Towards Rational Maintenance

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General

One may often come across statements like"We have a superb maintenance team and therefore we do not worry about maintenance because any breakdown is attended immediately". With these type of statements the question arises whether the plant is maintained properly or the fire is put out only after its appearance. Maintaining the plant throughout its lifetime involves the advice on new plant, examination upon arrival, planning and installing, instructing operators, servicing during operation, testing and research and finally disposal & salvage. In short a rational maintenance programme should maximise the running time (hence minimize the downtime) and minimize the maintenance costs. A rational maintenance programme to achieve the aforesaid objectives should incorporate the following features. They are :

1. Selection of the correct type of machinery.
2. Proper translation of manufacturer's recommendations into forms for periodic checking.
3. Proper Lubrication.
4. Proper documentation of the history.
5. Identification of the Key Plants and Catering Plants.
6. Lifetime estimation of spares.
7. Inventory control and purchase procedures.
8. Preventive maintenance and Breakdown maintenance.
9. Breakdown analysis and Research and Development work.
10. Method study with respect to the repair work and modern tools.

Preparatory Work

<u>Selection of the current type of machinery</u>

Standardisation of plant and machinery is the term used to buy or install similar units from the same manufacturer in order to minimize the inventory in the maintenance stores. Another chief advantage of standardisation is the job specialisation and equipment specialisation. For instance if there are 15 or 20 engines of similar type it is worthwhile training a special crew to maintain them and buy special equipment to maintain them. Before making the final decision on the machinery to be installed one has to consider the conditions prevaling in the surroundings. For instance when a particular type of bearing is lubricated by ordinary multi-purpose grease, one has to make sure that the working temperature of that bearing is much less than the melting point of the grease. Similarly if we are installing an engine which takes in air for combustion or compression one has to make sure that the air filtering unit is capable of handling the entire dust load in that particular atmosphere. Similarly the loading conditions, loading patterns and all other similar aspects have to be considered when the selection of the machinery is done. This will otherwise result in more breakdown and therefore more maintenance.

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Proper Translation of Manufactures Recommendation into forms for periodic Checking.

When a plant or machinery is designed, it will have a range of operating parameters for efficient operation. The manufacturer will generally give these best operating parameters and the routine maintenance programme for efficient operation. This operation manual should be read and understood by the maintenance engineers who translate these ideas into forms for periodic (daily, weekly, quarterly, monthly and yearly) checking, filled by semi-skilled workmen who normally carry out checking. These forms should be so formulated that the answers to be filled in consist of either one word or just a few words. Basing on the past experience the maintenance engineer can decide whether to increase the frequency of checking or reduce the frequency of checking (different from the manufacturer's recommendations).

Proper Lubrication

When there is relative motion between two mating parts there will be energy dissipation, due to friction, in the form of heat. This energy dissipation will increase with the increase of the co-efficient of friction and the heat generated will damage the parts. In order to minimize the friction and thereby the harmful beat generated lubricants are introduced between the mating parts. It is not the intention here to describe all about lubrications. However it is a general principle accepted among maintenance engineers that half the breakdowns could be eliminated if proper lubrication is ensured. The manufacturer in his operations manual will indicate the lubricants that should be used for each unit. He will indicate the level for filling and also the time for changing the lubricant. It is always advisable to use the lubricant advised by the manufacturer. However there are instances where one would not be able to find the specified lubricants. In those instances the general practice is to refer the case to a lubricant manufacturer to get an equivalent. This sometimes brings in lubricants which affects the performance of that particular unit. It is therefore essential to have a full documentation of the entire subject and also to follow up for any difference in performance. It is also important for the maintenance engineer to make sure that the substitute does not have any side effects. The lubricants should be checked frequently for the levels and availability.

Proper Documentation of the history

The term history includes the history of the plant, its capacities and capabilities, the history of breakdowns, the components or spare parts replaced the number of man-hours utilized, the average life quoted by the manufacturer and the actual average life of the spares and any other relevant information. It is therefore essential to start documentation as soon as the decision to purchase a machinery is drawn.

It is always advisable to write a brief note as to why the purchase of that machinery with the capacity was selected. These documents will in-turn act as a source of data for future planning. This also will provide data for research and development work and method study. The documentation format should be prepared in such a way that all the relevant information is readily available to the reader.

Identification of Key Plants and Catering Plants

In most industries the product of one plant unit goes as the raw material for another plant unit, until the final product is made. For instance consider a process plant with 5 plant units A, B, C, D, and E where the product of A is further processed in B and product of B is further processed in C and so on. It is a standard practice in plant design to have storage points for products of all A, B, C, D and E so that the entire industry need not be stopped because one plant unit is stopped. However all these plant units will not have the same importance.

The order of importance will depend on the cost of lost production and the availability of redundant capacity (which is determined by the cost) if it is in a process industry. For instance let us consider the process industry with the 5 plant units A, B, C, D and E. Unit A has excess capacity than unit B so that B need not to be stopped for want of raw material for limited stoppages of A. Similarly B has redundant capacity than C and C has excess than D. Due to cost of the plant and cost of starting and stopping plant D has less capacity than E. Also it is found that the cost of production lost is very high at D. Under these circumstances plant D becomes the "Key Plant" and all other plant becomes "Catering Plants". The breakdown in the Key Plant immediately indicates a loss in production. Whereas the breakdown in the Catering Plant will not indicate a loss for a limited time.

