A Case Study On Predictive Maintenance Of Oj/5522 Dt-40 Cnc Milling Machine

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Abstract: This paper focuses on the application of the predictive maintenance technology on OJ/5522 DT-40CNC Milling Machine at Ordinance Factory, Nagpur. Predictive maintenance technique has designed to determine the condition of in-service equipment/machine in order to predict when maintenance should be performed. This approach promises cost savings over routine or time-based preventive maintenance. The purpose of this study is to familiarize maintenance personnel with the basic information necessary for servicing and repairing of DT40 CNC Milling Machine.

Keywords: predictive, preventive, maintenance

1. Introduction

The losses suffered by manufacturing companies due to machinery failure and downtime for repairs are pronounced. The predictive maintenance technology has been extremely useful in accurately diagnosing machinery condition to identify machine problems which is helpful in scheduling the necessary repairs and saved the companies thousands of rupees in terms of lost production and wasted manpower and materials or parts.

1.1 Predictive Maintenance:
Predictive maintenance is a set of activities that detect changes in the physical condition of machine (signs of failure) in order to carry out the appropriate maintenance work for maximizing the service life of machine without increasing the risk of failure. It is classified into two types according to methods of detecting the sign of failure:

1.1.1 Condition-based predictive maintenance: Depends on continuous or periodic condition monitoring equipment to detect the signs of failure.
1.1.2 Statistical-based predictive maintenance: Depends on statistical data from the meticulous recording of the stoppages of the in-plant items and components in order to develop models for predicting failures.

1.2 Problem Statement:
1.2.1 To investigate various problems that occurs in OJ/5522 DT-40 CNC milling machine.
1.2.2 To investigate various solution methods that follows to tackle with those problems.

1.3 AIM:
The aim of this work is to study the maintenance practices of the machine and investigate the best maintenance practice that would improve equipment reliability, predict failures, reduce maintenance costs and augment profitability.

2. Problems Occur in the machine:

2.1 Machine Introduction:
DT-40 machine is a compact CNC vertical milling machine with power, speed and accuracy. It comprises of three linear axes, cam operated high-speed auto tool changer and numerical control through CNC system of Fanuc Oil System/Siemens 802D system. DT-40 is designed to work as a stand-alone machine. DT40 has its two linear axes of motion below the spindle and third one over the column. All the axes are supported and guided by circulation linear motion bearing system in which LM blocks move on LM rails. Ball races are provided within the LM blocks and balls are recalculated through end caps. There are four rows of balls between LM block and rail with two rows on either side. Further, the contact angle of balls with rail is 45 degree thus ensuring equal load carrying capacity in all directions. Elastic deformation of balls can take care of large deviations in installation surfaces and smooth movement of LM blocks without excessive forces is possible. The machine consists of following parts: Compact 3-axes CNC Drilling & Tapping Machining Center& Main spindle built with integral motor with oil cooling for high speed applications.
2.2 Machine Specification:

**Table No.2.2.1: DT40 CNC Milling Machine Specification**

<table>
<thead>
<tr>
<th>Particular</th>
<th>Unit</th>
<th>BLITZ 30</th>
<th>DT40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drilling capacity in steel</td>
<td>mm</td>
<td>dia. 15</td>
<td>dia. 25</td>
</tr>
<tr>
<td>Drilling capacity in Aluminium</td>
<td>mm</td>
<td>dia. 20</td>
<td></td>
</tr>
<tr>
<td>Tapping in steel</td>
<td>M14</td>
<td>M24</td>
<td></td>
</tr>
<tr>
<td>Tapping in Aluminium</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Table size</td>
<td>mm</td>
<td>600x400x2</td>
<td>650x400</td>
</tr>
<tr>
<td>Traverse rate - X / Y / Z</td>
<td>m/min</td>
<td>30 / 30 / 12</td>
<td>20/20/10</td>
</tr>
<tr>
<td>Table traverse - X / Y / Z</td>
<td>mm</td>
<td>450/300/250</td>
<td>500/350/400</td>
</tr>
<tr>
<td>Spindle speed</td>
<td>rpm</td>
<td>12000</td>
<td>60-6000/80-8000</td>
</tr>
<tr>
<td>Spindle motor power</td>
<td>KW</td>
<td>3.7 / 5.5</td>
<td></td>
</tr>
<tr>
<td>ATC Tool Storage capacity</td>
<td>10</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Tool Shank model</td>
<td>BT30</td>
<td>BT40</td>
<td></td>
</tr>
<tr>
<td>Max. tool diameter</td>
<td>mm</td>
<td>50</td>
<td>80</td>
</tr>
<tr>
<td>CNC System</td>
<td>Siemens / Fanuc</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.3 Standard Values Specified by Industry:

