A STUDY ON ELIMINATION OF DEFECTS FOR ENHANCEMENT OF COST-EFFECTIVENESS IN WIRE ROD MILLS IN INDIAN SCENARIO

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Abstract: The custodian of all standards of product quality and characterization is the quality controlling unit. In this thesis we have tried to identify the possible reasons like Segregation, Resolved Peralite, Laps, Fins, Chip off and other defects which are mainly responsible for the non-prime production by the Wire rod mill, there by suggesting the probable remedial measures, accounted the existing tests and examining procedures and have tried to bring certain alterations in method of visualization which can help in better identification and eradication of defective products. There is also the study on the enhancement of the cost-effectiveness with the minimization of defects arises due to the non-prime products.

Index Terms: Segregation, Resolved Pearlite, Laps, Decarburization, Fins, Chip off

I. INTRODUCTION

The quality of steel products that are built through a series of the following manufacturing processes namely steel-making process; hot-rolling process, cold-rolling process and heat-treatment process undergo thorough quality checkups. To build high quality products in demand, necessary processes increase, and then a pretty great number of operational conditions of manufacturing processes affect the product quality. Conventionally, the general method called statistical process control has been carried out in quality and operation management. Because there are a large number of operation conditions that have to be managed, the load of observation was high in the conventional method, and there is the problem that the conventional method cannot detect abnormality easily. To solve these problems, the quality control operations have been statistically designed. For the purpose of verification and tallying of data the quality section maintains records of various standard results and assumptions and emphasizes on customer satisfaction much more than monolithic numerical. They try to perform by checking almost all facets of production and emphasizes on visual, dimensional, mechanical and metallurgical tests with the help of Online Laboratory, Spectrum Laboratory and Central Quality Laboratory.

Quality control is basically the ensuring of proper standards of manufactured goods keeping in mind the dual factors of customer satisfaction and standardization. The most important advantage derived by introducing quality control is that it develops and encourages quality consciousness among the workers in the factory which is greatly helpful in achieving desired level of quality in the product and work in accordance with the desired standards.

Hence the quality section is the pivot around which the entire plant respires. It takes the most difficult decision as to which product should be delivered and which should be sent for recasting. It guides every section and binds every action in one garland.

II. WIRE ROD MILL

The purpose of the Wire Rod Mill is to roll the billets in order to produce the wire rods of varying sizes and TMT rod in coil forms.

- *Raw Materials at WRM:*

The main ingredient in the wire rod mill is the billets are prepared by the SMS plant. Here there are about 65 grades used here in the wire rod mill where different grade types are used for the different manufacturing purposes like:

- *Low Carbon Steel and CHQ:*

The carbon percent varies around 0.08-0.21 at max with other compositions of manganese phosphorus sulphur silicon aluminium.

- *Medium Carbon Steel:*

The carbon percent varies around 0.20-0.45 at max with other compositions of phosphorus and sulphur.

- *Boron Treated Wire Rod:*

The billets have the high amount of Boron of about 0.0008-0.0030 at maximum along with the natural composition of the billet.

- *High carbon steel:*

Here the carbon percent varies around 0.36-0.85 at max with other compositions of manganese phosphorus sulphur silicon aluminium. Here the Chromium of 0.15-0.20 percent added to achieve the mechanical properties.

- *Free Cutting Steel:*

The free cutting steel with a higher content of sulphur and phosphorus is used for the fabrication of parts for high-speed
automatic and semiautomatic machine tools.

III. WIRE ROD PRODUCTS

The final product obtained from WRM is the coiled wire rods which are needed to be tested before marketing in order to ensure the product quality.

A. Sample Testing:

The product which is obtained by rolling in wire rod mill is tested basically in two places, the Online Laboratory and the Central Laboratory of the quality controlling and ensuring section. In the online laboratory, the mechanical properties are basically tested and in the central laboratory the metallurgical properties are basically tested.

- *Mechanical Tests:*

The mechanical tests like 0.2% proof stress, % elongation, UTS, and reduction in area can be calculated by using UTM or Universal Testing Machine. Eddy current testing machine is used for grade checking of each coil during online production. Rockwell cum Brinell testing method is used to measure the hardness of the materials.

