Performance Analysis using OEE

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Abstract-- Any firm typically made a large investment in a piece of capital machinery and, in theory, it could run 24 hour a day for seven days a week at its optimum Speed. If it did this you gain the maximum value from the investment. In reality there is number of element that can affect the value gained from the investment. So that fully utilization of equipment can be done. Hence for fully utilization of any equipment any firm must have to calculate OEE. This paper represents the methodology applied in increasing the OEE of an Organization by exchanging the feed mechanism from Bowl Feeder to a Conveyor.

Keywords: OEE, Conveyor, performance ratio.

1. INTRODUCTION

In every developed country, it is the manufacturing industry that has spurred economic growth. It not only creates wealth but more importantly, absorbs and recreates the same many times over, within the economy. This is also true for India where the growth in manufacturing sector will provide the necessary impetus to a sustained growth of the economy forward and create employment opportunities for our people.

Nowadays many companies are interested to improve their maintenance system. Because, they have come to know that this is the system through which companies can reduce the cost of their products and can develop a reliable production process. A well designed maintenance structure can be helpful for the companies to get the competitive advantages. But majority of companies are not able to manage a maintenance system. The two main reasons for that are the lack of proper measurement and the lack of control systems for maintenance. The main goal of the maintenance is to reduce the failures of the industrial plant, machinery and equipments. This goal can be achieved by using different maintenance approaches such as corrective maintenance and preventive maintenance etc. A good maintenance approach and schedule can not be 100 percent effective at all the time. Unforeseen equipment breakdowns and requests reduce the efficiency of the plan. Even now a good maintenance schedule can get 70 to 90 percent efficiency. The idea with this project is to see the current situation of the company. Is the company using its manufacturing equipments in a proper way to get the competitive advantages? If not, then find out the main reason for that. Which kind of problem is there i.e. availability, quality or performance efficiency?

Vibratory bowl feeders are common devices used to feed individual component parts for assembly on industrial production lines. They are used when a randomly sorted bulk package of small components must be fed into another machine one-by-one, oriented in a particular direction.

Orientation relies on the shape and mechanical behaviour of an object, particular the position of its centre of mass in relation to its centre of volume. It thus works well for parts with rotational symmetry and a clear asymmetry to one heavy end. The exit orientation of a bowl feeder depends on the part's shape and mass distribution. Where this is not the orientation needed for the following assembly step, a feeder is often followed by a twisted conveyor that turns the part over, as needed.

With increasing integration across an entire production process, the need for feeders is sometimes reduced by supplying the components on tape packages or similar, that keep them oriented the same way during shipping and storage. These are most common in fields such as electronics, where components must be used in a particular orientation, but this cannot be detected mechanically.

OEE is the series of matrices which can be use for the utilization of machine at the job level, shift level, overall plan or enterprise level. Any firm typically made a large investment in a piece of capital machinery and, in theory, it could run 24 hour a day for seven days a week at its optimum Speed. If it did this you gain the maximum value from the investment. In reality there is number of element that can affect the value gained from the investment. So that fully utilization of equipment can be done. Hence for utilization of any equipment any firm must have to calculate OEE.

OEE is stands for overall equipment effectiveness. Essential it is a single figure that signifies the utilization of machine. This can be at a job level, shift level, overall plan or enterprise level. OEE is a measure of total equipment performance. OEE is also a three part analysis tool for equipment performance based on actual availability,
performance efficiency, and quality of product or output. OEE is used in two format "OEE data (information)" (the original intent) and a calculated "OEE percentage." OEE data (information) are quantified loss reasons categorized by specific equipment related loss types. OEE percentage is a calculated relative comparison metric used for a specific equipment or process over a period of time.

OEE is broken down into three measuring matrix of:
1) Availability ratio (AR)
2) Performance ratio (PR)
3) Quality rate (QR)

A. Availability Rate (AR)
The availability rate is the time the equipment is really running versus the time it could have been running. A reduced availability rate is an indication of equipment failure and issues around setup and adjustment

Availability Rate = Run Time / Total Time

B. Performance Rate (PR)
The performance rate is the quantity of material produced during the running time versus the quantity of material that could have been produced when taking in to account the manufacturers documented speed of the equipment. A low performance rate can be seen as a result of idling minor stoppages and reduced speed operation

Performance Rate = Actual Prod. / Standard Prod.