2.3.1 NAS Value

**Table No.2.3.1 NAS Value**

<table>
<thead>
<tr>
<th>NAS Value</th>
<th>Condition of Machine</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 5</td>
<td>Ok</td>
<td>None</td>
</tr>
<tr>
<td>5 - 8</td>
<td>Alert</td>
<td>None</td>
</tr>
<tr>
<td>8 - 50</td>
<td>Danger</td>
<td>Filtration</td>
</tr>
</tbody>
</table>

2.3.2 Machine(Spindle)Vibration

**Table No.2.3.2 Spindle Vibration**

<table>
<thead>
<tr>
<th>Value Range (Hz)</th>
<th>Condition of Machine</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>Ok</td>
<td>None</td>
</tr>
<tr>
<td>10 – 25</td>
<td>Alert</td>
<td>Stock Procured</td>
</tr>
<tr>
<td>25 – 45</td>
<td>Danger</td>
<td>Change</td>
</tr>
</tbody>
</table>

2.3.3 Hydraulic Pressure

**Table No.2.3.3 Hydraulic Pressure**

<table>
<thead>
<tr>
<th>Hydraulic Pressure Range (N/mm2)</th>
<th>Condition of Machine</th>
</tr>
</thead>
<tbody>
<tr>
<td>33 – 40</td>
<td>Ok</td>
</tr>
<tr>
<td>30 – 33</td>
<td>Alert</td>
</tr>
<tr>
<td>01 – 30</td>
<td>Danger</td>
</tr>
</tbody>
</table>

2.4 Instruments used for Preventive Maintenance:

2.4.1 Stroboscope: It helps to find the damage by creating a virtual stationary image.

2.4.2 Laser Shaft Alignment Instrument:
The TKSA 41 is an advanced laser alignment solution for achieving accurate shaft alignments. With two wireless measurement units, large sized detectors and powerful lasers, the instrument performs precise measurements in even the most challenging conditions.

2.4.3 Refracto Meter:
The refractometer is used to check the ratio of water and coolant. In OJ/5522 DT-40 CNC Milling machine the ratio of water : coolant is equal to 2:1.

2.4.4 U.V. Oil Leakage Detection Kit:
It is used to find hair line leakage in machine part like tanks. The oil from the detection kit is poured into the oil tank. This oil gets accumulated at the leakage point, then the U.V rays are impinging upon the oil and the defected area gets illuminated with blue colour.

2.4.5 Renishaw Ball Bar Test:
The ball bar itself is essentially a very high accuracy, telescoping linear sensor with precision balls at each end. Two precision magnetic mounts, one attached to the machine table and the other to the machine spindle or spindle housing. In use the balls of the sensor are kinematically located in the magnetic cups. This arrangement enables the ball bar to measure minute variations in radius as the machine follows a programmed circular path around the mount on the machine table.

2.4.6 Machine Condition Adviser:
Machine vibration is check by Machine condition advisor. It is capable of acknowledging easily, quickly, and accurately the condition of rotating equipment throughout machine. Early warning of potential machine problems before a costly failure occurs. Vibration of spindle and bearings are checked when the spindle is in 1800 rpm. Vibration reading is taken in every rotating part by placing on both vertical and horizontal on casing of bearing.

2.4.7 Fluke Thermal and Infrared Imaging Instrument:
Fluke Thermal Imaging instrument is used to find temperature of different parts of machine. Any anomaly in temperature tells us about defect in that part. Overheating is a sign of trouble, if there is red bright zone it shows severe problem. It basically cause in moving parts.