- *UTM (Universal Testing Machine):*

It is the most fundamental machine used to check the basic properties of the wire rod samples. The main purpose of using this machine is to determine the strength and ductility of the material. The certain properties calculated are [1]:

0.2% proof stress = load/area= X/ (πD²/4)
(X: load applied, D: diameter of cross section of the rod)
UTS = load at maximum point per unit area
% elongation = (final gauge length - initial gauge length)/initial gauge length X 100%
% reduction in area = (initial area – final area)/initial area X 100%

The main working mechanism of this machine is mainly dependent upon the application of tension on a sample of the wire rod for an interval of time such that it reaches its yield point and ultimately deforms to the plastic stage. Thus 0.2% Proof stress or Yield stress, UTS, % Elongation, % Reduction in area can be evaluated from the UTM for all the grade types.



Figure 1: Universal Testing Machine in Online Laboratory of WRM

- *Eddy Current Testing Machine:*

It is used to separate any other grade that is mixed with a single graded wire rod. There can be a chance of mixing up due to entrance of billets continuously in to the furnace which can result in a possibility of mixing up and hence result in product grade alteration. It is a sort of grade sorter which avoids grade mixing up and hence it is performed in all types of grades which are produced in a wire rod mill.



Figure 2: Red Signal of Eddy Current Tester showing Different Grade

- *Rockwell-Brinell Hardness Testing machine:*

Rockwell Hardness testing Machine is used to determine quench hardness, Jominey hardness and the hardness of the harder materials whose specification is not provided in the standards. This test is mainly observed in SAE4140, 40Cr4, C40Cr etc. This machine is preferably used for hardness measurement of various steel product samples ranging from rolled hardness, quenched hardness, and all types of samples.

- *Metallurgical Tests:*

In the Central Laboratory the chemical and the internal properties of the materials are tested to ensure the quality of the final product. Here in the metallurgical central laboratory, Mounting Machine, Polishing Machine and Microscope are used along with etchants for observing the microstructure and polishing the surface like 2% Nital and Sodium Picrate [2],[3].

- *Macro Test:*

The Macro testing is done to make the surface analysis of the billets and to detect any kind of defects present in it. Also some of the irregularities present in the product can be determined from this analysis. The defects which are present in the billet like porosity and piping can be seen by the macro examination.

- *Segregation:*

Segregation can be observed at the centre of the cross section of the wire rod. Segregation will occur during steelmaking during the time of solidification [4].

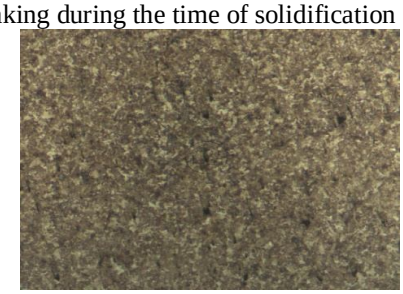


Figure 3: Microstructure of HC71/75 with 2D Segregation

- *Micro Test:*

The Micro testing is done to analyse the micro structure of the sample of the finished products which will determine that whether any kind of defects are produced within the internal structure of the sample.

- *Inclusion:*

Inclusions are a piece of foreign material in the cast part. Inclusion can be observed along the rolling direction along the rod in microscope at magnification of 100X [5].

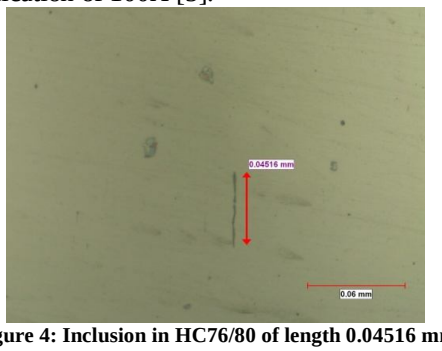


Figure 4: Inclusion in HC76/80 of length 0.04516 mm

- *Grain Size:*

The grain size of the micro structure varies from sample to sample. The grains may be smaller as well as may be bigger which depends on the time of the cooling the melt and the nature of cooling. Thus grain size varies in micro structure [6].

