# EFFECT OF SIZE DISTRIBUTION AND WATER CONTENT ON PROPERTIES OF IRON ORE PELLETS

A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENT FOR THE DEGREE OF

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**in**
**Metallurgical and Materials Engineering**

**BY**


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# NATIONAL INSTITUTE OF TECHNOLOGY ROURKELA

## CERTIFICATE

This is to certify that the thesis entitled **"EFFECT OF FINE SIZE AND WATER CONTENT ON PROPERTIES OF IRON ORE PELLETS"** submitted by **Abhishek Naik** (109MM0450) and **Mahesh Goenka** (109MM0440) in partial fulfilment of the requirements for the award of **Bachelor of Technology** Degree in **Metallurgical and Materials Engineering** at **National Institute of Technology, Rourkela** is an original work carried out by them under my supervision and guidance.

The matter embodied in the thesis has not been submitted to any other University/ Institute for the award of any degree.

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# ABSTRACT

Iron ore fines are converted to iron by the following route:

Fines → Pellets → Reduction to metallic Fe

Therefore, the process of formation of pellets has to ensure that its product has required properties to perform as desired during the stage of reduction. This thesis, and the work done as recorded, aims at identifying the optimum values of properties of the chief raw materials of pelletization: iron ore fines and water (moisture) so that the prepared pellets exhibit maximum productivity.

The size distribution and water content of the pellets need to be studied and correlated to such pellet properties as strength, percentage reduction and swelling during reduction to obtain relationships between these factors. These results can be used for adopting the most suitable values of process parameters in industrial pelletization.



**Keywords:** Size distribution, Water Content, Green Strength, Swelling, Reduction Behaviour

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# INTRODUCTION

## 1.1 Introduction to Pelletizing

India is one of the leading producers of steel, currently ranked 4$^{th}$ in the world with a production of 76.7 mtpa. Annual production of steel In India is expected to reach close to 200 million tonnes mark by the year 2020 making India world's second largest steel producer. India has about 28.5 billion tonnes of Iron ore reserves. However, almost 60% of the ore that is mined is in the form of fines of low iron content. These iron ore fines cannot be directly used in the blast furnace as they pose the following threats:

1. Iron ore fines severely reduced the permeability of the bed, jeopardizing the reduction reaction in the blast furnace
2. The fines leave the blast furnace in combination with the flue (top) gas, bringing down the efficiency of the furnace.

With the projected steel production, requirement of iron ore is expected to be around 350 to 400 million tonnes per year. This makes it imperial for the steel industry in the country, and even worldwide, to utilize the iron ore fines.

Agglomeration processes are used for this purpose. The major agglomeration processes for iron ore fines are pelletisation and sintering. The two processes complement each other as they utilise fines of different size ranges. Other lesser-known agglomeration processes include stamping, briquetting, etc. However, these processes have more or less been outdated due to the low efficiency and lack of economic viability.

With the fast-growing pellet industry and increasing use of iron ore pellets in the charge for ironmaking, pelletisation of iron ore fines has turned out to be an important area of metallurgical studies. Pellets now form a substantial part of the charge in blast furnaces and may be as high as 30% in some cases. It has already been used in secondary ironmaking processes with 100% pellet charging. Countries like South Korea and Japan have successfully reported

100% pellet charge trials in blast furnaces, with full-scale adoption said to be very likely in the near future.

Another major significance of pellets lies in the ability to consume magnetite ores, which were otherwise problematic for ironmaking processes.

The following is a classification of iron ore size used in various forms for ironmaking:

- Lump ore: 10-40 mm (charged directly)
- Sintering: Below 10 mm and above 100 mesh (typically 6-8 mm)
- Pelletisation: Below 100 mesh
- The pelletizing process was developed to treat fine concentrates of various materials_ It is defined as the process of forming larger spherical bodies by rolling moist fine particles on a surface without application of external pressures. Pelletization of fine powders has grown enormously in importance as an industrial process and particularly so in the iron ore industry. Besides such inherent advantages as densification and prevention of dust losses, the pelletization of iron ore has been found to markedly increase the efficiency of the blast furnace operation. This is due to the spherical shape and close size range of pellets which give a charge evenly distributed across the blast furnace stack. This reduces channelling and produces good solid-gas contact improving heat and mass transfer which, in turn, reduces coke consumption in the blast furnace.

## 1.2 <u>Definition of Pelletization</u>

Pelletisation of iron ore fines involves formation of spherical – shaped agglomerates by binding their concentrates using moisture and, if required, binding agents, followed by firing at high temperatures to establish permanent bonding.

Since its inception, the process has evolved to include a variety of pellet types and depending on the desired end-properties, the raw materials may be: iron ore fines, limestone, dolomite, binders such as bentonite, other additives and coke/coal powder.

### 1.3 **Pelletisation: Advantages**

The iron ore pellets formed exhibit the following superior properties:

- Uniform size of 9 – 15 mm
- High and uniform porosity of 25-30%
- Low abrasion and good transportability
- High iron content of more than 65%
- Uniform composition: Haematite is easily reducible
- Volatile content is eliminated and no loss occurs on ignition
- Mechanical strength is high and is sufficient to withstand high thermal stresses and reducing conditions

### 1.4 **Challenges faced by Pelletisation**

Pelletisation as an agglomeration is at a disadvantage because of the following drawbacks:

- The production cost is high, owing to grinding, firing and use of oil burners for induration.
- Pellets undergo swelling and consequently lose strength during reduction in the blast furnace.
- During pellet formation, the balls tend to stick to each other, especially during firing.
- Compared to sinters, pellets exhibit higher resistance to gas flow because of lower voidage.
- Though fluxed pellets are more favoured, they are difficult to produce.

- During reduction, fluxed pellets fracture to a greater extent compared to acid and basic sinter as well as acid pellets.
- Better qualities, like strength, of highly fluxed sinters, containing magnesia, are now preferred to pellets.
- While ironmaking requires high basicity of slag, fluxed pellets provide a maximum basicity of 1.2 only.

### 1.5 Stages of Pelletizing

Pelletisation of iron ore involves the following four stages:

1. **Raw Material Preparation:** This step involves:

- Grinding of iron ore to required uniform size
- Concentration of iron ore and separation of unwanted gangue material
- Addition of binders, additives, etc. for preparation of agglomeration mixture

2. **Green Ball Formation:** In this step, the pellets are rolled by addition of moisture. The ball formation may be done in either of the two ‘pelletizers’, namely:

- Disc Pelletizer – This consists of a disc of diameter 3.5-5.5 metres, with an inclination of 45 degrees to the horizontal plane. Provision for water spray is made while the material to be pelletized is fed directly on to the disc.
- Drum Pelletizer – It is a steel drum open on both ends. Its length to diameter ratio varies in the range 2.5 to 3.5. The typical value of the diameter is 2-3m while the length is 6-9 m. The speed of rotation is in the range 10-15 rpm. It has a slight inclination, a maximum of 5degrees, to the horizontal.

The major forces acting on the green balls are the capillary forces and the surface tension due to the water content. The liquid-solid interface acts cohesively to bind the fines together.

3. **Induration of pellets:** In this stage, the green balls are subjected to a cycle of heating and cooling at various temperatures in order to carry out drying, pre-heating and firing. For induration, three types of equipments are available:

- Vertical Shaft Furnace
- Travelling Grate
- Grate Kiln

C.

- C. Higher temperatures are avoided as they drastically reduce the porosity of the pellets. This is detrimental for blast furnace operation. The holding time at such temperatures also affect the quality of the pellets and should be chosen based upon consideration of required properties and additives used.

