Beneficiation of fine size lignite coal by Dry Sieve Technique (DST) deposits at Matasukh Mines of western Rajasthan, India.

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Abstract

The lignite coal is second maximum and limited reserve resource of energy after crude oil thus it is referred to as "reach of global coal reserve" so there is good need to modified lignite coal to give more efficient fueling system. The DST is a physical method to beneficiation of lignite coal by using fine size of coal particle. The lignite sample contained %FC 7.62, %AS 39.90, S 3.44%, Silica 50.02% and %VM 22.48 and marginally lowered CV 1748.84 kcal/kg. Lignite size range 98.81%, %RW 52.27 and FR 0.62 were detected in DST. The fine size lignite coal is beneficiated up to reduced %S 1.15 , ash decreases 3.73% and increase CV 2102.68 kcal/kg as value add product CV+353.84 kcal/kg .In order to overcome energy supply, the mining of lignite can be used for beneficiation by DST to energy supply and control pollution, along with other energy source.

Keyword: Fuel ratio, Coefficient of range, nesting of sieve.

1. Introduction

The beneficiation is any process that improves economic value of the lignite by removing the gangue minerals and impurities. Rajasthan is considered as museum of metallic and nonmetallic minerals, radioactive minerals, Lignite, Petroleum and Natural Gas. There are renewable energy source, these are self-recycled energy source and green and clean energy producer as Sun and Nonrenewable energy source. These are non-recycled energy source as lignite coal. This is perishable resource. The lignite coal is second maximum and limited reserve resource of energy after crude oil thus it is referred to as "reach of global coal reserve" so there is good need to modified lignite coal to give more efficient fueling system. The utilization of lignite was restricted due to high moisture content, low calorific value, low combustion efficiency. A total 10.10 million tons of lignite coal have been estimated of Matasukh mines lignite coal .Lignite coal is a sedimentary rock. The lignite coal is a fossil fuel as irregular distributions in different part of country and generally at west part of Rajasthan. The lignite coal of Matasukh mines of Rajasthan is of poor CV contains high impurities. To increase CV and remove impurities technologically is referred to beneficiation and modified lignite is referred to value add lignite. The lignite coal is also termed as hard coal [1] due to high excrete pollutant in environment however the lignite coal is used as fuel due to cheap and easily available near the industries to overcome the energy supply. The effect of so far reduction in particle size caused a decrease in the ignition temperature, however this particles size did not longer effect on the activation energy [2] of lignite coal particle under thermal burning power plant.

In lignite coal had a large quantity of inorganic impurity containing gray clay[3] at random distributes in carbonic matrix of mined lignite coal. The clay was of hydrophilic nature so it absorbed moisture from environment. This type of clay could be precipitated and removed[4] to beneficiation of lignite coal whereas hydrophobic nature of carbon repelled the moisture eventually the crack on sample surface take place by moisture absorbing. A physical structure exists as the cleats[5]. The formation was also responsible to break down of lignite coal in to small particle. By air the lignite coal broken down in to small size particle and by air and sacrificial cut raised up like fissures, cracks, veins, cleats [6] .The bright glows was shown by the presence of metal like calcium, aluminum, potassium and sodium which were present in lignite coal. The dark luminosity was by the presence of chalcophiles group of coal. In the bio fuel the type of mechanism

had been detected to break down in to small size particle. The sieve method is a mines engineering physical method to beneficiation of poor CV mines by using sieve to beneficiation. It is a selective breakage method based on mass, size and volume of coal particle. It is also known by the gradation of sample or gradation test or sieve analysis in the geology. Based on the size of sieve a scale is introduced to arrange of particle in decrease size is referred to relatively broad particle distribution spectrum. It is also referred to as particle size distribution. The sieves are referred to their mesh size, which is a number of wires per linear unit. There were sizes of coal in sample which showed maximum CV under thermal burning was referred to critical size.