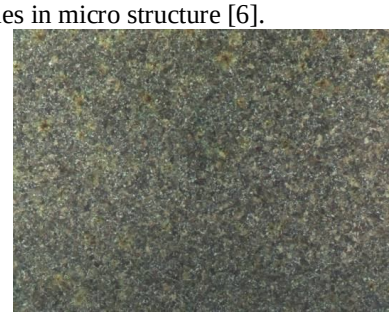


Figure 5: Microstructure of HC51/55 with fine grains

- *Resolved Pearlite:*

At 500 X magnification, when the inter-lamellar spacing between the pearlite and cementite becomes clearly visible where the pearlite can be seen distinctly, it is known as resolved pearlite. It is seen in the high carbon steel due to slow cooling.

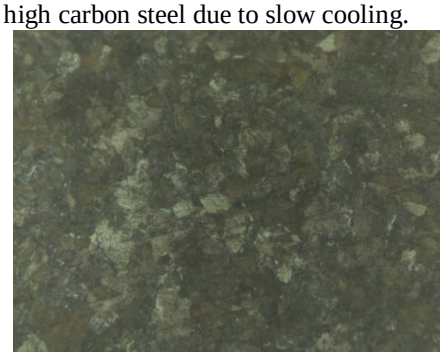


Figure 6: Resolved Pearlite in High Carbon grade

- *Grain coarsening:*

Grain growth is the increase in size of grains (crystallites) in a material at high temperature. The grain coarsening can be defined as the formation of the large grains of components over the certain region in the midst of the small grains.

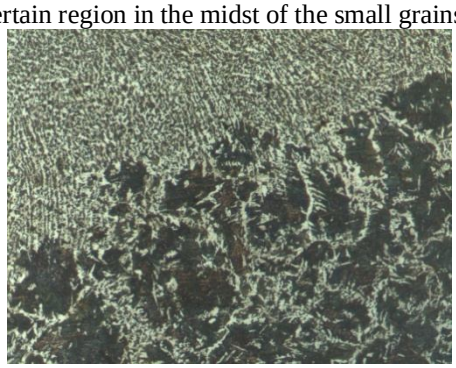


Figure 7: Grain coarsening of dimension 12mm in 15B25

- *Banding:*

In the hot rolled low alloy steels, pearlites and ferrite are arranged in the wide layers. In longitudinal section, this arrangement is visible as a banded structure. Band formation in boron grade steels promote crack formation and can lead to upset failure.

- *Decarburisation:*

Decarburisation refers to the removal of carbon from the outer surface of the billet due to continuous oxidation. The removal of carbon occurs by partial as well as complete decarburisation which determines the total length of decarburised part of the rolled billet. If this length exceeds 1% of the total diameter of the rod, then the sample is discarded [7],[8],[9].

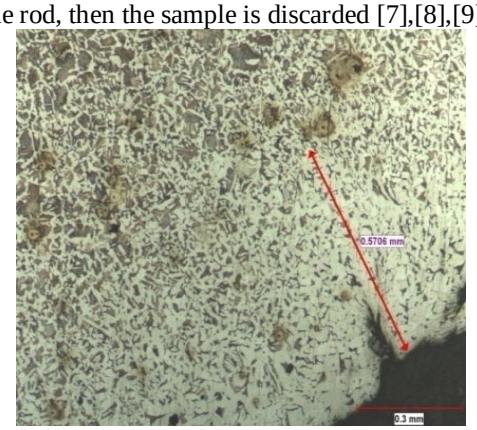


Figure 8: Microstructure of EN8D with Decarburisation of 1.8%

- *Grain Boundary Cementite:*

Since solubility of carbon is reduced with decreasing temperatures, both in austenite and in ferrite, carbon is diffused in the form of grain boundary cementite. Therefore, cementite will form during continuous transition which deposits along the grain boundaries.



Figure 9: Microstructure of HC76/80 with GBC B at 500X

The GBC is prevently seen in the hypoeutectoid steel where the cooling rate makes a vital role in determining the formation of grains in the microstructure. For slow cooling rate on conveyor, the microstructure will contain a large volume of coarse pearlite. As the amount of coarse pearlite will increase, the strength of the final product will decrease.