C. Quality Rate (QR)
The quality rate is the amount of acceptable material versus the total amount of material that is manufactured. A low quality rate is an indication of startup losses and the amount of scrap material.

Quality rate = Good Count / Total Count

II. CALCULATION OF OEE WITH BOWL FEEDER
By definition OEE is calculated as the product of availability, performance and quality rate

OEE = AVAILABILITY x PERFORMANCE x QUALITY RATE

In HARSHA ENGINEERS LTD. on 10th of November the data for OEE during one shift as below.

SPM of press = 250
L+UL time = 3
Batch no = SLAC1211141
Item = 32205 BJ2 (T8-line) SKF
Shift A
No of pockets = 18
Line 4A

1) Now for the calculation of Availability,
   Total availability = 510 min
   Available Min = 425 min
   M/c Cleaning = 60 min
   So, by definition of availability,
   Availability Rate = Run Time / Total Time
   Here run time is 425 and total time is 510
   Availability % = 425/510
   Availability % = 83.33%

2) Now for calculation of performance rate
   Piece per minute = 8.19
   Standard production rate = Act. Planned min. x piece per min. = 3480.00
   Performance efficiency % = Actual. Production / standard production = 2750 / 3480
   Performance efficiency % = 79.02 %

3) Now for calculation of quality rate,
   No. Scrap part = 20
   By definition of quality rate,
   Quality rate % = Good Count / Total Count.
   = 2730 / 2750
   Quality rate % = 99.27%

Now by the definition of the OEE, OEE is calculate as,

OEE = AVAILABILITY x PERFORMANCE x QUALITY RATE
= 83.33 % x 79.02 % x 99.27 %
OEE = 65.36 %

III. WORLD CLASS OEE
OEE is essentially the ratio of Fully Productive Time to Planned Production Time (refer to the OEE Factors section for a graphic representation). In practice, however, as we discussed above OEE is calculated as the product of its three contributing factors:

OEE = Availability x Performance x Quality

This type of calculation makes OEE a severe test. For example, if all three contributing factors are 90.0%, the OEE would be 72.9%. In practice, the generally accepted World- Class goals for each factor are quite different from each other, as is shown in the table below.

<table>
<thead>
<tr>
<th>OEE FACTOR</th>
<th>WORLD CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVAILABILITY</td>
<td>85%</td>
</tr>
<tr>
<td>PERFORMANCE</td>
<td>100%</td>
</tr>
<tr>
<td>QUALITY RATE</td>
<td>100%</td>
</tr>
</tbody>
</table>

So as above,

OEE 85%

Of course, every manufacturing plant is different. Worldwide studies indicate that the average OEE rate in manufacturing plants is 60%. As you can see from the above table, a World OEE is considered to be 85% or better. Hence comparing organization’s OEE and world class OEE we seen that the company OEE is very low compare to world class OEE, so our target is to achieve that figure.

IV. DESIGN OF FLAT BELT CONVEYOR

i. Live load = \( \frac{c}{3.6 \times 3.6} = \frac{3 \times 10^5}{3.6 \times 252} = 3.30 \) kg/m
ii. Total Live Load = 3.30 × Length of conveyor = 3.30 × 1.8 = 5.952 kg.

iii. Dead Load = The load consist of weight of roller belting and drive pulley = 52.8 kg

iv. Belt pull = (A+B) × co-efficient of friction = (5.952 + 52.8) × 0.05 = 2.9376 kg

v. Effective Belt Pull = total belt pull × 1.25 = 2.9376 × 1.25 = 3.672 kg

vi. Tension T₁ = effective belt pull × T₁ factor = 3.672 × 1.42 = 5.2142 kg

vii. Belt width = = 110 mm

viii. Effective Tension (Tₑ) = Total empty friction + Load friction + Load slope tension

Here,
Return side Tension= Fₑ × W × L × 0.4
= 0.020 × 16.1 × 1.8 × 0.4
= 0.2318 kg/m

Total Empty friction = Fₑ × (L + tₑ) × W
= 0.025 × (1.8+3) × 16.1
= 1.5456 kg.