The moisture loss is indirect proportional to the size of particle. Thus by reducing the size of lignite particle the CV increased due to water molecule lose in nesting of sieve by the moisture loss increased, due to break down of hydrogen bond. The oxygenated functional group of carbonic substances was free from impurity so the volatile nature of carbonic matter increased eventually CV increased at high temperature under dry sieving. The overall NOx and SO_2 emissions [7] have also been reported for unstaged and air-staged combustion conditions. The first step in controlling alkali gaseous phase concentrations in flue gas [8] understands their behavior during coal combustion. The behavior of sodium and potassium in coal during the initial stage of combustion was investigated. The solid bio fuel pellets combined with sieving analysis the method gave randomly distributed fissures; cracks could also be seen in the micrograph. These were made by the calcinations of dolomite and calcites as a result of thermal shock during metamorphism [9]. The breakdown of lignite coal was carried out consisting of two orthogonal sets cleats -face and butt[10] and the both cleats were the almost perpendicular to the bedding. The microspores in a coal increased with rank and vary from 19.3% in lignite to 75% in anthracites [11].There was fractional divided in DST by size of particle along with magnetization separation of pyrites [12]. In sieved matter had a large No. of metal oxide which can be indirectly reduced by CO to get metal by calcinations in thermal power plant. Thus the size was empirical significant factor of mined lignite coal and the optimum condition studied by dry sieving technique to beneficiation of lignite coal.

2. Experimental samples and DST

2.1 Sample collection and selection

The experiment samples were the main requirement to research work. We took lignite coal S-7 sample as solid stage from the Matasukh mine of Nagaur, Rajasthan, India. The lignite coal of Matasukh mines contains high impurity with high percentage of silica (50.02%) and sulpher (3.34%) which may cause of particulates and acid rain. The lignite coal was of having high impurity and poor CV for thermal plant using so it is used in local cements and other industries. Matasukh mines are my research spot and sample collection center. A fully Govt. owned company Rajasthan state mine and minerals limited (RSMML) has been monitoring the lignite coal excavation in Rajasthan and commenced its exploration in 1993 and The commercial production of Lignite coal from this mine was commended from nov.2003.The covering area is 2.5 sq kms. Lignite seams of 0.20 to 12 mts thickness was intersected under an overburden of 48.7 to 84.5 mts thickness. The lignite coal seems is near the crest of earth having depth 30-40 meter.

Experimental sample selection was elementary and initial step to beneficiation of lignite coal to use in lab .The S-7 samples were collected from Matasukh mines 10 kg weight in run mining process. The collected samples were dried in open air and by average weight sampling the 100 gm. of sample was used for analysis. The lignite coal of Matasukh mines contains high impurity of silica (50.02%).The S-7 No. sample was selected for beneficiation of lignite coal due to having marginal CV 1748.84kcal/kg at 35% moisture in research work.

Table 1
Basic sample S- 7 proximate analysis at 35% Moisture.

S. No.	Proximate analysis parameters	Value
01	%FC	7.62
02	%VM	22.4

03	%AS	34.9
04	%S	3.3
05	%Silica	50.02
06	%Iron	7.66
07	%Aluminium	32.37
08	%Calcium	2.80
09	CV kcal/kg	1748.8

VM=Volatile matter, AS=Ash, FC=Fix Carbon, C V=Calorific Value.

The metals were detected as metal oxide in ash. The heavy metals were also reported in this sample. The Silica, Iron, Magnesium, Aluminium and Calcium were detected in the fine size sample. The metal may be used in agriculture purpose for micro nutrition. The fine size of lignite coal was introduced in this DST due to easy operational mechanism. The lignite coal sample of Matasukh mines is of having soft nature. There is low % of transmittance in FTIR which shows the high impurities among carbonic substances and there is FTIR signals below 500 cm $^{-1}$ which shows the presence of in carbonic substances among the carbonic matter. The presence of FTIR signals between 4000 cm $^{-1}$ to 500 cm $^{-1}$ region shows the carbonic substances with oxygenated functional group. The presence of oxygenated carbonic matter is represented by Fig.1.

