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**An Optimal Maintenance Strategy for Effective Utilization of Engineering Workshop in
Technical Institutes**

Yogesh P.Deshmukh

Mechanical Engineering Department,
G. H. Raisoni College of Engineering & Management, `
Amravati- 444603 (M.S), India

Abstract

Engineering workshop at the institute level is an important instructional area in the campus. It is subjected to frequent changes in operators after one batch of student to another. Workshop Supervisor and instructors face an uphill task to maintain the machine tools to be made available to students in good state of condition. Lack of experienced maintenance personnel and unavailability of time slot in the working hours leaves the machine tools unwarranted to any of the standard maintenance procedures. It is common scenarios in every institute to witness machine tools are under maintenance and less numbers available in commensurate to the students in the batch of 15 to 20. The paper recommends the combination of Preventive and Condition-Based Maintenance procedure to be followed to ensure all time availability of machine tools to the students in every batch. Recommendations on testing methods, maintenance plans is included to assist the Instructors and supervisor. Method of maintenance for several components of different machine tools is also elaborated.

Keywords: Machine tool, workshop, maintenance.

Introduction

Maintenance

General

This research paper is proposed to set up suggested practice as well as to give broad opinion and direction in the maintenance of machine tools and auxiliaries in workshop at engineering institutes. Maintenance proposals are based on engineering standards and familiarity in workshop practice and manufacturing process facilities. Although, machine tools and situations vary to a great extent, and sound engineering and management decision must be used when considering these recommendations. Other sources of information must be checked (e.g., manufacturer's suggestions, strange operating conditions, own experience with the machine tool, etc.) in combination with these maintenance suggestions.

Preventive Maintenance

Preventive maintenance (PM) is an activity of maintaining engineering equipment on a customary schedule based on utilization timing or meter readings. The purpose of PM is to "avert" maintenance problems or breakdowns before they occur by pursuing routine and all maintenance procedures. The aim is to accomplish lesser, shorter, and more unsurprising outages.

Advantages of PM are,

- It can be anticipated, facilitating budgeting, planning, and arranging resources possible.
- When appropriately practiced, it normally prevents most of the problems, thus reducing enforced outages and hence reduction in maintenance costs.
- It assures supervisors that machine tools are in good state and is being maintained.
- It is easily to understand and justify.

PM also has some drawbacks,

- It consumes more time and resource intensive.
- While scheduling and performing the maintenance activity, it does not consider actual machine tool condition.
- Instead of solving, it can cause the problems in machine tools (e.g., damaging o-rings and seals, stripping threads).

Despite these demerits, PM has proven well in the past and is still the important one among the most maintenance plans.

Traditionally, institutional engineering workshop has been experiencing PM as the standard maintenance activity. The maintenance suggestions in this paper

should be assumed as “baseline” activity; based on PM philosophy, which can be implemented when supervising a maintenance program.

However, while applying PM suggestions due care is expected to be taken. Wholesale implementation of PM suggestions without considering machine tool condition may result in a extra workload. This may lead to the defeat of the objectives of pursuing PM, since important machine tools can get deprived of required maintenance. To moderate this problem, maintenance supervisors may prefer to use a consciously chosen, successfully implemented, and suitably drafted reliability-centered maintenance (RCM) plan.

Whether applying a PM, condition-based maintenance (CBM) or RCM plan, or a combination of all these, the main focus of the maintenance staff should be on scheduled maintenance. The highest priority should be given to scheduled maintenance than special projects.

Reliability-Centered Maintenance

RCM plans are fast in popularity and have been implemented in a few power plants with good results. The objective of these plans is to prevent enforced outages while at the same time getting rid of unnecessary maintenance by providing proper amount of maintenance at the right moment. Implemented properly, RCM can get rid of some of the disadvantage of PM and may result in a more focused, efficient maintenance plan. RCM seems very striking in times of less funding, non-availability of skilled maintenance personnel, and the stress to “stay online” because of electric service industry deregulation.

Some highlights of RCM are,

- At the initial set up, it may be time consuming and labor intensive
- To be effective, it may need extra monitoring of measurements like vibration and temperature. This may reason to new measuring tools with its self PM or more human supervision with multiple inspections.
- For some machine tools, it may result in a delayed maintenance attitude or “run-to-failure”, which may unease some supervisors and instructors.
- Based on the success of the previous maintenance schedule and machine tool condition, “trial and error” form of revisions may require at initial and later stages of maintenance.

