and energy, as well as protecting the environment by using these mineral admixtures (Agricultural waste). The mixing of these wastes depends on many factors, such as the type of admixture and the cement replacement level. For this purpose, rice husk ash, bagasse and by product from thermal waste and fly ash were used after thermally treated at a temperature of 65º C. The results showed that as the percentage of replacement level increases in the entire admixtures, water absorption was also increased. Yu et al.[8] also carried out some experiments on cement concrete with partial replacement by RHA, and proposed the sequence of reaction in strength development. Recently, Sharma et al.[9] reported the use of saw dust as an alternate fuel for the production of clinker.

It is therefore, planned to carry out some systematic investigations on the use of agro-waste orange peel as an alternate fuel along with pet coke in the manufacture of cement without affecting it's quality adversely. It will be mixed with pet coke in different proportions and used for clinkerisation and the produced clinker will be analysed for its quality parameters.

EXPERIMENTAL

Raw mixtures (Fuel + alternate fuel + kiln feed) were prepared and these were mixed with sufficient amount of water to make a homogenous hard paste. This small peanut like granules were made by hand and these granules were placed in oven upto 250 to 300º C to make them moisture free and completely dry.

The alternative fuel was mixed in desired proportions (according to GCV) to replace the pet coke before clinkerisation, so that the ash content produced by alternative fuel will also become a part of clinker and the advantage of heat produced by burning alternative fuel will also be taken in this process. Each sample of the clinker so produced was analysed to find out the optimum amount (ratio) of alternative fuel without affecting the quality of cement.

After getting these granules dried, these were subjected to calcination in an electrical furnace for 20 to 25 minutes, whose temperature rises from 900º C to 1450º C because it is a known fact that in a cement kiln, it takes about 20 to 25 minutes for the material to pass from one end to another (in the range of temperature 900º - 1450ºC). Then the clinker was taken out from the furnace in a steel tray, where it was rapidly cooled to retain C_3S content of the clinker.

Complete clinkerisation was checked by the colour of the clinker as it is known that if clinkerisation is complete, the colour will change to greenish black (colour remains brownish and dusty, if clinkerisation is incomplete). This is further confirmed by weighing the clinker and weight loss was observed during clinkerisation because of the emission of CO_2. Complete clinkerisation was also assured by checking its free CaO by ethylene glycol method, where the free lime content will be maximum (3 to 4%) (according to BIS) with complete clinkerisation.

This clinker was then powdered in a pulveriser and sieved in 90 μ sieve and the analysis was performed as per standard methods.

RESULTS AND DISCUSSION

On the basis of Gross Calorific Value (GCV) of pet coke (GCV = 8236), the amount of orange peel (GCV = 2500) was mixed. 2.981 g of orange peel was considered equivalent to 10% of pet coke (on the basis of GCV) and these values are presented in Table 1.

Table 1: Composition of clinker with 0 % orange peel (Pet coke = 100%, Orange peel = 0 %)

Kiln Feed = 150 g	Pet coke = 9.05 g		Orange peel = 0.0 g
Parameter	**XRF (%)**	**EDTA (%)**	**Average (%)**
SiO_2	21.57	21.62	21.60
Fe_2O_3	4.72	4.65	4.69
Al_2O_3	5.22	5.23	5.23
CaO	64.67	64.72	64.70
MgO	1.02	1.02	1.02
SO_3	1.56	1.57	1.57
K_2O	0.52	-	0.52
Na_2O	0.17	-	0.17
Cl	0.0133	-	0.0133

Cont…

Kiln Feed = 150 g	Pet coke = 9.05 g		Orange peel = 0.0 g
Parameter	**XRF (%)**	**EDTA (%)**	**Average (%)**
Free CaO			2.68
LSF			92.51
SM			2.18
AM			1.12
C_3S			57.40
C_2S			18.63
C_3A			5.92
C_4AF			14.26

Free lime was estimated by ethylene glycol method; LSF, SM and AM were calculated on the basis of the results obtained while C_3S, C_2S, C_3A and C_4AF were determined by Bogue equations

Similarly, it was calculated for higher percentage of orange peel. The results are presented in Tables 2-11.