B. Defects in Wire Rods:

In wire rod rolling, steel is heated above its temperature of recrystallization and is passed through several grooves in the rolling mill. Typical series of grooves are diamond-diamond and diamond-square and box passes upstream in the roughing mill and square-oval or falls round-oval downstream in the rolling line.

There are some common defects available in wire rod mill which can be mostly seen by naked eyes or by magnifying glass after being etched.

- *Lap:*

Laps always run longitudinally on the wire and usually arise when fins are folded and rolled into the surface of the wire in the subsequent roll passes.

Detection: It can be detected by parallel double lines which are running longitudinally along the direction of rolling.

Occurrence: It occurs during the overfilling of passes, in misaligned entry guides, during guide failures of entry guides to hold & feed the bar centrally.

- *Fins:*

Fins usually occur when a groove is overfilled. Overfilling can occur when the rolls are not set properly or the reduction is too large. Fins usually occur along the entire wire.

Detection: It can be noticed by protruded portion formed at the side of the wire rod and along with it, it can be detected visually.

Occurrence: It mainly occurs due to the overfilling of finishing pass.

- *Scratch:*

Scratches are detected visually and are caused by unintentional contact with build up on mechanical parts and mill components during rolling. Scratches typically have a more rounded bottom and less scale than a seam or crack.

Detection: It can be detected with the naked eye or with low magnification, even in scaled condition. It seldom opens up in upsetting or torsion tests.

Occurrence: Scratches are caused by scoring of the stock by sharp or pointed objects.

- *Decarburization:*

Decarburization is detrimental to the wear life and fatigue life of steel heat-treated components. This article explores some factors that cause decarburization while concentrating on its measurement.

Detection: Decarburization layer can be observed under microscope.

Occurrence: It occurs due to excess heating in furnace.

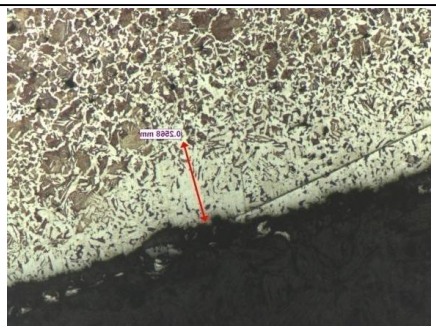


Figure 10: Grain of EN8D with Decarburization at 0.2568 mm

- *Banding:*

Banding is the defect observed in the wire rod during the time of cracking where in the inter-ferrite distance, the inter-ferrite increases with thickening of the pearlitic deposition in the rod.

Detection: It can be detected as the lamellar streaks of ferrite and pearlite observed under microscope.

Occurrence: It occurs due to the slow cooling on conveyor.

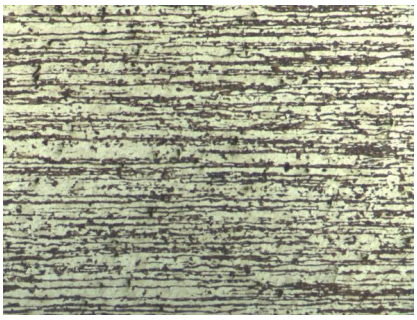


Figure 11: Grains of 19MnB4 with Banding

- *Segregation:*

After hot rolling, the presence of segregation in the centre of wire rod can lead to a non-uniform transformation, resulting in bands of martensite in the microstructure. This is considered to be a defect, called centre-martensite.

Detection: Segregation can be observed at the centre of the cross section of the wire rod.

Occurrence: Segregation will occur during steel-making during the time of solidification.

- *Inclusion:*

Inclusions are a piece of foreign material in the cast part. An inclusion can be a metallic, inter-metallic or non-metallic piece of material in the metal matrix.

Detection: Inclusion can be observed along the rolling direction, along through the rod in microscope at the magnification of 100X.

Occurrence: Inclusions occur due to the entrapping of the impurities in the mould during steelmaking.

C. Aggregate Details of Non Prime and Rejected Materials for 2015 & 2016 with respect to Indian Industries:

Many products become rejected and non-prime in the process of manufacturing due to presence of defects. These defects can not only be detrimental at the plant

level but also can hugely affect profits of an entire organization. We have tried to establish the proportions of various rejections in respect to the emerging steel industrial hubs in India. The data are reported in the monthly production reports of the reputed industry of India and considering all the data the final aggregate details have been prepared for the two years in order to understand the comparison of reduction in non-prime products in two successive years.