- It should reflect in a more handy maintenance workload focused on the most significant machine tool.

RCM is not a reason to shift to a “breakdown maintenance” viewpoint or to do away with vital PM in the name of reduction in maintenance staff/funding.

However, to reduce problems related with a PM plan, maintenance supervisors may choose to apply a consciously selected, effectively implemented, and properly drafted RCM plan.

For a workable RCM plan at engineering facilities, it must:

- Be selected as the local maintenance viewpoint by management.
- Be put into practice according to generally accepted RCM plans.
- Be drafted so that maintenance proposals are defensible.

Condition-Based Maintenance

This plan emphasis on ascertaining the state of individual pieces of machine tool.

Features of CBM are,

- Monitoring machine tool parameters like temperatures, forces, pressures, tool life, vibrations, leakage current, etc.
- Testing when troubles are suspected and/or on a scheduled basis such as alignment testing, dynamometer testing, vibration testing, and infrared scanning.
- Monitoring carefully supervisor and instructor-gathered data.
- Reduction in overall costs by getting results in intelligent maintenance decisions by putting focus only on machine tools that actually needs attention.

CBM has some drawbacks for not so easy and expensive to judge some quantities. It demands knowledgeable and steady analysis to be effectual; and also condition monitoring machine tools and auxiliaries themselves need maintenance. Application of entire CBM program is not possible because of these drawbacks.

Combination of Preventive and Condition-Based Maintenance

As a matter of fact, PM and CBM combination is the most preferred practical approach. The valid information on when the machine tool should be maintained can be provided by the relevant Monitoring, testing, past data and PM schedule. If one keeps the perfect record of past maintenance performed on the “as found” state of the machine

tool, it is easy to resolve the maintenance problems at stake. In this way, based on monitoring and expertise, maintenance time table of the machine tools can be lengthened.

Maintenance and testing methods

General

Maintenance activities are classified into three broad categories:

- Routine Maintenance - actions that are carried out while machine tools and auxiliaries are in service. These activities are anticipated and can be programmed and budgeted. In general, these activities are planned on a time based or measure based plan resulting from predictive or preventive maintenance approach. Some cases are visual inspections, functional tests, cleaning, lubrication, measurement of working quantities, and oil tests.
- Maintenance Testing - actions that require using testing equipment to judge condition in an off-line state. These actions are anticipated and can be planned and budgeted. They may be planned on a time or measure basis but preferably be planned to coincide with planned machine tool outages. Since these actions are anticipated, some organizations consider them preventive maintenance or routine maintenance.
- Diagnostic Testing – Actions that require using testing equipment to check the condition of machine tool after abnormal events, such as machine tool failure/ its repair/ its replacement or when machine tool deterioration is suspected. These actions are not anticipated and cannot be planned because they are needed after a forced outage. Each organization must budget for such events. Some examples are headstock troubleshooting, centering, and vibration testing.

This paper addresses planning of maintenance actions as per first two categories. It does not feature follow-up work caused by routine or maintenance testing; also it does not feature diagnostic testing. Also, instructors and maintenance personnel may be employed for other actions such as developments and construction, but this paper does not feature these activities.

Maintenance plans and documentation

Entire, detailed, and current documentation is vital to a valuable maintenance program. Whether you are

practicing preventive, reliability-centered or, predictive maintenance, keeping track of machine tool situation and maintenance carried or planned is significant. Maintenance suggestions contained in this paper should be utilized as the basis to set up or refinement of maintenance schedule. Suggestions can be transformed into Work Orders or Job Plans in any maintenance management system. The moment these work orders and job plans are finalized, implementation of well-programmed predictive or RCM is feasible. The past maintenance record should be kept ready so as to readily refer while performing the maintenance activity at all times. This is of importance while planning and performing a current maintenance program and supports documentation required for all the machine tool reviews. Regular maintenance and unexpected maintenance must be properly documented, as also special work carried during overhauls and replacement. The all time availability of updated drawings to instructors and maintenance personnel is very most important. Accurate drawings are of much importance for current maintenance work, testing work, and new construction work; but they also are helpful during urgency for troubleshooting. In addition, perfect drawings are very important for the continued safety of the instructor and student working on the machine tool.

Machine tool maintenance

Packing/Mechanical seals

Packing

Using compression packaging is the most general way of controlling leakage from a gear shaft. The stuffing box contains many rings of packs with a packing gland adhering the packing in its place and also maintains the required compression.