# CHAPTER – 2

# LITERATURE REVIEW

## 2.1 <u>Mechanism Of Green Ball Formation</u>

The process of green ball formation has 2 steps:

1. Nucleation or seed formation
2. Growth

The formation of green balls is dependent on moisture content. Moisture content less than a critical value leads to its non-uniform distribution leaving behind some fines relatively dry. Moisture content more than the critical value leads to larger growth rate but, pellets can be easily deformed due to increased plasticity. Seed formation is favored only at critical moisture level. Seeds contain moisture content little more than the critical value as it leads to increase in plasticity and hence better growth by *Layering* or *Assimilation.*

When water is sprayed on the ore, the surface of the particles gets wetted and a water film is created on the surface of the ore particles. Due to surface tension of water, liquid bridges are formed when wet particles come in contact with each other.

The first agglomerates are formed due to the combined effort of the movement of particles inside pelletizer and the added water. Now the balls hence formed are loose. With the addition of more water the agglomerates become denser.

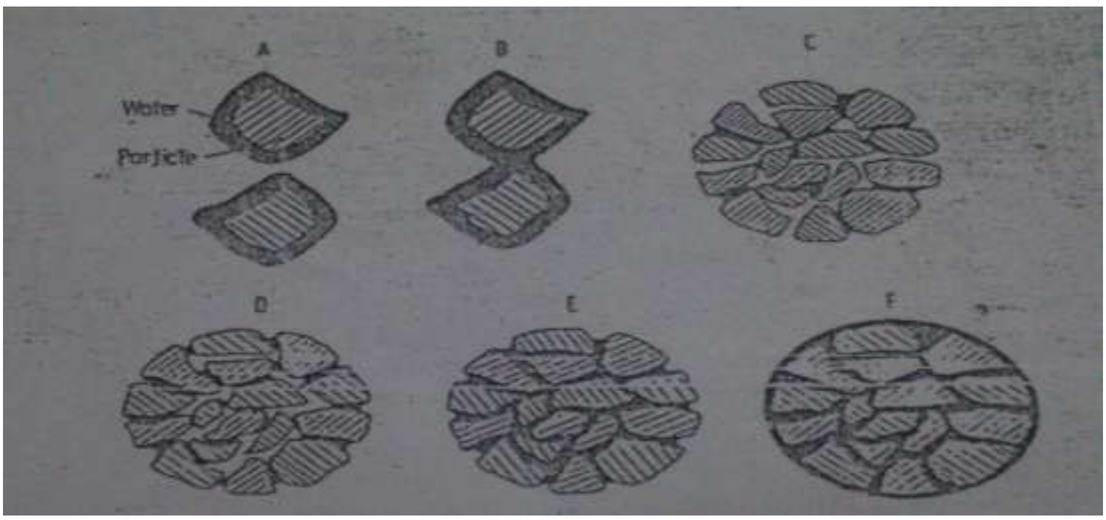


**Fig. 2.1 Influence of water addition on green ball formation**

Now the capillary forces of individual liquid bridges become active. The optimum of this phase is attained and pores are filled with liquid bridges. But, water has not yet coated the whole agglomerate uniformly.

When the solid particles are coated fully with water film, then we know that the final stage has arrived. Now the capillary action ceases and the surface tension between of water droplets becomes fully active.

The rolling movement of grains relative to each other plays an important role. As the number of contact points increases the amount of adhesion also increases due to load of rolling material.

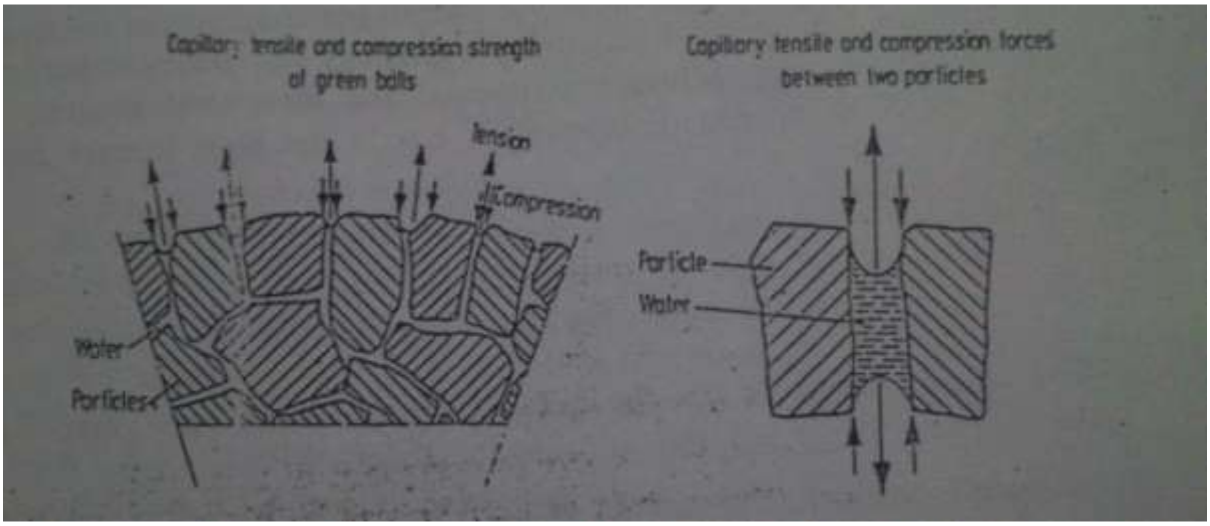


**Fig. 2.2 Influence of capillary forces on bonding mechanisms**

The pressure due to movement has some negative influence too. Damage of mechanically weak granules is one of them. It results into either crumbling into minor fragments or disintegrating into finer particles.

**BALL GROWTH** takes place by two ways:

1. **Growth by Assimilation:** If no fresh feed material is added for balling the rolling action may break some of the granules mainly the smaller

granules. They coalesce with the growing ones. Bigger the balls the larger it will grow. The smaller ones are weaker and tend to break.

2. **Growth by Layering:** It is possible when balling proceeds with addition of fresh fed material. There is a continuous supply of fresh material. Balls pick up material while rolling on a layer of fresh feed. Amount of material picked up is directly proportional to the exposed surface area of the rolling balls.