NATURE OF DEFECTS	Production amount in 2015 (Ton)	Production amount in 2016 (Ton)
HIGH OVALITY	234.386	95.132
UTS CHANGE	316.042	40.11
GUIDE FAILURE	27.075	0
MULTICUT & JUMBLE	112.159	17.062
UNCOOLING	31.197	0
FINNING	15.259	53.932
LAPPING	39.491	30.254
REJECTION	86.608	5.556
CONVEYOR HOLD	77.144	124.823

TABLE I. PRODUCTION OF DEFECTIVE PRODUCTS IN 2015 & 2016

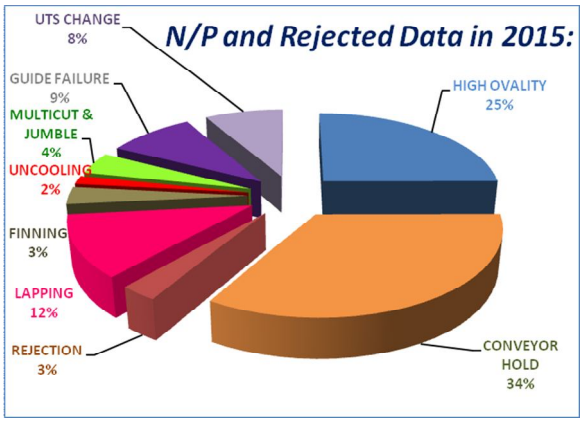


FIGURE 12: REJECTED PRODUCT IN 2015

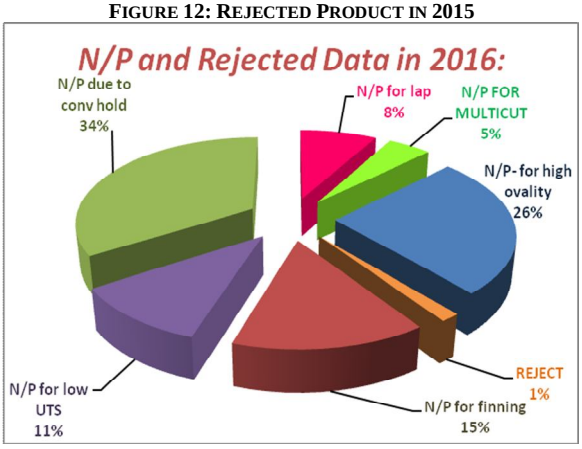


FIGURE 13: REJECTED PRODUCT IN 2016

IV. ANALYSIS OF DEFECTS

When there is the vivid analysis on the causes of the Non-Prime and Rejected products formation for the years 2015 and 2016, it is found that there is the formation of the about 96% Non-prime products along with 3% Rejected products. Amongst the Non-Prime products there are several reasons for the formation of these products which causes a huge loss of Rs. 8000 per ton for the company. The causes of such a vast loss are as follows:

- *Conveyor Hold:*

A conveyer hold can be defined as the stacking of the semi finished products on the Stelmore conveyor, thereby, having the unwanted cooling resulting in the alteration in the properties of the rod. In the Stelmore conveyer, the rods are cooled either by air cooling by electrically driven blowers.

The stacking of the rod on the conveyer mainly occurs due to the front position and is seen in case of high carbon steel mainly where the front end of the rod gets stuck within the moving rollers or gets jumbled up while entering through the reform tub. The front end must fall at an angle of 270 degrees inside the spinal, but due to its softness, while coming out from the laying head at a temperature of around 900 degree centigrade, the front end of the rod gets displaced at any certain direction other than the required one, thus resulting in the stacking of the rod between the rollers and hence stops the normal cooling procedure.

For the last two consecutive years, the conveyer hold yields an amounting over 30% of the non-prime products which could probably be stopped by the precautions, like introduction of flappers in the delivery end of laying head in order to collect the front positioning of the rod.

- *Ovality:*

The Ovality can be defined as the deformation in the shape of the rod due to the deposition of extra materials over the spherical rod. It can be the consequence of the defects like fining and lapping which results in a high percentage of non-prime materials of around 25% for the past two consecutive years.