Mechanical seals

Mechanical seals are used in all machine tool applications. Mechanical seals permit very little leakage and can be designed to function at high pressures. Correctly fitted mechanical seals have a long service life and need little maintenance.

Bearings

The function of the bearings is to position and hold the shafts of a machine tool. The bearings can offer axial support (thrust bearings), radial support (line or guide bearings), or both. The most universal types of bearings are fluid film and antifriction.

Antifriction bearings

While supporting a load by using rolling elements, rolling friction coefficient should be low. Hence, antifriction bearings are preferred over fluid film

bearing (sliding friction). The most common kind of antifriction bearings are ball and roller bearings, relating to the shape of the rolling elements in bearings. As per the load they are needed to support, bearings can be classified as radial, thrust, or radial-thrust bearings. An antifriction bearing is an element manufactured with precision, and therefore during installation it is advised to take great care. During installation of any type of bearing, instructors or/and maintenance personnel must follow the instructions provided by the bearing manufacturer. While handling antifriction bearings, the main thing to be taken in mind is cleanliness. A little deposit of abrasive dirt or dust may lead to the wearing of bearings rolling elements; hence it is advised to clean the assembly elements from dust and dirt before doing installation work. The new bearing should be used as received from the manufacturer without being cleaned or wiped. Adapters and not hammers should be used to press the bearings on the shafts because it is pushed by applying same pressure over the inner race only.

Shaft couplings

To connect the driver shaft with the driven machine shaft, couplings are used. Two basic types of couplings are, rigid and flexible. Rigid couplings with threaded and flanged type are widely used. Just the periodic maintenance or lubrication at the most is required to maintain the couplings in good state if it is initially properly aligned.

Shaft alignment

Misalignment is found and many a times with a serious problem. Improper alignment can cause untimely wear or failure of bearings, shaft couplings get overheated, and, in some cases, torn or broken shafts. Although, the type of machine tool and its design decides the procedure for alignment.

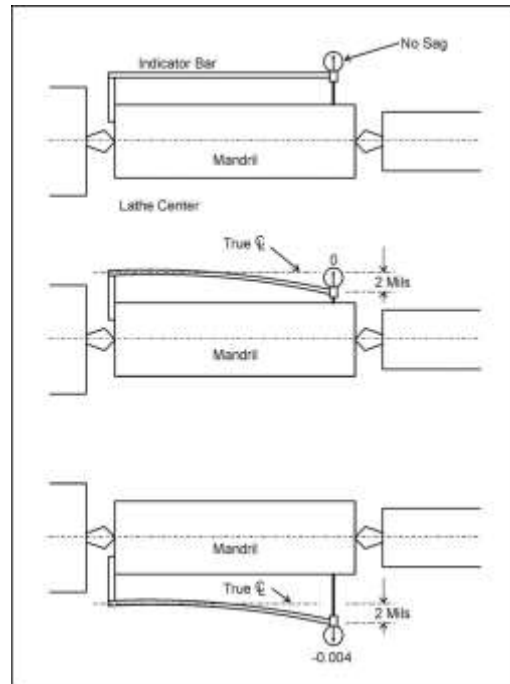


Fig.1 Checking indicator bar for sag

Face and rim alignment method

The face and rim method of alignment utilizes a dial indicator attached to one of the coupling flanges to check for angular (dogleg) and parallel (offset) misalignment.

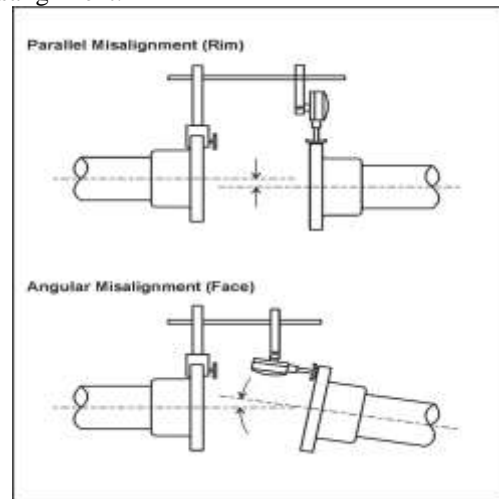


Fig.2 Face and Rim alignment method

Vibration monitoring and analysis

Preventive or predictive maintenance plan can get useful result by applying vibration monitoring and analysis. There is a range of vibration monitoring methods available. Permanent mounted and hand held sensors are used to monitor continuous level of vibration and readings to be noted periodically

respectively. The type of vibration monitoring system used depends on the machine tool being monitored. Before deciding on the vibration monitoring system for a particular machine tool, supervisor, instructors and maintenance personnel should consider the potential benefits of the system as regards to reducing downtime, safety point of view and overall cost.