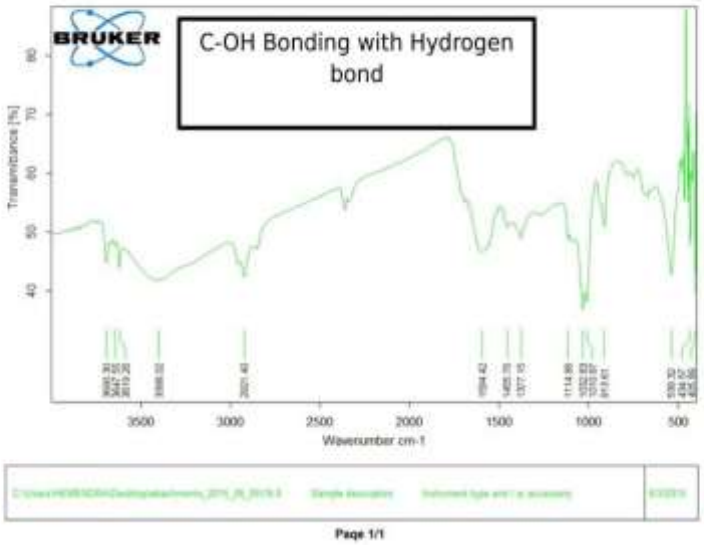

Fig.1 The presence of oxygenated matter by FTIR

2.2 DST

The sieves were main part of this technique to find out distribution spectrum. There were arranged sieve in the decreasing sieve size in this sieve technique which was referred to as nesting of sieve. The sieve was taken as size +50mm to -200mesh in present research. At first the row sample lumps was spreaded on the floor allow to dry under climatically circumstances to four days. Under this condition the lumps started to lose moisture having cracks on the surface of coal and start to crumble down it. As a result the bigger lumps

was broken down in to small size lumps which depended upon the rate of dehydration .After drying the sample manually was broken down of non-cracks lumps. Now large size was selected by manually and remaining was sieved in successive order of decrease size of particle by nesting of sieve. Thus all sample was divided in to 8 group based upon the size of particle contain large amount of each sample. Each sample having of large amount was reduced by the coning and quartering method [13] by this the sample was spreaded like disk on the ground and quartered by normal scale. By taking opposites quarter in next reduced step was carried out to reduce the sample whereas the remaining two opposite quartering were placed in stoke sample of group. Finally the suitable 100 gm. amount of each size group was collected for analysis. The large size sample could not be mass reduced in more than two step was mechanically broken down in to small size and again coning and quartering method was carried out to reduce sample. The using sieve which was taken in experiment to analysis of lignite coal was placed in successive order to decreasing size from top to bottom. At first the known weight of aggregate sample was placed in the tope sieve to separation and shaken by mechanically to take operate separation. The shaken time, sieve stack and sieve movement parameters effected the gradation test. After shaking the material through the nested sieve the retained weight of each sieve was weighted and 100 meshed for homogenous of each sample was used for analysis of lignite coal. Coal was the characterized by the heterogeneity of the surface and structure. The pores of different sizes and shapes affected in the coal structure of sample. Later on it was sieved by nesting of sieve to get different size and arranged in to decreasing size order as distribution spectrum +50mm to -200mesh. These were sequenced as below order 1. +50 mm, 2. 20 mm to 50mm, 3. 10mm to 20mm, 4. 4.75 mm to 10mm, 5. 1mm to 4.75mm, 6. 100 mesh to 1mm, 7. 200mesh to 100mesh, 8. -200 mesh. The Bomb calorimeter was used to determine CV of lignite. The oven, Furnace and electric balance were used to weight loss. The every size of sieve fraction was sieved by 100 mesh analyzed to determine the minimum size of lignite coal particle to give up optimum CV by DST. The graphical representation has been given in nesting of sieve in Fig.2.