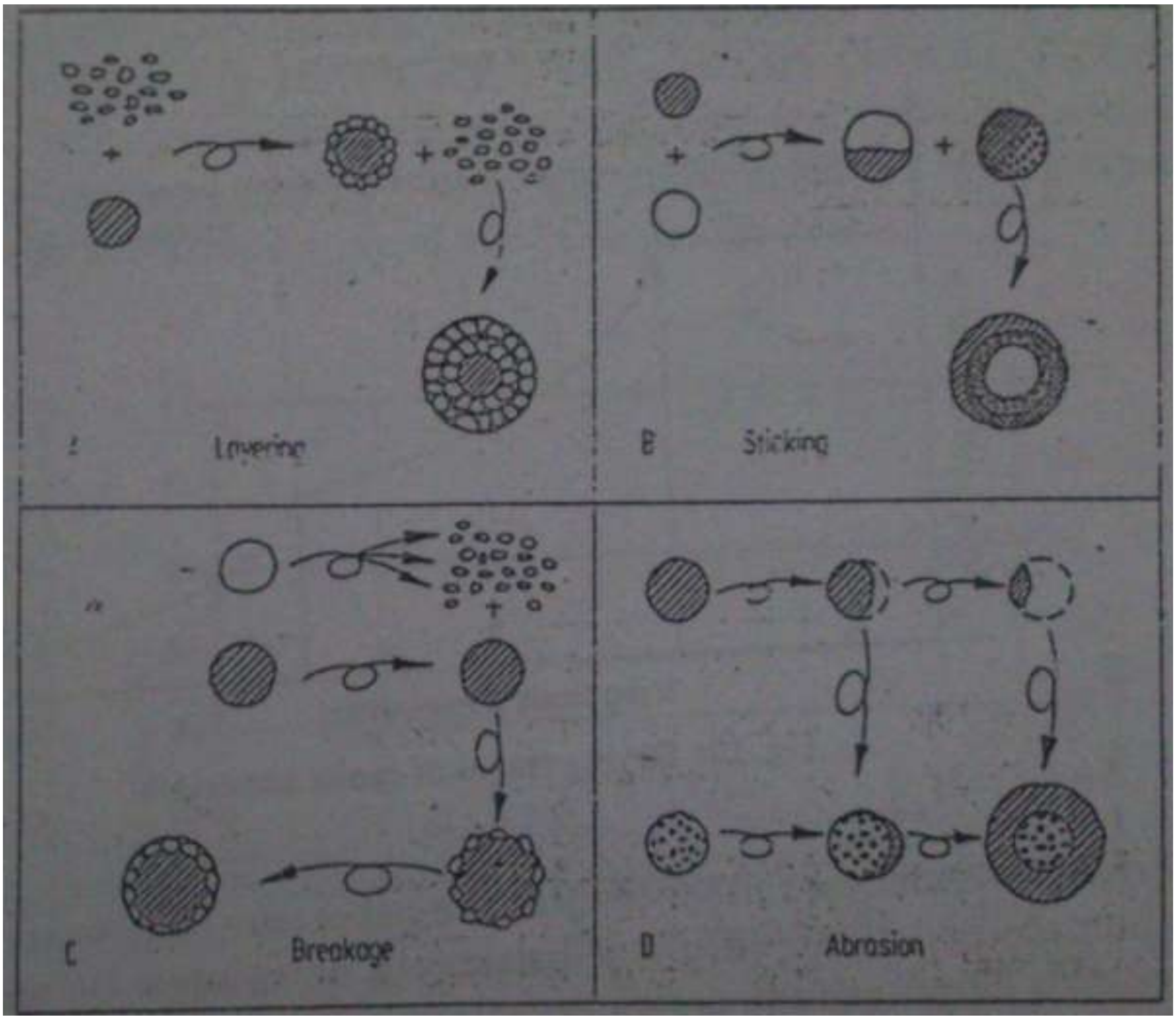


**Fig. 2.3 Alternatives for green pellet formation**

## 2.2 **Drop Number:**

The drop number is a measurement of the strength of the wet green pellet under sudden impact. The testing involves dropping of the green pellet from a height of 45 cm on to a steel plate and the breakage is visually observed. The drop number implies the average number of drops until fracture takes place.

It provides information regarding how often the green ball can be dropped or impacted upon until cracks are formed.

Green pellet strength is a significant parameter for the productivity of an iron ore pelletizing plant. The drop number describes the green pellet strength during a fast impact, for example, the impact that occurs during unloading from a conveyor belt. The drop number must be sufficiently high so that the green pellets can withstand the transportation from the balling circuits to the pelletizing machine. However, the drop number is influenced by variations in plasticity and elasticity: it increases with increasing moisture content.

The drop number values are also fairly unreliable and operator dependent, because the breakage point is visually judged.

## 2.3 **Parameters affecting reduction behaviour of pellets**

As an important material for ironmaking, oxide pellet may break and disintegrate due to the strength decrease during reduction, which will cause significantly adverse impacts on field production. Microstructure investigation of the pellets reveals that the increase of porosity and generation of particle defect in the periphery lead to strength loss and those inducements gradually shift to the inner part of pellets as the reduction proceeds. In addition, the effects of iron oxide phase transition on strength change have to be accounted for. The largest strength loss (about 75.85%) occurs as hematite is reduced to magnetite.

Then with magnetite reduced to wustite, strength continues to decrease slightly. Finally strength improves with the formation of metallic iron phase.

Oxide pellets with advantages of uniform size, high strength and good permeability in furnace are widely used in shaft furnace smelting. However, the breakage and disintegration of pellets during reduction may bring about significantly adverse impacts to field production.

In high temperature reduction process, the strength changes are led mainly by two reasons. The first one is internal stress. Iron oxide phase transformation during reduction may cause the generation of internal stress. The other is thermal stress. As temperature of periphery is higher than that of core, so periphery expands outwardly. The volume changes with phase transition in the reduction process were measured to be:

$$Fe_2O_3\,(100\%) \rightarrow Fe_3O_4\,(124\%) \rightarrow Fe_xO\ (131\%) \rightarrow Fe\ (126\%)$$

## 2.4 Swelling of Pellets during Reduction

During reduction, highly oxidised pellets of good quality pass through several process stages while structural changes occur. It is imperative that in these phases the pellet quality is maintained as far as possible. Such changes may already occur at a rel - C, resulting in certain degradation and thus impairing the gas permeability of the pellet charge.

C, the pellet volume increases, known as swelling, decreases the voids in the charge accordingly and thus impedes the gas flow.

With swelling, the strength may diminish so that the pellets may even crumble, whereby, the gas permeability is further impaired. According to the chemical composition of the pellets, they start to deform plastically at a relatively early stage and can thus also impede the gas flow. Various methods are adopted for examination of pellet quality during the reduction stages conforming to existing standards.

# CHAPTER - 3

# EXPERIMENTAL PROCEDURE

## 3.1 Sample Preparation

### 3.1.1 For Green Strength Measurement:

Pellets were prepared using haematite iron ore of uniform composition. The following procedure was adopted:

- The iron ore was crushed to obtain fines using a hand crusher.
- Sieve analysis was carried out with 100 mesh size sieve. The +100 size was stored separately while the sieved part was passed through a second round of sieving with 350 mesh size. Again, the +350 mesh was retained.
- Various samples were prepared by varying two parameters:
- The moisture content: Values used are 11%, 13%, 15% and 17% water by weight.
- The weight percentage of fines of the sizes: 350 mesh, 100 mesh and +100 mesh. The following combinations were used:

➢ 100% 350 mesh

➢ 90% 350 mesh, 5% 100 mesh, 5% +100 mesh

➢ 80% 350 mesh, 10% 100 mesh, 10% +100 mesh

➢ 70% 350 mesh, 20% 100 mesh, 10% +100 mesh

- Therefore, for every size combination of fines, four types of samples were prepared, each of different moisture content. Conversely, for any fixed moisture content, four size combinations were used.
- 50 g of iron ore was used for each sample preparation. In accordance with the varying size distributions, the following weight of individual sizes was used:

➢ 50g 350 mesh

➢ 45g 350 mesh, 2.5g 100 mesh, 2.5g +100 mesh

➢ 40g 350 mesh, 5g 100 mesh, 5g +100 mesh

➢ 35g 350 mesh, 10g 100 mesh, 5g +100 mesh

- Correspondingly, four values of moisture content was used by weight and the following amounts of water was used:
  - 11% - 5.5g
  - 13% - 6.5g
  - 15% - 7.5g
  - 17% - 8.5g
- Hence, with four values of both parameters, a total of sixteen samples were obtained. Four green balls were attempted to be prepared for each sample.
- The required amount of water was added to the powder and thoroughly mixed. This formed lumps in the powder. The lumps were then hand-rolled to obtain the green balls.
- Two samples were used for Drop Test to measure the green ball strength, while another two were used for further experiments.