This mainly occurs due to the incorrect parting between the stands where the guides may be displaced during pass change due to which the alignment of the passes and guides are changed resulting in the oval structure of the rod.
The rolling gap between the two rods must be of 12 meters in order to differentiate between them, but when the gap decreases and comes one after another then there will be size reduction due to improper parting between the rods resulting in the ovality.

- *Finning:*

The fining can be defined as the external growth of the rod in form of fin like structure which results in the lapping and ovality of the rod. Finning can be of two types: Sharp Fin and Fin in form of lap where the sharp fin projects outward of heated billet and lap will

be in the inside of heated billet. This defect has been increased to a huge extent in 2016 to 15% whereas in the year 2015, it was to the tune of only 3%.

The threat of fining occurs due to the displacement of the passes where the two rolls held one above another. The main reason of fining will be the variation in the rolling parameters where the heating cooling and the speed of the rolling will play an important role in determining the prime materials.

It can only be prevented by the preventive maintenance and periodic inspection of the alignments of the guides and passes.

- *Lapping:*

Lapping is a similar type of defect where there is an excess deposition of metal on the rod due to irregular rolling of the rods. The defect of lapping is almost constant and rather decreased in 2016 by 4%, where 2015 holds a percentage of 12% lapping.

The main cause for this defect is the wearing out of the passes where the pass, alongside been worn out, increases the vacancy in the shoulder part thus hindering the stress applied for compression in the shoulder part and thereby increasing the overlapping.

It has been reduced to a great extent this year by 4% by adopting proper maintenance and preventive measures where the formation of the fins are prevented and wearing out of the rolls are periodically taken care of.

- *Multicut and Jumbled:*

The jumbling of the rod can be defined as the removal of the stucking materials in the path of its movement along with the breaking of the rings in the laying head. The non primitivity of the rod due to multicut accounts to a constant amount of 4-5% in the last two years.

The material defects like piping and porosity may cause breaking or detachment of the rings while moving through the laying head and results in the multicutting of the rod and this inculcates in the jumbling of the rods in the laying head.

It can be checked by various measures. The bars need to be checked per heat number, where checking will result in the detection of the defects like piping and porosity which may be present in the billet and thus reduce the multicut of the rod.

- *UTS Variation:*

The UTS variation is a major problem which will alter the desired properties of the rod and as a result it will not be able to fulfill the demands of the customer resulting in the formation of nonprime materials. This UTS variation will take place due to the imperfect functioning of process parameters in the path of the formation of the wire rod.

The main reason for the variation in the UTS depends upon the improper cooling in the process parameters. The rolling depends on the heating of the billet in the furnace. Thus, the product will be having the temperature tolerance of more than 20 degrees and will result in UTS variation in the material.

The remedy for keeping the UTS unaltered is to properly check the entire heating and cooling process and to have proper control over heating and cooling procedures, to ensure proper inspection in subsequent intervals.

- *Guide Failure:*

One of the serious defects leading to non prime products is guide failure. The guides are the certain holds or an obstacle which direct the billet and places them inside the pass in a proper manner and direction. When there is a displacement of the guides from the entry path of the rolls during the time of pass change, this will result in the guide failure.

The main reason for the guide failure is the improper lubrication of the guide where the guides are not provided the air-oil mixture properly.

The main precaution which is to be taken is to confirm that the air oil mixture must always flow to the guide continuously so that for easy gripping the path of the guide is lubricated.

- *Uncooled:*

This is another reason for the non primitivity of the materials, though occurs at a very low amount but still is very harmful for the production of rods in the plant.

But if the rod is not cooled to the desired extent and the over-heated bar moves to the laying head for the spherical coil formation, then there will be the distortion in the property and will result to the formation of non-prime products. In the WRM plant it is good to see that there is a very amount of uncooled non-prime wire rod formation in the last year 2015 which has been reduced to nil in this year of 2016.

It can be avoided by cutting the front and the rear part by trim shear and chopping shear respectively. Also the billet should be uniformly heated with absence of temperature variation inside the reheating furnace.