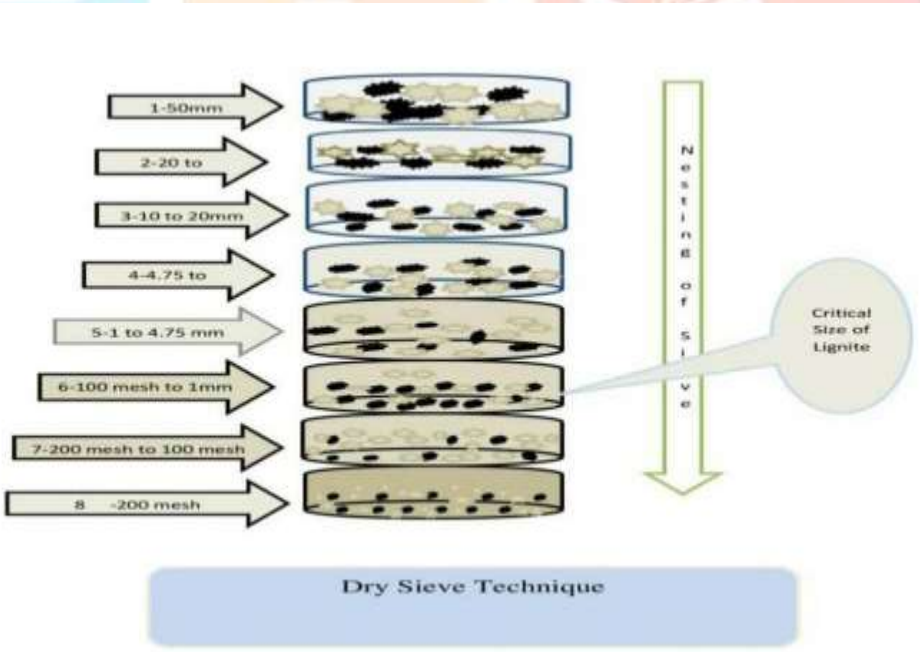

Fig.2 The representation of sieve nesting in DST

2.2.1. Retained Weight

At the end of the shaking period, the amount of material retained on each sieve is determined by weighing. The below parameters are measured in this experiment.

The% retained weight is calculated as below formula

$$\% \text{ RW} = \frac{\text{W1}}{\text{W}} * 100 \qquad (1)$$

Here RW=Retained weight in percentage, W_1=Retained weight in gm.
W_2=Passing through sieve gm., $W=W_1+W_2$ Total weight in gm.
The passing percentages can be calculated as
% PW=100-RW% (2)
%PW= Passing percentage of weight, %RW=Retained weight in percentage.

The large size sample could not be mass reduced in more than two step was mechanically broken down in to small size and again coning and quartering method was carried out to reduce sample. Later on it was sieved by nesting of sieve to get different size and arranged in to decreasing size order as distribution spectrum +50mm to -200mesh. The every size of sieve fraction was sieved by 100 mesh analyzed to determine the minimum size of lignite coal particle to give up optimum CV by DST. The sieve retained material represents plus sign whereas the negative sign represents passing weight.

Table 2

%RW of S-7 sample of lignite, Dry Sieve Size 50 mm to 200 mesh at 35% moisture.

S. No.	Size mm	Average size	%RW
1	+50mm	+50mm	53.30
2	20mm to 50mm	35mm	50.10
3	10 mm to 20mm	15mm	39.91
4	4.75 to 10mm	7.37mm	37.14
5	1 mm to 4.75mm	2.87mm	50.00
6	100mesh to 1mm	0.57mm	52.27
7	100 to 200mesh	0.223mm	68.09
8	-200mesh	0.298mm	100

2.2.2. Proximate analysis

The analysis of lignite coal which was carried out by measuring the physical parameter is referred to proximate analysis of lignite and used parameters are termed as the principle parameters. These parameters are of having fundamental properties of lignite coal. These are moisture, volatile matter, ash & fixed Carbon. In proximate analysis determine moisture, volatile matter, ash & fixed carbon as mass loss in percentage as in experiment. The high value the volatile matter and fix carbon are in favor of good quality and contains combustible part of lignite coal whereas the high value of moisture and ash are in favor of low quality lignite coal and contains noncombustible part of lignite. This analysis the physical parameters are used to beneficiation of lignite coal. The analysis of lignite coal which was carried out by measuring the physical parameter is referred to proximate analysis of lignite.