### 3.1.2 <u>For Study of Reduction Behaviour:</u>

Two pellet samples were subjected to drying in the muf

C for duration of 30 minutes. These dried samples were later used for study of reduction behaviour.

## 3.2 <u>Testing</u>

### 3.2.1 <u>Green Strength Measurement: Drop Number</u>

The following procedure was adopted for quantifying the strength of the green pellets by measuring their Drop Number:

- The various green samples were tested immediately after formation, to avoid hardening and drying due to surrounding atmosphere, which also would have led to loss of moisture.
- A square steel plate of side 2 ft. and thickness 5 mm was used for this purpose.

- The plate was placed on a level floor and a vertical height of 450 mm was measured and marked.
- Two balls of each sample were subjected to the test by allowing them to fall from the said height.
- The dropping was continued until cracks appeared and fracture occurred.
- The number of drops was recorded to obtain the Drop Number of the green pellets.
- The Drop Number data was then compared for various values of moisture content and size distributions to make deductions.
- Consequently, this data was studied graphically and the results noted.

### 3.2.2 <u>Reduction Behaviour: Swelling and Percentage Reduction</u>

- The dried pellets are now subjected to tests, as following, for studying their reduction behaviour.
- Two properties of the samples were now measured:
- Weight (to be considered as initial weight; before reduction)
- Diameter, using Vernier Callipers (to be considered as initial diameter; before reduction)
- Then, the pellets were packed in stainless steel containers, filled with coal. The containers have a small orifice on the top to allow any gaseous products to escape.
- C, for 20 minutes.
- Thereafter, the containers are allowed to cool in open air. The orifice is covered with a refractory material to prevent atmospheric oxidation at high temperature.
- After cooling, the weight and diameter are measured again to record any changes.

- Using the initial and final values, two properties of the pellets are studied:
- Percentage Reduction: It measures the amount of oxygen removed from the ore as a percentage of decrease in oxygen content of the pellet upon reduction.
- The iron content of the iron ore fines used is 62.5%. Accordingly, the amount of oxygen is calculated:
- Oxygen content in ore = (48/112)*62.5%

  = 26.785%
- Using this value, the amount of oxygen in each pellet before reduction was calculated.
- The loss in weight of the pellet after reduction is due to the removal of oxygen.
- Therefore, the reduction is calculated as:
- $$\% \text{ Reduction} = \frac{\text{loss in weight}}{\text{Initial wt. of oxygen}} \times 100\%$$
- The swelling was calculated in terms of the percentage increase in diameter of the spherical pellets as:

$$\%\text{increase in diameter} = \frac{\text{inc. in diameter}}{\text{Original diameter}} \times 100\%$$

# CHAPTER – 4

# RESULTS

## 4.1 <u>Drop Test</u>

### 4.1.1 <u>Tabulation</u>

The following table records the Drop Number of various samples:

| **GREEN STRENGTH OF PELLETS** | | | | | |
|---|---|---|---|---|---|
| TABULATION OF DROP NUMBER | | | | | |
| Moisture □ | | 11% | 13% | 15% | 17% |
| Size Distribution □ | | Drop No. | Drop No. | Drop No. | Drop No. |
| 100% 350 mesh | Sample 1 | N.A. | 8 | 14 | 2 |
| | Sample 2 | N.A. | 7 | 18 | 2 |
| 90% 350 mesh, 5% 100 mesh, 5% +100 mesh | Sample 1 | N.A. | 4 | 7 | 2 |
| | Sample 2 | N.A. | 6 | 7 | 3 |
| 80% 350 mesh, 10% 100 mesh, 10% +100 mesh | Sample 1 | N.A. | 5 | 5 | 2 |
| | Sample 2 | N.A. | 4 | 7 | 2 |
| 70% 350 mesh, 20% 100 mesh, 10% +100 mesh | Sample 1 | N.A. | 3 | 5 | 3 |
| | Sample 2 | N.A. | 3 | 6 | 3 |

**Table 4.1 Drop Number of samples for green strength measurement**

**Fig.4.1 Sample of 15% Water Content, 90% 350 mesh size pellet: Before and After Drop Test**

### 4.1.2 <u>Graphical Representation</u>

#### 4.1.2.1 <u>Drop Number vs. Water Content:</u>

The following graphs were plotted correlating the Drop Number and Water Content of the samples (Please note that the higher Drop Number from either of the two samples is used):