- *Rejection of materials:*

The materials which have high and maximum non primitivity are rejected unconditionally and result in scraps. They are either thrown away, or sold as scraps, or are kept as rejected standard of materials. The largest amount of rejection results due to sharp fins that exceeds the tolerance level and hence are rejected.

The rejection of materials have been reduced to 1% till 2016, but still if proper maintenance and care is undertaken then rejection of materials will be nil and will never occur again resulting in a comparative high profit for the company.

V. COST EFFECTIVENESS WITH ELIMINATION OF DEFECT

It is necessary to know that the defects are mainly predominating in any of the particular type of grades of the billet. From keen observation it is seen that there are 8 reasons for the formation of non prime materials and they occur in particular grade types.

Ovality is observed in *SAE1008, PSC116* and *HC71/75*. **Conveyor hold** is mainly observed in almost all the grades of *High Carbon Steel*, **Finning** is seen in *Boron Grade, High Carbon Steel* and in *SAE1008, SAE1018* predominantly. **Lapping** is seen in *SAE1010, SAE1018,* and occasionally in *15B25* and *High Carbon Grade*. Similarly, **Multicut and jumble** is seen in *Low carbon steel*, **UTS change** in all grades of *High Carbon Steel*, mainly *HC76/80, HC81/85.*

The proper carrying out of remedial measures and preventive procedures can ensure the success of our proposition. In the commercial approach, these failures in the production lead to loss of the company and henceforth cost-effectiveness has been considered along with the irradiation of the defects.

The company used to produce raw materials of varying grades which have different cost of production. The rates of the grades differ and hence the profit from them will obtain accordingly.

Cost of **Mild Steel grade** (**type of Low Carbon**) = *Rs 25000 per ton.*
Cost of **High Carbon grade** = *Rs 25500 per ton.*
Cost of **Value Added Grade** (**Boron grade**, **Alloy grade**, **Electrode & Welding grade**) = *Rs 28000 per ton.*
Cost of **Low Carbon Steel grade** = *Rs 24000 per ton.*
Cost of **MIG** (**Weld-MIG Grade**) = *Rs 24000 per ton.*
Considering all products at a stake, i.e., the average cost of all grades = *Rs 26000 per ton.*
From the finished products, the **prime goods** are sold at *Rs 33000 per ton*.

From these cost details and the nonprime data already available to us, we have calculated the net probably savings in the fiscal year 2016 and net loss for financial year 2015-16.

Non-prime	Non-Prime in ton'15	Non-Prime in ton'16	Prime Profit Rs.	Non-Prime loss in Rs	Savings in Rs
High-ovality	234.39	140.63	1265684	843790	2109474
Conveyor Hold	316.04	92.954	697151	697151	1394303
Finning	31.197	31.197	280773	187182	467955
Rejection	27.075	18.05	126350	144400	270750
Lapping	112.16	112.16	1009431	672954	1682385
Multicut & jumbled	39.491	39.491	355419	236946	592365
UTS change	77.744	77.744	583080	583080	1166160
Guide failure	86.608	86.608	779472	519648	1299120
Uncooling	15.259	15.259	114443	114443	228885
Target Total savings in Rupees in 2016					9211397

TABLE II. TOTAL SAVINGS ESTIMATED BY ERADICATION OF DEFECTS

Thus from the above calculations it clearly there can a profit of Rs 9211396.8, ie, in words, around Ninty-two lakhs of amount can be saved in this fiscal year, 2016. Thus the thought of Cost-Effectiveness came through the elimination of defects, which can save the several hundred lakhs of money for the Indian Industry.

Financial Month	Total quntity of non prime in tonnes	Non-prime in Rupees	Prime in rupees	Loss incurred
15-Apr	53.773	967914	1774509	806595
15-May	70.158	1262844	2315214	1052370
15-Jun	59.208	1065744	1953864	888120
15-Jul	115.352	2076336	3806616	1730280
15-Aug	74.735	1345230	2466255	1121025
15-Sep	150.584	2710512	4969272	2258760
15-Oct	83.082	1495476	2741706	1246230
15-Nov	98.235	1768230	3241755	1473525
15-Dec	70.239	1264302	2317887	1053585
16-Feb	84.215	1515870	2779095	1263225
16-Jan	91.749	1651482	3027717	1376235
16-Mar	30.916	556488	1020228	463740
Total loss incurred in financial year 2015-16				14733690