Table 3

Moisture 35%, Size 200 meshes to 50mm mesh.

Size Group	Size	%FC	%VM	%AS
1.	+50mm	9.26	16.66	39.08
2	20 to 50mm	9.59	17.61	37.80
3	10 to 20mm	10.88	16.04	38.08
4	4.75 to 10mm	10.44	17.43	37.13
5	1 to 4.75mm	12.97	19.38	32.65
6	100meshto1mm	12.99	20.75	31.26
7	200to100mesh	11.64	22.26	31.10
8	-200 mesh	2.59	23.35	33.66

2.2.3. The fuel ratio is detected as ratio of fixed carbon and volatile matter. The fuel ratio is recorded as

$$FR = \frac{\%FC}{\%VM} \quad (3)$$

The principal parameters descending order are as %AS>%VM >%FC of Matasukh mines lignite, therefore FR is less than unit which shows the low quality of Matasukh lignite. The FR indicates the easiness of ignition and burnout lignite in thermal power plant. The fast release of the volatiles matter provides a hotter thermal environment, without reducing. The fuel ratio is in favor of beneficiation lignite coal.

2.2.4. Sulpher

Sulphur is a hazards pollutant in lignite of Matasukh mines. Sulphur reacts with water drops in the clouds and converts into sulphuric acid and is cause of acid rain. The ultimate analysis is carried out for sulphur of lignite coal of Matasukh mines. This is measured by Eschka's process. A mixture of 2 part MgO and1 part Na_2CO_3 is Eschka's mixture due to this used mixture, this process is termed as Eschka's process .It is calculated as

$$\%S = \frac{\text{Wt.of BaSO4 ppt.in coal x}*32}{\text{Wt.of coal sample}100* 233} * 100 \quad (4)$$

Table 4

The %S for lignite Sample (07) of Matasukh mines,

Size range=50mm to 200 mesh in Dry Sieve Method.

S. No.	Wt.gm.	Size	C.V. kcal/kg.	%S
1	5330	+50 mm	1592.32	3.65
2	2340	20 to 50mm	1666.88	3.24
3	930	10 mm to 20mm	1694.16	3.69
4	520	4.75mm to 10mm	1727.58	3.50
5	440	1mm to 4.75mm	2032.54	3.75
6	230	100mesh to 1mm	2102.68	2.15
7	143	200 to 100 mesh	2067.48	3.71
8	67	-200 mesh	1379.88	4.36

2.2.5. Colorific Value

The calorific value is the total energy released as heat when a substance undergoes complete combustion with oxygen under standard conditions. It is known as the heating value or energy value also of usually for lignite coal fuel. The calorific value is conventionally measured with a bomb calorimeter. In present research the Goutal's formula is also used to calculate the C V by the principle parameters as:

$$C\ V = 82*\%FC + 50*VM \text{ kcal/kg.} \quad (4)$$

The C V of S-7 is given in Table 4 of size range +50mm to200 mesh in different sieve technique.

3.Results and Discussion

Naturally occurred lignite coal has a large amount of metal oxide ,Non metal oxide which are responsible to produce pollutants so it has challenge to use it by modified method. In this paper, the beneficiation of lignite coal of Matasukh mine of Nagaur, Rajasthan was studied by DST. In this technique the dry lignite coal was subjected to fine size 100 mesh sieves in up grading process.

4.1. The natural form of S-7 lignite is of pores, light in weight. At initially the proximate analysis of S-7 lignite sample was determined which were as %VM 22.48, %AS 34.99, %FC 7.62.The CV of S-7 lignite sample contained 1748.84 kcal/kg at 35% moisture. Due to marginal CV, this sample was selected for this research work.