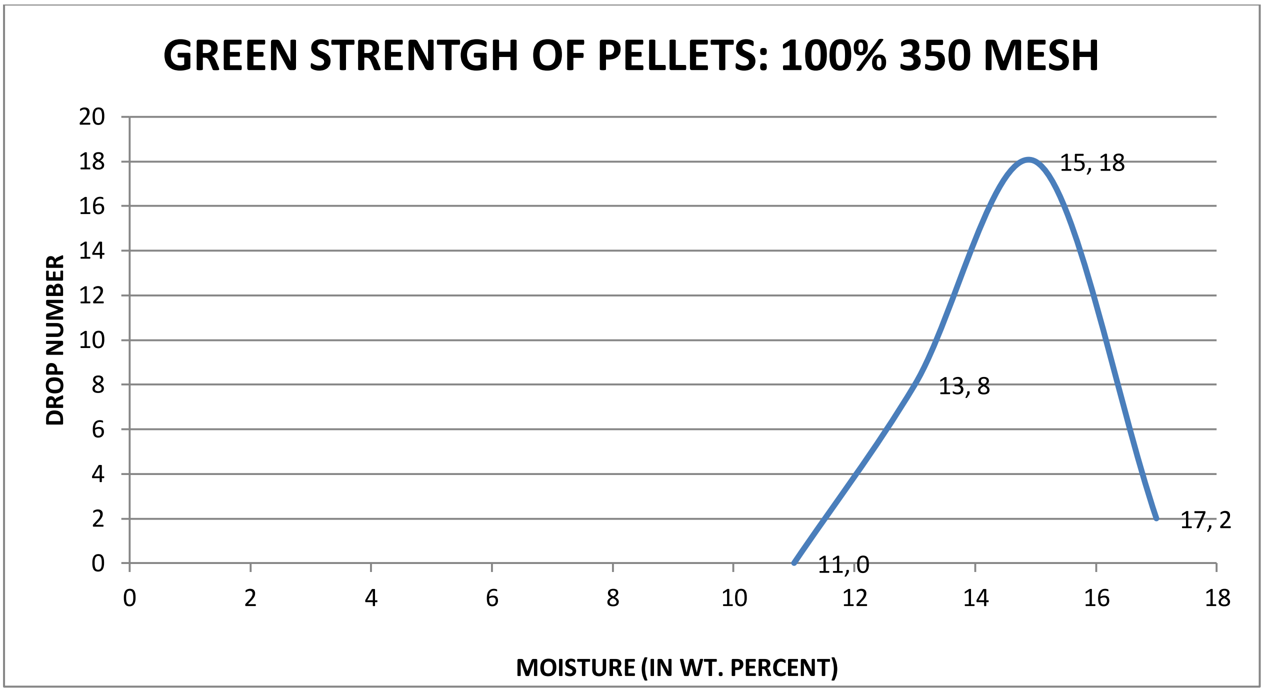


**Fig. 4.2 Drop Number vs. Water Content for 100% 350 mesh size**

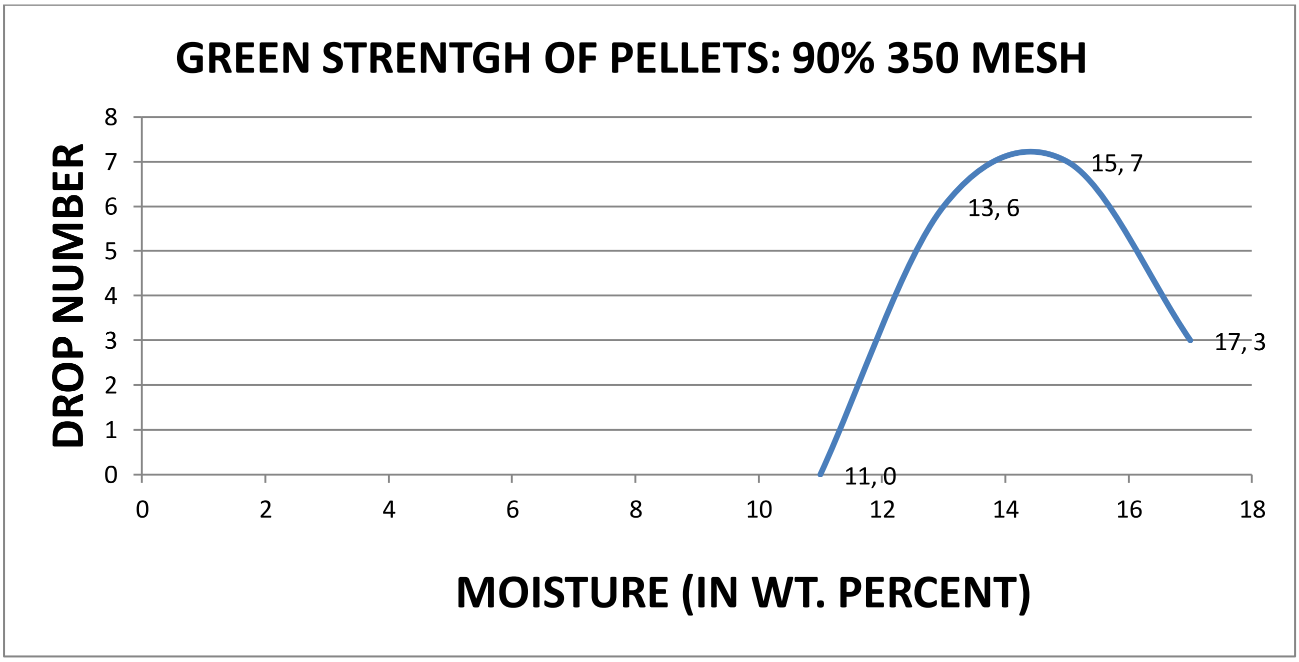


**Fig. 4.3 Drop Number vs. Water Content for 90% 350 mesh size**

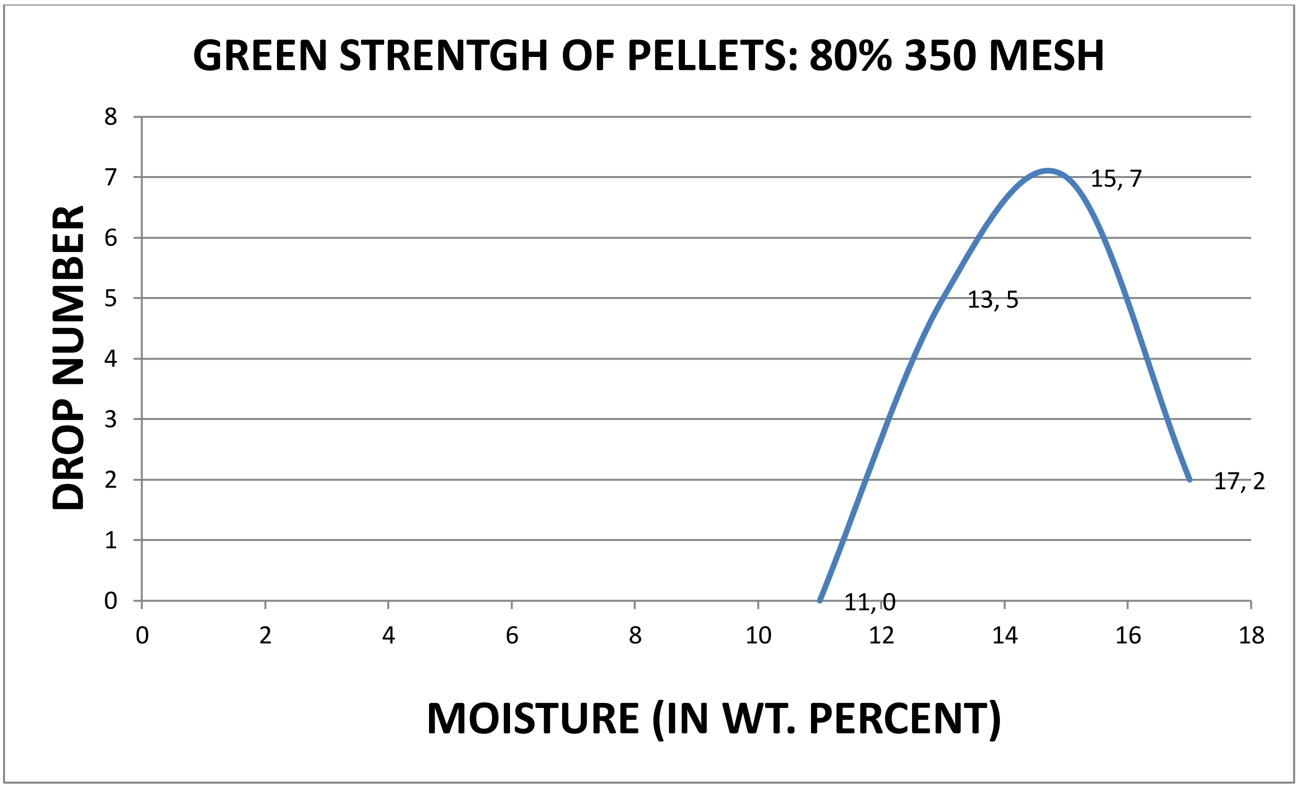


**Fig. 4.4 Drop Number vs. Water Content for 80% 350 mesh size**

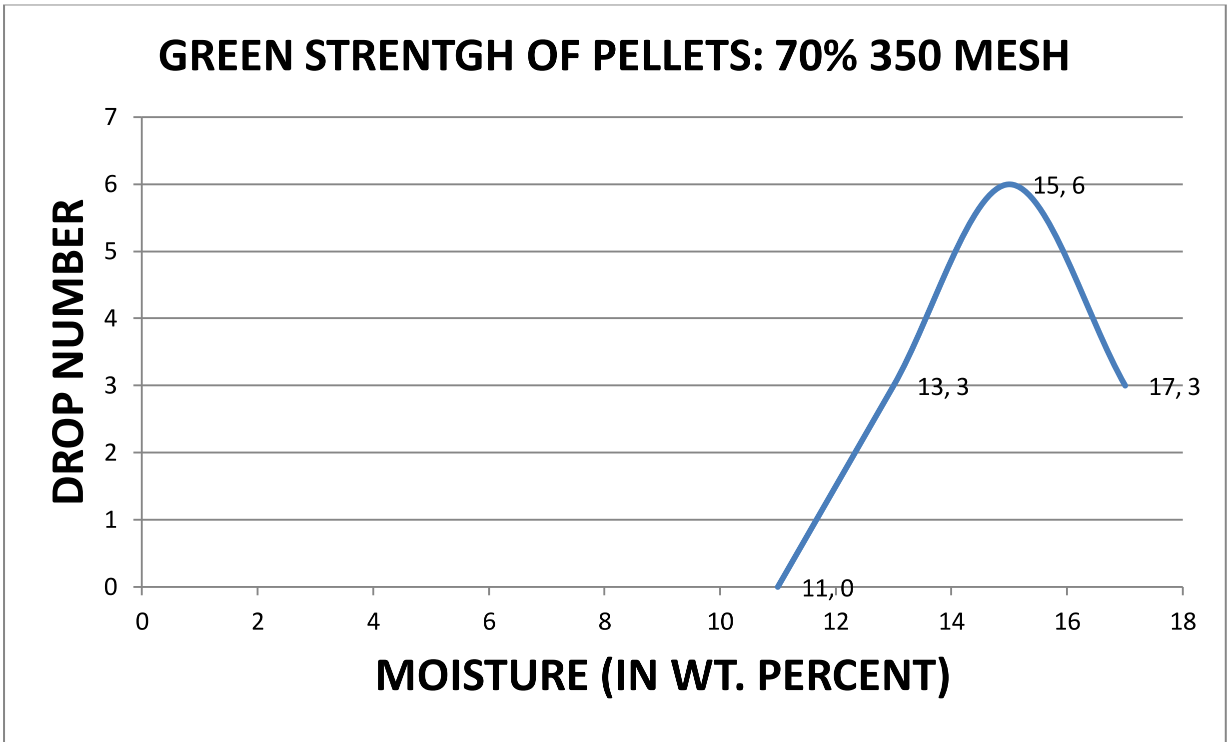


**Fig. 4.5 Drop Number vs. Water Content for 70% 350 mesh size**

#### 4.1.2.2 <u>Drop Number vs. Size distribution:</u>

The following graphs were plotted correlating the Drop Number and Size distribution of the samples (Please note that the higher Drop Number from either of the two samples is used):

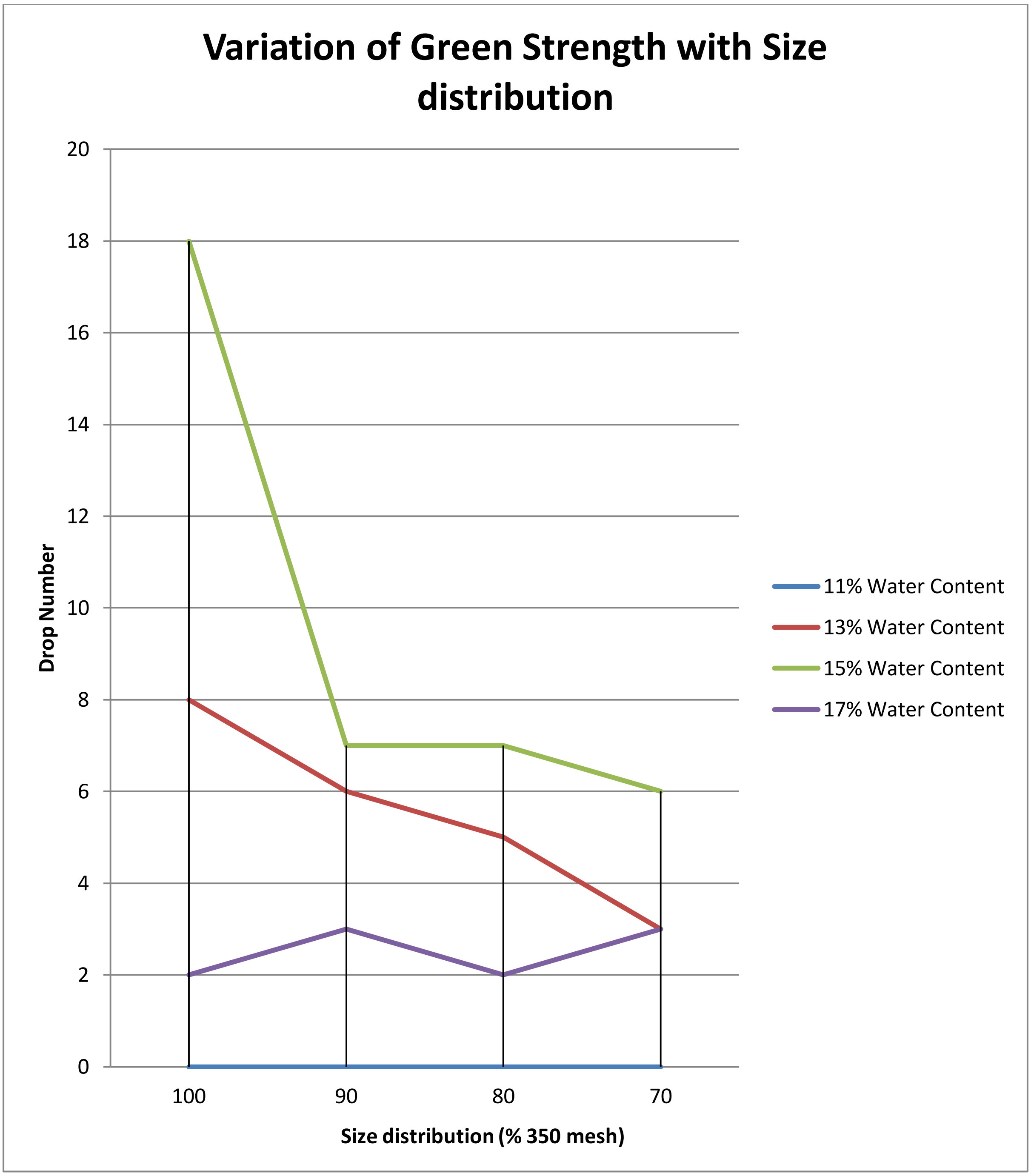


**Fig.4.6 Drop Number vs. % 350 mesh size**

### 4.1.3 <u>Observations & Inferences</u>

From the data obtained and the observation made during testing, the following has been recorded:

- The samples prepared using 11% water content by weight could not be rolled into pellets. This may be attributed to insufficient water content for binding.
- The green pellets formed using 15% and 17% water content deformed in shape immediately after the first drop.
- The extent of deformation was greater for the 17% water content samples.
- Maximum Drop Number was obtained for a water content of 15%.
- The Drop Number for samples using 13% water content was closest to the peak values obtained for 15% water content samples.

### 4.1.4 <u>Results</u>

The following results are obtained:

- Based on water content, the green strength of the pellets follows the order: 15% > 13% > 17%
- Based on size distribution (350 mesh content), the green strength of the pellets follows the order: 100% > 90% > 80% > 70%
- However, the drop number hardly varies with size for 17% water content.
- The best result is obtained for 13% water content, where
  - The green strength is sufficient
  - It shows a linear decrease in strength with decreasing uniformity in size distribution.
  - The maximum strength is obtained for uniform composition (100% 350 mesh in this case).

Owing to the obtained results, it may be safely stated that water content of 11% and 17% is not suitable for pelletization of iron ore fines. While the former does not provide sufficient binding for ball formation, the latter causes ‘flooding’ of the balls, leading to low green strength and instantaneous deformation and fracture upon impact. Therefore, these water contents will not be considered for further experimental testing.