TABLE III. TOTAL LOSS INCURRED DUE TO DEFECT IN 2015-16

From this above simulation it clearly visible that there is loss of Rs 14733690, i.e., in words, the company has incurred a loss of amount around One crore fourty seven lakhs in this financial year, 2015-16. This huge amount of loss incurred by the corporation can be eradicated by considering only a few practical remedial measures which have been mentioned for each of the defects. The proper technical utilization of resources and eradication of loop-holes not only limits itself to technology but directly influences the commercial and economic aspects.

CONCLUSION

It is clearly seen that in some of the cases, the causes of the non-prime products have increased in 2016 which is not at all permissible and wanted in the production. Also it is good to see that many of the factors have turned out to zero in the same year and it is the challenge of the company to reduce all the factors to nil to have the maximum profit for them. Now we are going to compare the reduction of the factors for non-prime products graphically for the year of 2016 with respect to 2015.

The comparison of both the years indicates the changes in the amount of defects incurred due to changed conditions. It encounters ad-hoc factors and abridges the required clarifications for product and quality empowerment.

CAUSES	2015 Percent	2016 Percent	Reduction (%) in 2016
HIGH OVALITY	25	26	-1
CONVEYOR HOLD	34	34	0
REJECTION	3	1	2
LAPPING	12	8	4
FINNING	3	15	-12
MULTICUT & JUMBLE	4	5	-1
UTS CHANGE	8	11	-3
GUIDE FAILURE	9	0	9
UNCOOLING	2	0	2

TABLE IV. COMPARISON OF DEFECTIVE PRODUCTS IN 2015 & 2016

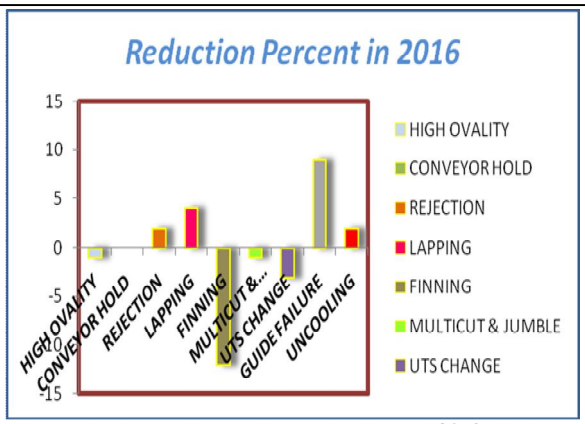


FIGURE 14: REDUCTION PERCENT IN 2016

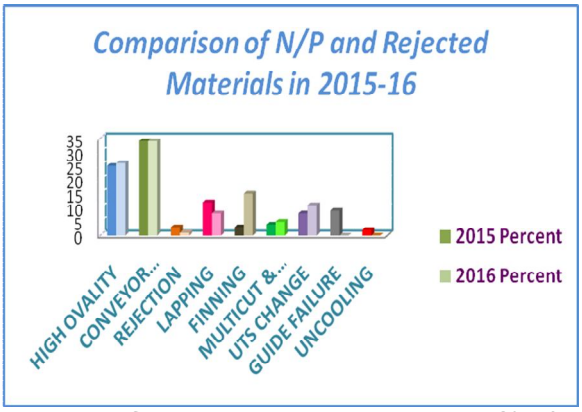


FIGURE 15: COMPARISON OF REJECTED PRODUCT IN 2015 & 2016

The fixed costs of lighting, plant rent and installations do not vary from year to year. This research can be used as a reference to influence the indirect costing due to defect increment and its corresponding decrease due to proper maintenance from the commercial aspect. From the economic aspect, it can be used as a standard for anticipation of losses due to probable reduction of defects. From the technical point of view, new machines and more efficient quality checking devices can be invented to ensure much more coverage of quality data and product character. Newer processes and techniques of sampling can be utilized. This project is a connector between technology, commerce and economics which can be utilized by future geniuses to uphold their brainstorming innovations.

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[6] ASTM E112-13, Standard Test methods for Determining Average Grain Size
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