Table 2: Composition of clinker with 10 % orange peel (Pet coke = 90%, Orange peel = 10 %)

Kiln Feed = 150 g	Petcoke = 8.145 g		Orange peel = 2.981 g
Parameter	**XRF (%)**	**EDTA (%)**	**Average (%)**
SiO_2	21.52	21.59	21.56
Fe_2O_3	4.63	4.77	4.70
Al_2O_3	5.19	5.28	5.24
CaO	64.64	64.79	64.72
MgO	1.02	1.04	1.03
SO_3	1.22	1.38	1.30
K_2O	0.52	-	0.52
Na_2O	0.17	-	0.17
Cl	0.0133	-	0.0133
Free CaO			2.83
LSF			92.66
SM			2.17
AM			1.11
C_3S			57.69
C_2S			18.29
C_3A			5.92
C_4AF			14.30

Table 3: Composition of clinker with 20 % orange peel (Pet coke = 80 %, Orange peel = 20%)

Kiln Feed = 150 g	Petcoke = 7.240 g		Orange peel = 5.963 g
Parameter	**XRF (%)**	**EDTA (%)**	**Average (%)**
SiO_2	21.59	21.62	21.61
Fe_2O_3	4.59	4.65	4.62
Al_2O_3	5.25	5.33	5.29
CaO	64.61	64.73	64.67
MgO	1.02	1.03	1.03
SO_3	1.05	1.12	1.09
K_2O	0.53	-	0.53
Na_2O	0.16	-	0.16
Cl	0.0132	-	0.0132
Free CaO			2.74
LSF			92.40
SM			2.18
AM			1.15
C_3S			56.87
C_2S			19.05
C_3A			6.20
C_4AF			14.06

Table 4: Composition of clinker with 30 % orange peel (Pet coke = 70 %, Orange peel = 30%)

Kiln Feed = 150 g	Petcoke = 6.335 g		Orange peel = 8.944 g
Parameter	**XRF (%)**	**EDTA (%)**	**Average (%)**
SiO_2	21.66	21.57	21.62
Fe_2O_3	4.55	4.61	4.58
Al_2O_3	5.19	5.24	5.22
CaO	64.61	64.65	64.63
MgO	1.04	1.03	1.04
SO_3	1.01	0.95	0.98
K_2O	0.52		0.52
Na_2O	0.18		0.18
Cl	0.0133		0.0133
Free CaO			2.88
LSF			92.45
SM			2.21
AM			1.14

Cont…

Kiln Feed = 150 g	**Petcoke = 6.335 g**		**Orange peel = 8.944 g**
Parameter	**XRF (%)**	**EDTA (%)**	**Average (%)**
C_3S			57.20
C_2S			18.83
C_3A			6.07
C_4AF			13.94

Table 5: Composition of clinker with 40 % orange peel (Pet coke = 60 %, Orange peel = 40%)

Kiln Feed = 150 g	**Petcoke = 5.430 g**		**Orange peel = 11.926 g**
Parameter	**XRF (%)**	**EDTA (%)**	**Average (%)**
SiO_2	21.59	21.68	21.64
Fe_2O_3	4.62	4.53	4.58
Al_2O_3	5.21	5.27	5.24
CaO	64.42	64.64	64.53
MgO	1.03	1.02	1.03
SO_3	0.75	0.82	0.79
K_2O	0.54		0.54
Na_2O	0.17		0.17
Cl	0.0134		0.0134
Free CaO			3.02
LSF			92.20
SM			2.20
AM			1.15
C_3S			56.48
C_2S			19.43
C_3A			6.15
C_4AF			13.92

Table 6: Composition of clinker with 50 % orange peel (Pet coke = 50 %, Orange peel = 50%)

Kiln Feed = 150 g	**Petcoke = 4.525 g**		**Orange peel = 14.907 g**
Parameter	**XRF (%)**	**EDTA (%)**	**Average (%)**
SiO_2	21.61	21.76	21.69
Fe_2O_3	4.51	4.59	4.55
Al_2O_3	5.22	5.29	5.26
CaO	64.51	64.49	64.50
MgO	1.04	1.03	1.04
SO_3	0.62	0.68	0.65
K_2O	0.54		0.54

Cont…

Kiln Feed = 150 g	Petcoke = 4.525 g		Orange peel = 14.907 g
Parameter	**XRF (%)**	**EDTA (%)**	**Average (%)**
Na_2O	0.17		0.17
Cl	0.0134		0.0134
Free CaO			2.68
LSF			91.97
SM			2.21
AM			1.15
C_3S			55.91
C_2S			20.00
C_3A			6.23
C_4AF			13.85

Table 7: Aomposition of clinker with 60 % orange peel (Pet coke = 40 %, Orange peel = 60%)

Kiln Feed = 150 g	Petcoke = 3.620 g		Orange peel = 17.889 g
Parameter	**XRF (%)**	**EDTA (%)**	**Average (%)**
SiO_2	21.68	21.75	21.72
Fe_2O_3	4.58	4.63	4.61
Al_2O_3	5.17	5.25	5.21
CaO	64.45	64.51	64.48
MgO	1.03	1.03	1.03
SO_3	0.51	0.54	0.53
K_2O	0.55		0.55
Na_2O	0.17		0.17
Cl	0.0134		0.0134
Free CaO			2.95
LSF			91.86
SM			2.21
AM			1.13
C_3S			55.82
C_2S			20.16
C_3A			6.02
C_4AF			14.01