## 4.2 Percentage Reduction

### 4.2.1 Tabulation

The following results were obtained:

| **REDUCTION BEHAVIOUR OF PELLETS** | | | | | | | |
|---|---|---|---|---|---|---|---|
| TABULATION OF WEIGHT LOSS | | | | | | | |
| Moisture --□ | | 13% | | | | | |
| Size Distribution □ | | Initial Wt. | Final Wt. | Loss in Wt. | Initial Oxygen wt. | % Reduction | Avg. % Reduction |
| 100% 350 mesh | Sample 1 | 3.7 | 3.36 | 0.34 | 0.99 | 34.34 | 32.9 |
| | Sample 2 | 3.33 | 3.05 | 0.28 | 0.89 | 31.46 | |
| 90% 350 mesh, 5% 100 mesh, 5% +100 mesh | Sample 1 | 4.88 | 4.46 | 0.42 | 1.3 | 32.3 | 33.45 |
| | Sample 2 | 2.94 | 2.67 | 0.27 | 0.78 | 34.61 | |
| 80% 350 mesh, 10% 100 mesh, 10% +100 mesh | Sample 1 | 9.23 | 8.49 | 0.74 | 2.47 | 29.95 | 29.58 |
| | Sample 2 | 3.34 | 3.08 | 0.26 | 0.89 | 29.21 | |
| 70% 350 mesh, 20% 100 mesh, 10% +100 mesh | Sample 1 | 5.55 | 5.24 | 0.31 | 1.48 | 20.94 | 24.295 |
| | Sample 2 | 3.52 | 3.26 | 0.26 | 0.94 | 27.65 | |

**Table 4.2 Weight Loss upon Reduction of Pellets of 13% Water Content**

| REDUCTION BEHAVIOUR OF PELLETS | | | | | | | |
|---|---|---|---|---|---|---|---|
| TABULATION OF WEIGHT LOSS | | | | | | | |
| Moisture --□ | | 15% | | | | | |
| Size Distribution □ | | Initial Wt. | Final Wt. | Loss in Weight | Initial Oxygen wt. | %Reduction | Avg. %Reduction |
| 100% 350 mesh | Sample 1 | 12.62 | 11.85 | 0.77 | 3.38 | 22.78 | 22.46 |
| | Sample 2 | 5.58 | 5.25 | 0.33 | 1.49 | 22.14 | |
| 90% 350 mesh, 5% 100 mesh, 5% +100 mesh | Sample 1 | 13.96 | 13.5 | 0.87 | 3.73 | 23.32 | 24.34 |
| | Sample 2 | 5.03 | 4.59 | 0.34 | 1.34 | 25.37 | |
| 80% 350 mesh, 10% 100 mesh, 10% +100 mesh | Sample 1 | 11.54 | 11.11 | 0.43 | 3.09 | 13.91 | 17.69 |
| | Sample 2 | 4.55 | 4.29 | 0.26 | 1.21 | 21.48 | |
| 70% 350 mesh, 20% 100 mesh, 10% +100 mesh | Sample 1 | 11.03 | 10.69 | 0.34 | 2.95 | 11.52 | 15.295 |
| | Sample 2 | 5.69 | 5.4 | 0.29 | 1.52 | 19.07 | |

**Table 4.3 Weight Loss upon Reduction of Pellets of 15% Water Content**

### 4.2.2 Graphical Representation:

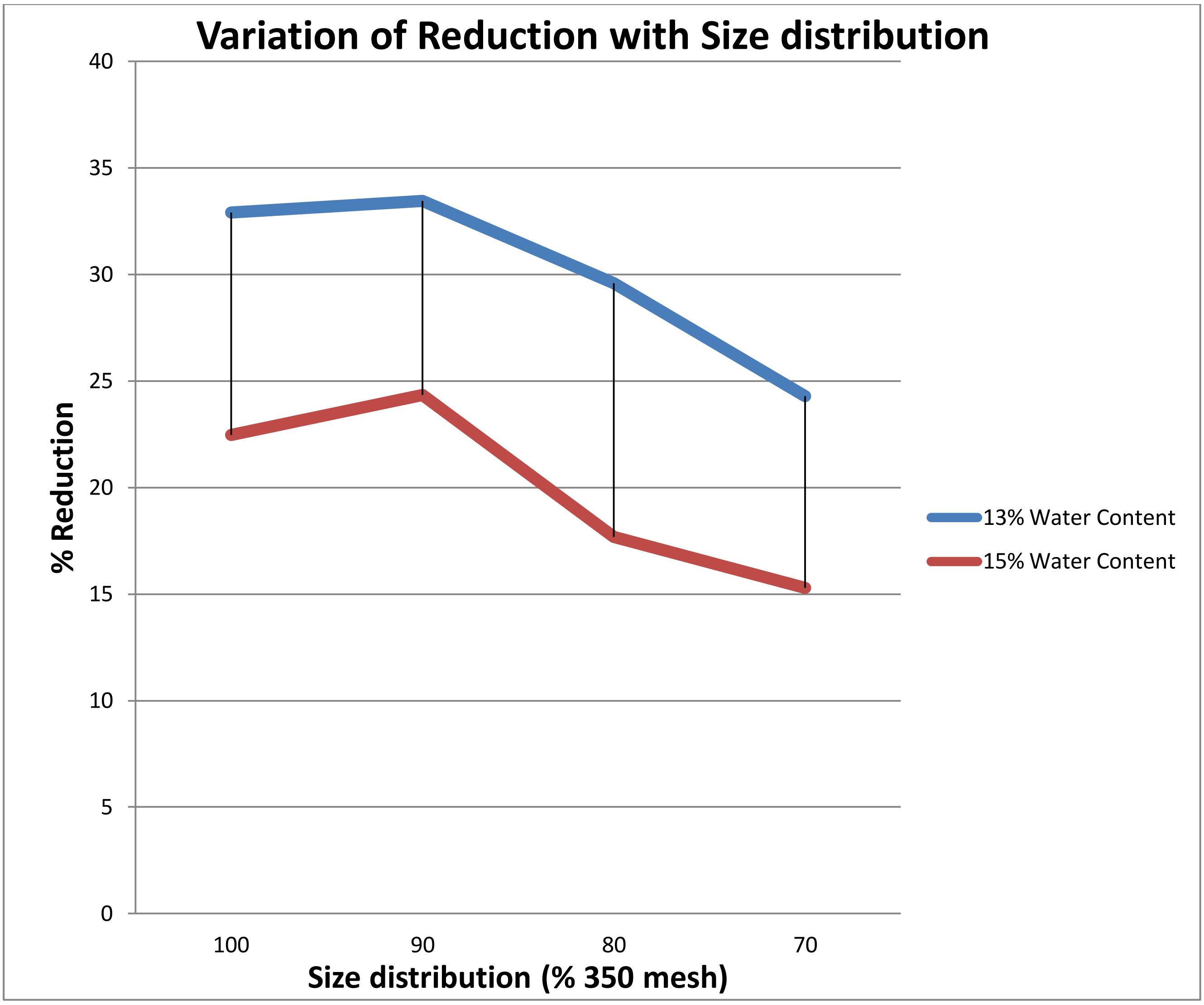


**Fig.4.7 Percentage Reduction vs. % of 350 mesh size**

### 4.2.3 Results

The following results were obtained:

- Percentage reduction was higher in the case of 13% water content compared to 15% water content.
- Appreciable reduction was observed for 100% and 90% 350 mesh size distribution only, with the latter exhibiting a greater extent.
- Maximum reduction occurred for 90% 350 mesh size, balled with 13% water content.