The chemical composition of S-7 lignite sample is chemically determined. There are high percentage of silica in lignite of Matasukh which is noted 50.02% .The another metal have been determined as oxide in Matasukh lignite as Fe_2O_3 7.66%, CaO 2.80% and MgO 0.40%. The high percentage sulphure (3.34%) is also reported in the Matasukh lignite.These metal may be used in the soil improvement for agriculture area. The results have been given in Table1.

4.2.The high retention weight is measurement of successful of DST in lignite beneficiation. The high value of RW 52.27% is recorded in favor of this technique for the 0.57 mm average fine size of lignite coal particle. The minimum RW 37.14% is recorded for 7.37 mm size. The results are represented in Fig.3 and Table 2.

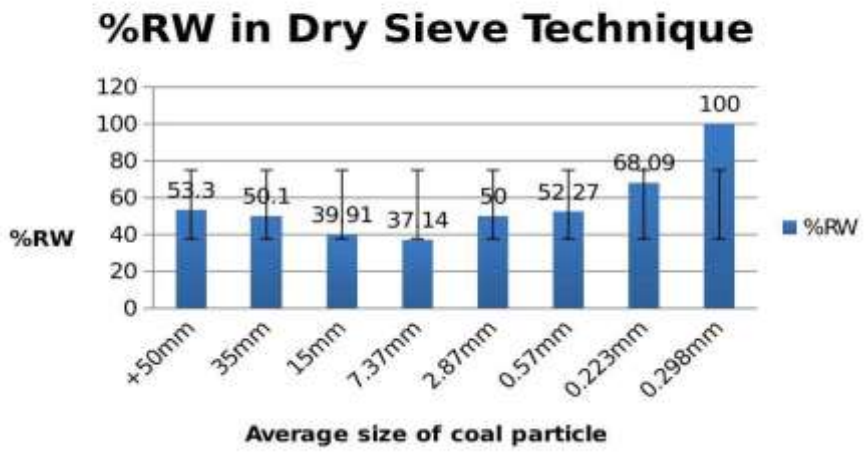

Fig. 3 Retention weight in DST.

4.3.The comparative study of S-7 sample was studied as percentage ash for 50 mm to 200 mesh fine size fraction.The100 mesh to 1 mm size lignite particle has ash 31.26%.The ash decreases 3.73% as value add product for this fine fraction and reduces as fly ash in thermal power station. The fixed carbon is in favor of beneficiation and this has recorded 12.99% for this fraction. This fraction increase 5.37 % of fixed carbon as value add product. The volatile matter increase 20.75% in this fraction..The principal parameters descending order are as %AS>%VM >%FC of Matasukh Mines lignite, therefore FR is less than unit which shows the low quality of Matasukh lignite. The FR of fuel indicates the easiness of ignition and burnout in thermal power plant. At high value of fuel ratio, the fast release of the volatiles matter provides a hotter thermal environment, without reducing the oxygen. The FR directly interlinked with CV of DST. The fuel ratio is in favor of beneficiation. In present FR 0.63 is recorded and the value added FR is recorded 0.29 for 100 meshes to 1mm fraction in DST. The FR value is Minimum: 0.119,Maximum: 0.678 Mean: 0.538875, Median: 0.5765, STDev: 0.167421950099.The results of fixed carbon have been recorded in Table 3 and represented in Fig.4 .