Carring Side empty Friction = Total friction – Return side friction
= 1.5456 – 0.2318
= 1.3138 kg.

Load Friction = F₁ × (L+ t₁) × C + H
= 0.025 × (1.8+3) × 3.30
= 0.396 kg.

Load slope tension = 3.6 × H
= 3.30 × 1.20
= 3.96 kg.

So, effective tension Tₑ = Total Empty Friction + Load Friction + Load slope tension
= 1.5456 + 0.396 + 3.96
= 5.9016 kg.

ix. Power Calculation:

\[ P = \frac{9558 \times 0.44}{3000} = 0.44 \text{ HP} \]

x. Motor RPM Calculation:

\[ N = \frac{9558 \times P}{Mt} \]

Here,
Mₑ = \frac{1}{2} × D × (F + µwg)
= 0.5 × 0.120 × (2.9376 + 0.3 × 16.1 × 9.81)
= 3.02 Nm

\[ N = \frac{9558 \times 0.44}{3000} = 1390 \text{ RPM} \]

Diameter of shaft:

Total Load on Shaft = total live load + dead load
= 5.952 + 52.8
= 58.752 kg
= 576.36 N

Load at Point C = load at Point D = \[ \frac{576.36}{2} = 288.18 \text{ N} \]

Here,

Bending Moment @ A=0
Bending Moment @ B=0
So,
\[ 288.18 \times 15 + 288.18 \times 165 = R_B \times 180 = 0 \]
\[ R_B = 51872.37 \]  
\[ R_B = 288.18 \text{ N} \]

Here,

\[ R_A + R_B = \text{Total load} \]
So,
\[ R_A = 288.18 \text{ N} \]

Bending Moment @ C = 288.15 × 15 = 4322.7 N-mm
Bending Moment @ D = 288.15 × 15 = 4322.7 N-mm

So, Maximum Bending Moment M = 4322.7 N-mm

Here Torque,
\[ T = \frac{P}{60} \times \frac{0.44 \times 746 \times 60}{2 \times 3.14 \times 1390} \]
\[ = 221328 \text{ N-M} \]

\[ = 221328 \times 10^3 \text{ N-mm} \]

\[ T_e = \sqrt{M^2 + T^2} \]
\[ = \sqrt{(4322.7)^2 + (221328 \times 10^3)^2} \]
\[ = 22.55 \times 10^3 \text{ N-mm} \]

We know, \[ T_e = \pi \times \tau \times d^3 \]
\[ 22.55 \times 10^3 = \frac{\pi}{16} \times 42 \times d^3 \]
\[ d^3 = \frac{16 \times 22.55 \times 10^3}{\pi \times 42} \]
\[ d = 14.2 \text{ mm} \]

take \ d = 18 \text{ mm} \]

V. CALCULATATION OF OEE WITH CONVEYOR

In Harsha Engineers Ltd. On 15th of March the data for OEE during one shift are as below,

SPM of press is 250
L+UL time 3
Batch no SLAC1303126
Item R - 30 - 76XJ NSK (SUZHOU, CHINA)
Shift A
No of pockets 18
Line 4A

1) Now for the calculation of Availability,
Total availability = 510min
Available Min = 405 min
Total Down Time = 105 min
So, by definition of availability,
Availability Rate = Run Time / Total Time
Here run time is 405 and total time is 510
Availability % = 405/510
Availability % = 79.41%

2) Now for calculation of performance rate,
Piece per minute = 8.19
Standard production rate = Act. Planned min. x piece per min. = 3480.00
Performance efficiency % = Actual Production / standard production = 3283 / 3480
Performance efficiency % = 94.33 %