Table 8: Composition of clinker with 70 % orange peel (Aet coke = 30 %, Orange peel = 70%)

Kiln Feed = 150 g	Petcoke = 2.715 g		Orange peel = 20.870 g
Parameter	**XRF (%)**	**EDTA (%)**	**Average (%)**
SiO_2	21.67	21.81	21.74
Fe_2O_3	4.58	4.52	4.55
Al_2O_3	5.15	5.23	5.19
CaO	64.41	64.48	64.45
MgO	1.03	1.02	1.03
SO_3	0.44	0.47	0.46
K_2O	0.52		0.52
Na_2O	0.18		0.18
Cl	0.0134		0.0134
Free CaO			3.12
LSF			91.79
SM			2.23
AM			1.14
C_3S			55.70
C_2S			20.32
C_3A			6.06
C_4AF			13.85

Table 9: Composition of clinker with 80 % orange peel (Pet coke = 20 %, Orange peel = 80%)

Kiln Feed = 150 g	Petcoke = 1.810 g		Orange peel = 23.851 g
Parameter	**XRF (%)**	**EDTA (%)**	**Average (%)**
SiO_2	21.64	21.69	21.67
Fe_2O_3	4.63	4.63	4.63
Al_2O_3	5.22	5.30	5.26
CaO	64.48	64.58	64.53
MgO	1.01	1.04	1.03
SO_3	0.32	0.36	0.34
K_2O	0.53		0.53
Na_2O	0.17		0.17
Cl	0.0134		0.0134
Free CaO			2.93
LSF			92.01
SM			2.19

Cont…

Kiln Feed = 150 g	Petcoke = 1.810 g		Orange peel = 23.851 g
Parameter	**XRF (%)**	**EDTA (%)**	**Average (%)**
AM			1.14
C_3S			56.04
C_2S			19.85
C_3A			6.11
C_4AF			14.09

Table 10: Composition of clinker with 90 % orange peel (Pet coke = 10 %, Orange peel = 90%)

Kiln Feed = 150 g	Petcoke = 0.905 g		Orange peel = 26.833 g
Parameter	**XRF (%)**	**EDTA (%)**	**Average (%)**
SiO_2	21.66	21.72	21.69
Fe_2O_3	4.57	4.68	4.63
Al_2O_3	5.21	5.26	5.24
CaO	64.42	64.68	64.55
MgO	1.04	1.01	1.03
SO_3	0.25	0.32	0.29
K_2O	0.52		0.52
Na_2O	0.17		0.17
Cl	0.0133		0.0133
Free CaO			3.18
LSF			91.99
SM			2.20
AM			1.13
C_3S			56.10
C_2S			19.87
C_3A			6.05
C_4AF			14.07

Table 11: Composition of clinker with 100 % orange peel (Pet coke = 0 %, Orange peel = 100%)

Kiln Feed = 150 g	Petcoke = 0.000 g		Orange peel = 29.814 g
Parameter	**XRF (%)**	**EDTA (%)**	**Average (%)**
SiO_2	21.54	21.89	21.72
Fe_2O_3	4.57	4.62	4.60
Al_2O_3	5.19	5.25	5.22
CaO	64.44	64.55	64.50
MgO	1.03	1.03	1.03

Cont…

Kiln Feed = 150 g	**Petcoke = 1.810 g**		**Orange peel = 23.851 g**
Parameter	**XRF (%)**	**EDTA (%)**	**Average (%)**
SO_3	0.18	0.22	0.20
K_2O	0.53		0.53
Na_2O	0.17		0.17
Cl	0.0133		0.0133
Free CaO			3.04
LSF			91.87
SM			2.21
AM			1.14
C_3S			55.83
C_2S			20.15
C_3A			6.06
C_4AF			13.98

It was observed that almost all parameters of clinker remained in permissible limits, only sulphuric anhydride content was reduced from 1.57% to as low as 0.20%. This reduction in sulphuric anhydride is due to lower percentage of sulphur in orange peel waste as compared to higher content in pet coke. This will improve the quality of clinker and other parameters are also not affected adversely. This will help in solving the problem of disposal of agro-waste like orange peel along with providing an energy supplement for pet coke and the geo-based conventional fuels. Agro-wastes are generated every year and it will go on increasing day by day and its use as alternate fuel will reduce the pollution load of environment.

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