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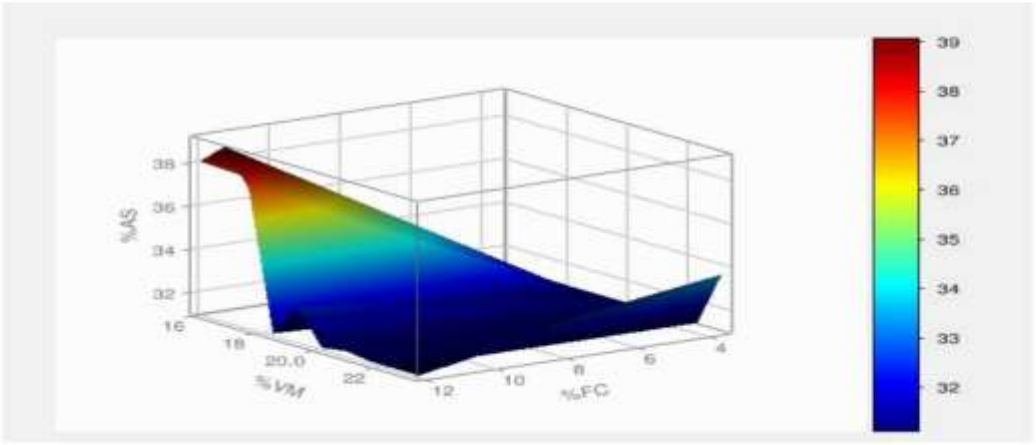

Fig. 4 Principal parameters change in DST.

4.4. The average sulphure is measured 3.3 % in lignite samples of Matasukh mines. In the present research, it is observed that 1.15% maximum decreasing of sulphur take place for 100 meshes to 1mm of size fraction. In general, the pure lignite sections tend to be softer then higher ash components and some of higher quality material is possible by crushing. The results have been represented in Fig. 5 and Table 4.

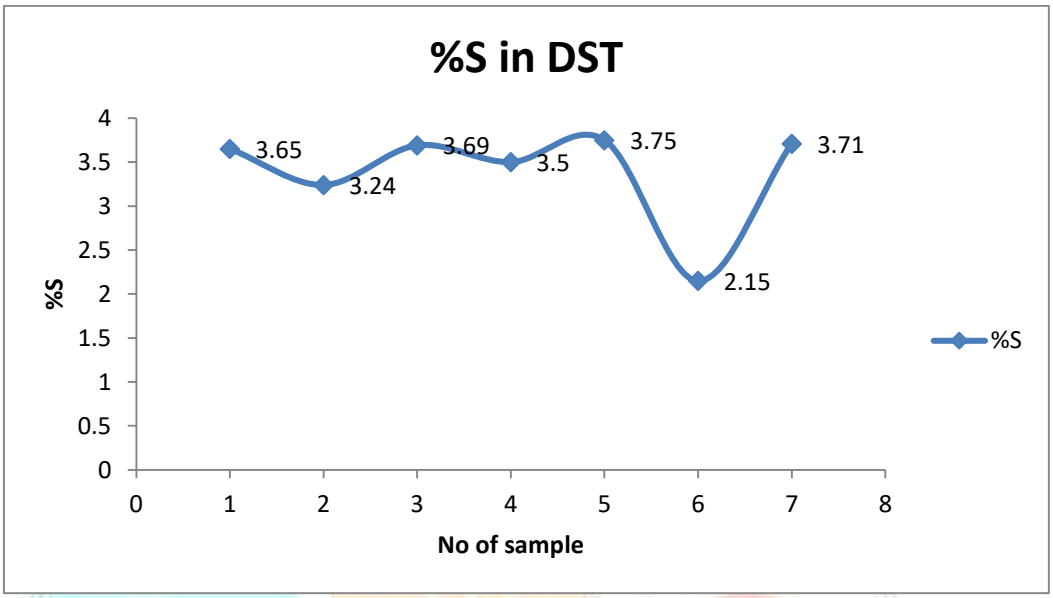

Fig. 5 %S in DST.