Lifetime Estimation of Spares

Normal Distribution

In measuring the lifetime of a spare a scale is needed as the measure of variability. This scale is the computed standard deviation and is an estimate of the extent to which the observations will be scattered from the average value M. In a normally distributed event 66% of the occurences will be within ± 1 time the standard deviation s, from the mean, and 95% of the occurences will be within ± 2 times the standard s from the mean. The frequency of occurences, the mean and standard deviation s in a normal distribution is related as in figure I.

Examination of the curve in figure 1 shows that approximately 66% of the area under the curve is found between (m + s) and (m - s). Thus it would be expected that approximately 66% of the observation of some measured property would fall within these limits. Approximately 95% of the area would be within the limits (m - 2s) and (m + 2s). When s is small the curve will be narrower and when s is large the curve will be broader.

Lifetime of Spares

From the documentation of the history of the plant, the lifetime of any particular spare at every failure could be obtained. This will have a mean m and standard deviation s. Then one can be 97.5% confident that the mean lifetime of that particular spare is more than (m - 2s). Thus the value (m - 2s) could be assumed as the mean life time of that spare with 97.5% confidence.

Inventory Control and Purchase Procedures

Inventory control is the term used to maintain the stocks of spares and consumables at the optimum level. One such system of inventory control is the fixed order quantity system, where components are issued from stores and records called bin-cards indicating the stock levels kept. When stock levels reach a pre-determined re-order level a new order is placed to replenish stocks. Generally a buffer stock is kept. Order quantity is usually fixed and often is the Ecomomic order quantity.

Let B = Buffer Stock
L = Lead time in time units
R = Average demand per time period
S = Standard deviation of demand per time period
K = Constant depending on risk of being out of stock. (From normal distribution chart, for instance if the risk is 1%, K = 2.33)

The buffer stock required to protect against demand falling in section = B = $K\sqrt{LS}$ = $2.33\sqrt{LS}$ and Re-order Level= (LR + B).

Normally a two bin system is preferred where two bin cards are maintained for each item. One card always gives the quantity which is equal to the re-order level. The other card carries the excess over the working stock. When the working stock is over that card will read empty and immediately an order to replenish is placed.

Actual Maintenance work

Preventive Maintenance and Breakdown Maintenance

Having thus selected the correct type of machinery, translated manufacturer's instructions into forms for periodic checking, ensured proper lubrication, documented the history, identified the Key Plants and Catering Plants, estimated the lifetime of spares and enforced proper inventory control and purchasing procedures, the plant is ready for the actual maintenance work.

"Preventive Maintenance" is a method where the plant is deliberately stopped periodically and all the parts which are expected to fail before the next planned stoppages are replaced with new ones, even though they have some more lifetime before failing. This will reduce the downtime by interim failures of the worn-out spares. "Breakdown Maintenance" is another method where all the units or spares that fail only are replaced.

Normally the cost of a breakdown is made up of two components, namely:-

(i) Cost of the repair and
(ii) Cost of loss in production.

The cost of the repair is the cost of spares used and the cost of labour. The cost of the loss in production is the cost of the production lost because of the stoppages for the breakdown and repair. Limited stoppages of the "Catering Plant" do not produce any loss in production because of the redundant capacities. However any stoppage in the "Key Plant" results in production losses. Generally the cost of production loss is very much higher than the cost of the repair. A rational maintenance proframme will therefore adopt preventive maintenance programme for the Key Plant" and breakdown maintenance programme for the "Catering Plant" of an Industry. However the functions described in the preparatory work must be done for all the plants. The life estimate and the history of the plant should be used to decide the units to be replaced in a preventive maintenance programme.

Breakdown Analysis and Research and Development Work

All the breakdowns should be properly documented so that the lifetime, condition of failure, operating condition before failure and all other relevant details are available for the engineer to carry out the breakdown analysis. From the past history the average lifetime of the component could be calculated.

From the manufacturer's specifications the expected average life could be obtained. If there is a vast difference then it is a good case to study. Furthermore if there is an unusual change in the breakdown pattern there again a case - study is needed. Another area for Research and Development Department is to identify quantum of maintenance work and study better ways and methods to increase the lifetime of spares and reduce the quantum of work which occurs frequently. The breakdown analysis is mainly done to reduce the downtime and to introduce better methods to improve the life of the machinery.

Method Study with Respect to the Repair Work and Modern Tools

The method which is practised to dismantle, clean and assemble a plant and machinery, may be an old one with the use of tools and equipment available at that time.

With the advancement of science and technology, specially in the field of electronics new equipment and tools have come into existance. This equipment may ease down the work and cut down the downtime. It is therefore, essential for the Research and Development Department to carry out a periodic method study to keep in pace with the advancement of science and technology.

If a maintenance system incorporates all these features, then it is a rational system. With such a system the risk of running out of stock is pre-determined. With proper staffing and other managerial functions such as scheduling of jobs, the maintenance work will proceed impersonally. When such a system is in operation it also becomes a place where research and development can commence at any time because it has all the past data in records. With the preceding analysis one can now answer for oneself whether our maintenance is rational.

Bibliography

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