3) Now for calculation of quality rate,
No. Scrap part = 179 pices.
By definition of quality rate,
Quality rate % = Good Count / Total Count.
= 3104 / 3283
Quality rate % = 94.55%
Now by the definition of the OEE, OEE is calculate as,
OEE = AVAILABILITY x PERFORMANCE x QUALITY RATE
= 79.41 % x 94.33 % x 94.55 %
OEE = 70.82 %

VI. COMPARISON OF OEE’S FOR BOTH SYSTEMS
1) Average OEE:

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Chart 1: OEE for Month of Aug 2012
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2) Availability ratio (AR):

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Chart 3: AR for Month of Aug 2012
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3) Performance ratio (PR):

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Chart 4: PR for Month of Aug 2012
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VIII. ANALYSIS OF DATA AND CONCLUSION

Now as above discussed data we can say after using conveyors OEE increases but the drawback is, AR and QR decreases. The reasons for this are as follow:

(1) Cages were falling down from the conveyors. Due to this, defects like bend, dent, missing of cages and line marks on cages were found. Now for avoiding this, guide ways of M.S. were placed on both the sides of the conveyor. Because of this, cages stopped falling. But now, by applying guide ways, the cage comes in the contact with the guide way material and this results in the dents in the cages.

To overcome this problem, we replaced the material of the guide way from M.S. to Aluminum because of its low wear rate. Also nylon rubber sheet were introduced between the material contacts so that it doesn’t go weak and dents were avoided by this.

(2) The above mentioned remedy was useful to stop the falling of the cages but as we all know the capacity of the facing is double than that of notching. So whenever 1 piece undergoes the notching operation, 2 pieces finishes the facing operation. Now due to this the conveyor gets filled within 4-5 minutes and cages have to stay awaiting one over the other.

(3) Since the cages are not arranged in a proper manner on the conveyor, it results in uneven loading in the notching process and it doesn’t fit on the collets. Due to this, defects like bottom height variation, pocket missing and pocket shifting are generated.

(4) For the solution of this problem we placed block sensors in such a manner that its master panel is functioned with ON-OFF Delay Time for the Facing process. Here the facing machine is given the ON Delay Time of 2 seconds and OFF Delay Time of 3 seconds.

(5) But due to this, feeding has to be done manually in different parts in accordance with the part numbers. If this was not done, the cage would overflow and ultimately defect gets generated.

(6) This way by using conveyor OEE is improved as per our target. PR increases up to 14.49% but AR gets decreased by 5.13% and due to the generation of various defects QR also foes down by 3.46%.

As discussed above AR goes down because of the following losses:

(1) Set Up Losses: Suppose cages gets fit unevenly on the collets and when the notching process starts, according to the cage design there remains gap between the cage and the die punch, die punch has to be re-grinded and during this period machine remains OFF which ultimately affects the A. Also “BU  S” are seen on the cages.

(2) By die punch re-grinding tool rework loss increases and this also directly affects the AR.

(3) After the die punch re-grinding, its settings are configured. Then onwards 2-3 pieces are hindered for quality checking which affects the QR and rejection is also increased.

(4) Lines are often reset because either cages fall down or get blocked or gets one over the other. This generates “Line Organization Losses”.

(5) After making the die punch it has to be set and adjusted according to the measurements. In this way this loss is also generated.
Ultimately AR reduces to 5.13 %, PR Increase to 14.49 % and QR reduces to 3.46%.

This way we started the analysis again. Our target OEE is 85% whereas OEE achieved is 70.91 % so further modifications are to be done by analysis and data collection.

IX. CONCLUSION

For fully utilization of any equipment any firm must have to calculate OEE. This paper represents the methodology applied in increasing the OEE of an Organization by exchanging the feed mechanism from Bowl Feeder to a Conveyor. Hence our main focus is on first pillar i.e. overall equipment efficiency. Today Harsha’s bench mark is 70% OEE. But as per world class OEE measure is 85% for a single line. So we have to achieve that target for achieving company’s goal. So after achieving 85% OEE we have increase the production. Also improve in quality of product and performance of machine.

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