4.5. The relation between size and CV has been maintained in DST which shows that the CV and %FC increased with reducing of size. The size fraction 0.149 mm to 1mm contained CV 2102.68 kcal/kg and %FC 22.99. The standard deviation is recorded 289.63.The DST gives 353.84 kcal/kg as value add product. The DST CV is Minimum: 1379.88, Maximum: 2102.68, Median: 1710.87, STDev: 242.05 .The results has represented in Fig.6 and Table 4

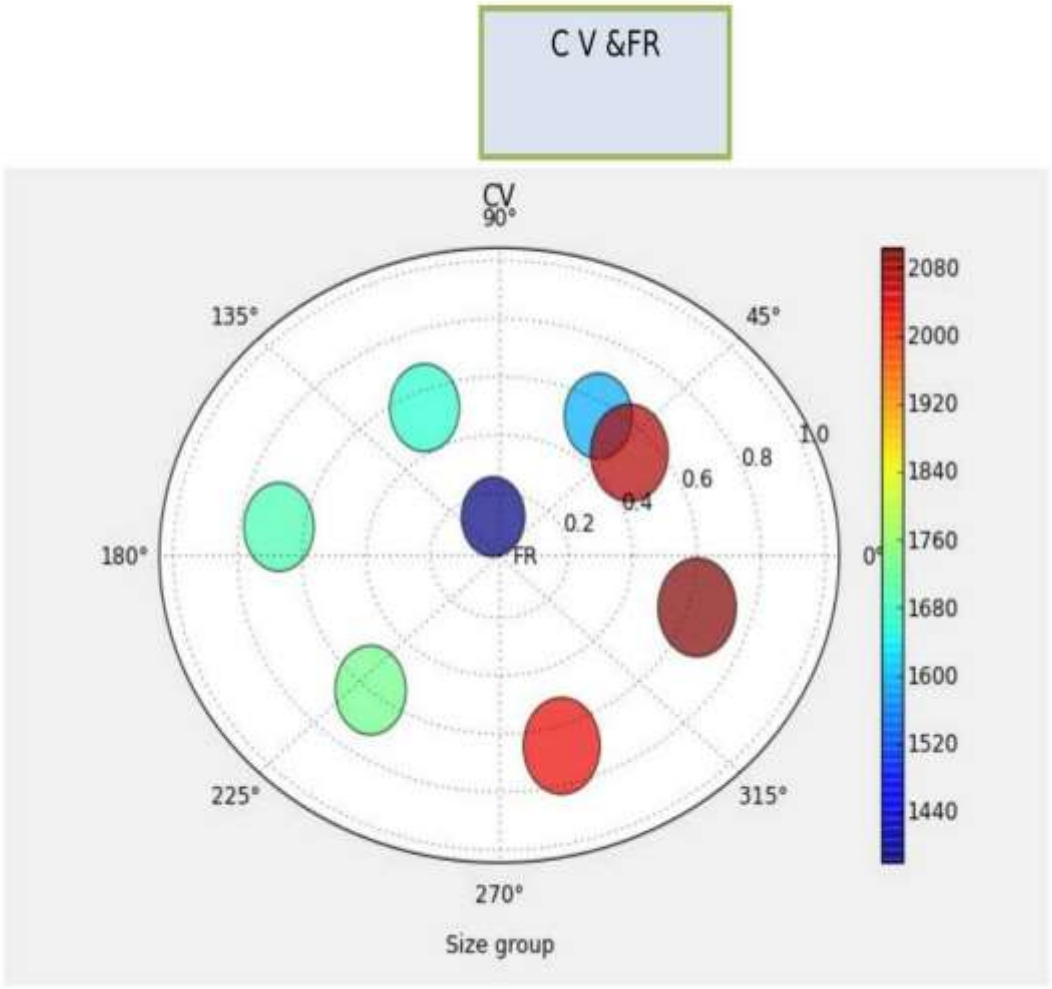

Fig.6 C V and FR in DST.

Conclusion

1.The lignite has %RW 52.27 recovery and FR 0.62 for 100 meshes to 1mm size by DST.
2. The 100 mesh to 1mm fraction CV has decreased %S 1.15 by DST.
3. The 100 mesh to 1mm fraction CV has increased 2102.68kcal/kg and the CV +353.84 kcal/kg gives as value add lignite. The results show that the size of fraction and C V are highly correlated in DST.

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