## 4.3 Swelling

### 4.3.1 Tabulation:

The following data was recorded:

| SWELLING BEHAVIOUR OF PELLETS | | | | | | |
|---|---|---|---|---|---|---|
| TABULATION OF INCREASE IN DIAMETER UPON REDUCTION | | | | | | |
| Moisture ---□ | | 13% | | | | |
| Size Distribution \| □ | | Initial Diameter | Final Diameter | Increase in diameter | %Increase in diameter | Avg. %increase in diameter |
| 100% 350 mesh | Sample 1 | 13.2 | 13.82 | 0.62 | 4.69 | 4.71 |
| | Sample 2 | 13.12 | 13.74 | 0.62 | 4.72 | |
| 90% 350 mesh, 5% 100 mesh, 5% +100 mesh | Sample 1 | 14.74 | 15.2 | 0.46 | 3.12 | 5.59 |
| | Sample 2 | 13.12 | 14.18 | 1.06 | 8.07 | |
| 80% 350 mesh, 10% 100 mesh, 10% +100 mesh | Sample 1 | 17.52 | 18.54 | 1.02 | 5.82 | 3.39 |
| | Sample 2 | 12.36 | 12.72 | 0.12 | 0.97 | |
| 70% 350 mesh, 20% 100 mesh, 10% +100 mesh | Sample 1 | 15.22 | 15.34 | 0.12 | 0.78 | 0.62 |
| | Sample 2 | 13.24 | 13.3 | 0.06 | 0.45 | |

**Table 4.4 Increase in diameter upon reduction for 13% water content**

| SWELLING BEHAVIOUR OF PELLETS | | | | | | |
|---|---|---|---|---|---|---|
| TABULATION OF INCREASE IN DIAMETER UPON REDUCTION | | | | | | |
| Moisture ---□ | | 15% | | | | |
| Size Distribution □ | | Initial Diameter | Final Diameter | Increase in diameter | %Increase in diameter | Avg. %increase in diameter |
| 100% 350 mesh | Sample 1 | 19.74 | sample fractured | N.A. | N.A. | 2.8 |
| | Sample 2 | 14.98 | 15.4 | 0.42 | 2.8 | |
| 90% 350 mesh, 5% 100 mesh, 5% +100 mesh | Sample 1 | 20.58 | 21.08 | 0.5 | 2.43 | 3.11 |
| | Sample 2 | 14.28 | 14.82 | 0.54 | 3.78 | |
| 80% 350 mesh, 10% 100 mesh, 10% +100 mesh | Sample 1 | 19.7 | 20.32 | 0.62 | 3.14 | 2.83 |
| | Sample 2 | 14.22 | 14.58 | 0.36 | 2.53 | |
| 70% 350 mesh, 20% 100 mesh, 10% +100 mesh | Sample 1 | 20.8 | 21 | 0.2 | 0.96 | 0.86 |
| | Sample 2 | 15.48 | 15.6 | 0.12 | 0.77 | |

**Table 4.5 Increase in diameter upon reduction for 15% water content**

### 4.3.2 Graphical Representation:

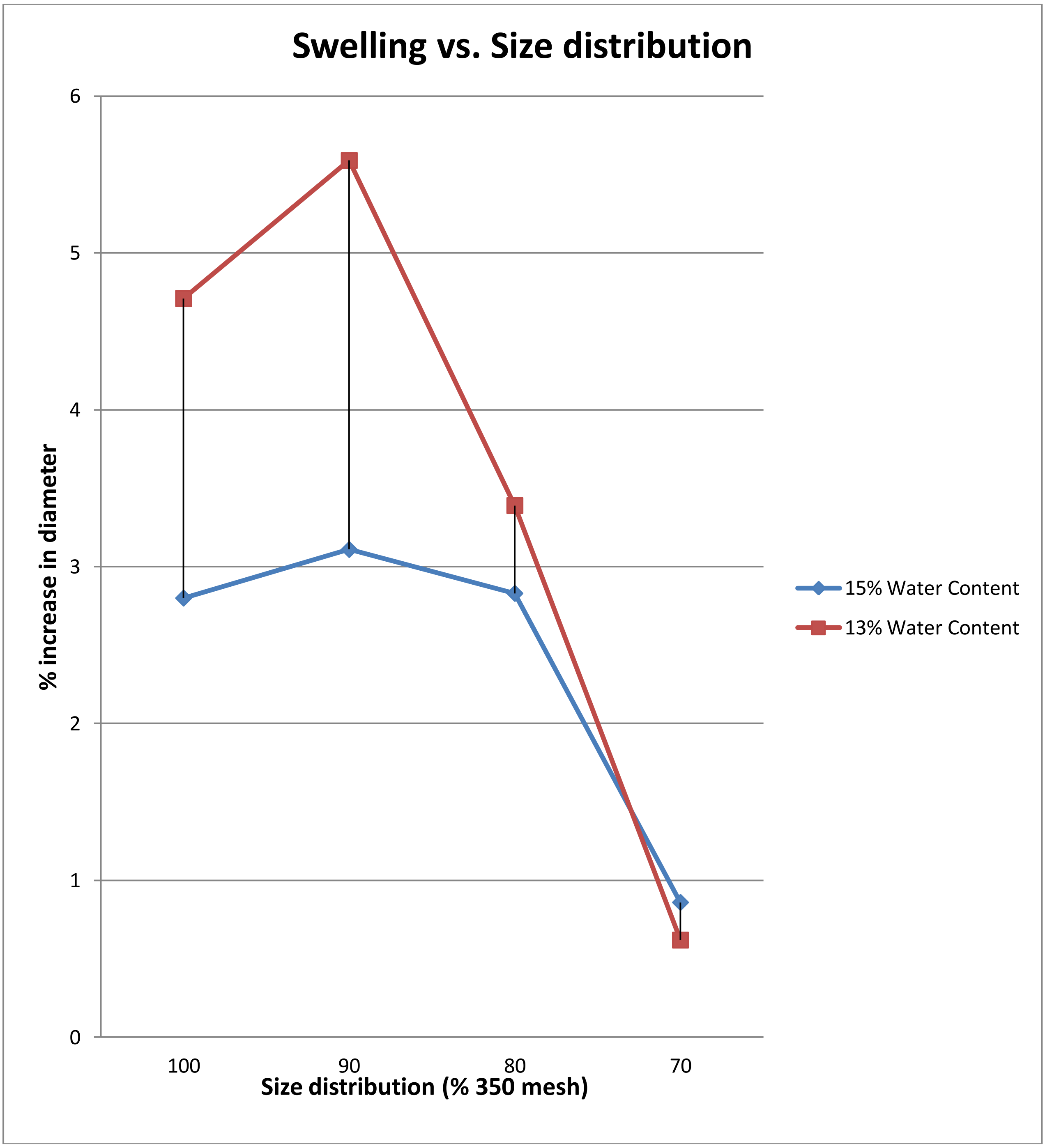


**Fig.4.8 %increase in diameter vs. % of 350 mesh size**

### 4.3.3 **Results**

The following results were obtained:

- Higher swelling was observed for 13% water content compared to 15% water composition.
- However, it is well within the safe limit of 5%, which is desirable for ease of reduction.
- The swelling data conforms to the higher %reduction obtained for 13% water content.
- Desired swelling values were observed for 100% and 90% 350 mesh size.
- Swelling in 15% water content was low; so was the reduction. This may be due to the excessive water, causing extreme compactness and lack of porosity, which is not favourable for reduction.

# CHAPTER – 5:

# CONCLUSION

- Water Content:

13% water content is ideal for pellet formation as it provides a proper combination of porosity, hence reduction, and strength.

- Size distribution:

90% 350 mesh has shown sufficient strength as well as desired values of percentage reduction and swelling.

The pellet industry may, for large-scale production, favours utilisation of as much 100 mesh size as possible. Hence, efforts may be made to utilize the fines of this size without compromising on the performance of the pellet during reduction in furnace.

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