Proximity probe systems

It is a non contact type of sensor. Relative to the position of the shaft, proximity probe senses its position by generating a corresponding direct current (dc). In an engineering workshop proximity probes can be used to measure the main shaft run out on the headstock or drive motor. A distinctive proximity probe having two radially mounted probes located at the guide bearing location; 90 degrees apart can be used. The shaft run out can be continuously monitored by the proximity probe, while the controls are centrally located to alarm or/and system shutdown indicating shaft run out. However, alarm and the shut-off points may vary from one machine tool to another. By experimental trial and error the set points can be adjusted.

Accelerometer systems

Vibration monitoring systems based on accelerometer which vary in its capability and complexity are available. This light in weight vibration sensors measures the electrical output proportional to the acceleration in the machine tool being checked. Accelerometer type systems measure frequency vibration upto 5 Hz and can be designed for even higher.

Signature analysis

A common way of examining vibration data is by using a spectrum plot. It is an X-Y plot in which the X-axis signify the vibration frequency, in cycles per second (Hz); and the Y-axis signify acceleration or velocity or displacement measure of vibration amplitude. A spectrum plot signifies operating frequencies of the functional elements of the machine tool being tested in the form of amplitude peaks. For that particular element of machine tool, the earlier plot presents the signature of its vibration.

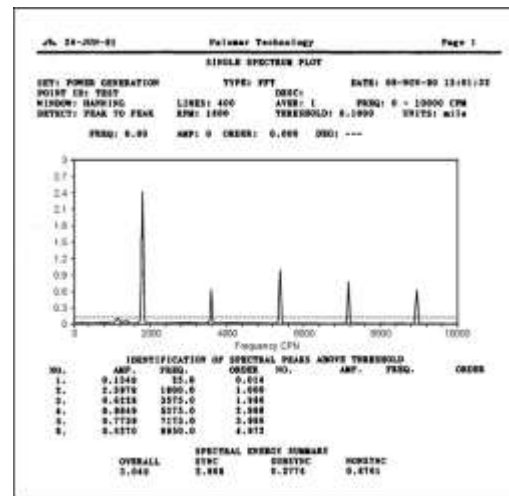


Fig.3 Spectrum plot

An operational problem may be highlighted in the spectrum plot with rise in amplitude or appearance of new peak in further plots. A signature analysis can be of great help while scheduling stoppages for bearing replacement. To perform vibration analysis, a basic understanding on properties of machine vibration and knowhow of the testing equipment is necessary. Training is offered by the developers of vibration monitoring systems.

Oil and Lubricants

The primary purpose of a lubricant is to decrease friction and wear in between two moving surfaces, but it also work as a coolant, get rid of corrosion, and provide protection against dirt and other contaminants. To achieve the desired purpose of using lubricant, due care is required while selecting the lubricant and also while applying it. The machine tool manufacturer also provides detailed information on the nature of lubricant with the method of application and on the scheduled maintenance for any sort of application.

Oil lubrication

Application of oil lubrication can take many forms but the intention is common to maintain a film of lubricant between the moving surfaces. For proper lubrication, it is quite certain that correct selection and correct application of oil is required, also it should be ensured to keep it clean without contamination. Characteristic of lubricating oil may vary from one application to another.

Grease lubrication

Lubricating oil in combination with thickening agent forms a lubricant called grease. The grease with 85-95% of base oil carries out actual lubrication. The thickening agent decides certain properties of the grease, as heat resistance, water resistance, etc.

Various property enhancer additives can also be added to get better performance.

Hydraulic oil

The main function of hydraulic oil is to transmit power, but it should also lubricate the elements of the hydraulic system.

Conclusion

Combination of Preventive and Condition-Based Maintenance procedure elaborated in this paper will certainly ensure all time availability of machine tools to the students in every batch. Suggested practice has the potential to enhance the life span of machine tools and its auxiliaries. Under such maintenance methodology, engineering workshop can work effectively under comparatively limited budgeted allocation by the management.

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