2.5 Preventive Maintenance Schedule:
Complete preventive maintenance of Drilling and Tapping Machine DT40 is given below: To ensure proper operation of machine all the checks listed below should be performed at recommended intervals & any malfunction noticed while performing the checks must be rectified before resuming the operation.
2.5.1 Check List for the operator:
I) Daily Checks:
i. Check hydraulic reservoir oil level
ii. Check oil level in CENLUB lubricator and refill if necessary.
iii. Check the flood coolant level.
iv. Clean the machine daily after every shift.
v. Clean inside of spindle nose with lint free wiper.
vi. Clean all exposed limit switches and their trip dogs.
vii. Check that doors of the cabinet are properly closed and locked.
viii. Clean operator's panel of CNC with a clean piece of cloth.
ix. Record it any abnormal event happens on machine or near machine.
x. Check tool data in spindle and magazine before start of the work.
xi. Clean magazine pocket of ATC thoroughly whenever new tools are loaded in the magazine.

II) Weekly Checks:
(i). Clean entire machine including operator controls and hydraulic wipe is power pack.
(ii). Drain the airline filter bowl by releasing a knob at the bottom of the bowl with air pressure on. Secure the knob to its position after draining.
(iii). Check all hydraulic, coolant and air links including flexible hoses for any leakage or damage.

2.5.2 Check List for Maintenance Staff:
I) Daily Checks:
(i). Check hydraulic reservoir oil level and fill if necessary IOC servo-system 32 or equivalent.
(ii). Check oil level in CENLUB lubricator and refill if necessary IOC servo system 32 or equivalent.
(iii). Check the flood coolant level and refill necessary.

A) Check list for the Spindle:
(i). Rated speed is correct.
(ii). No abnormal vibration.
(iii). No abnormal sound.
(iv). No abnormal odour.

B) Check for axes motors:
(i). No abnormal vibration.
(ii). No abnormal sound.
(iii). No abnormal odour.
(iv). Check voltage at input to the machine. Corrective action immediately taken in power supply system in case voltage variation is found more than 415V, 15%.
(v). Check doors of cabinets are properly locked.

II Weekly Checks:
(i). Listen to hydraulic unit in operation and correct any abnormal sound.
(ii). Check all hydraulic / coolant lines including flexible holes for any leakage or damage pipes.
(iii). Check “axes lubrication” piping for any loose connection, broken pipe.
(iv). Insure that service switch is positioned at ‘0’ position for inhibiting machine parameter entry.

II Monthly Checks:
(i). Check the hydraulic oil cleanliness and replace if necessary.
(ii). Check X, Y, Z axes guide ways and ball screws for proper lubrication.
(iii). Check hydraulic system pressure at 25 kg/cm.
(iv). Check for proper function of end seals of LM blocks and replace any damaged seal.
(v). Clean the Interior of electrical cabinet preferably with a vacuum cleaner.

III Quarterly Checks:
(i). Check hydraulic pressure line filter, replace the element if necessary.
(ii). Check CENLUB unit filter, clean or replace if necessary.
(iii). Check all axes reference positions.

IV Annual Checks:
Check hydraulic pump/ motor alignment.

2.6 Problems Occur in the Machine:
2.6.1 Spindle Problem
2.6.2 Bearing Problem
2.6.3 Hydraulic Oil Pressure Problem
2.6.4 Hydraulic Oil NAS Value
2.6.5 Temperature change effecting properties of hydraulic oil.

3. Values Obtained After Using Preventive Maintenance:

3.1 Observation Table:

<table>
<thead>
<tr>
<th>Date of Observation</th>
<th>NAS Value</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>25th December,16</td>
<td>5</td>
<td>None</td>
</tr>
<tr>
<td>25th January,17</td>
<td>6</td>
<td>None</td>
</tr>
</tbody>
</table>

3.1.1 NAS Value

<table>
<thead>
<tr>
<th>Date of Observation</th>
<th>Value of SCA</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>25th December,16</td>
<td>1.2</td>
<td>None</td>
</tr>
<tr>
<td>25th January,17</td>
<td>1.29</td>
<td>None</td>
</tr>
<tr>
<td>25th February,17</td>
<td>1.37</td>
<td>None</td>
</tr>
</tbody>
</table>

3.1.2 Machine(Spindle)Vibration:

3.1.3 Machine (Spindle) Vibration:
4. Result:
Following results are summarized by taking various readings from OJ/5522 DT-40 CNC milling machine using predictive maintenance:
4.1 NAS value of oil is in between 0 to 5.
4.2 Pressure value is in between 33 to 40.
4.3 Value of frequency on system condition adviser is in between 0 to 10.

5. Conclusion:
From this study, it is be proved that predictive maintenance is very effective tool used in industries which helps to maximize the service life of equipment/machine without increasing the risk of failure.

6. Acknowledgment:
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References:

<table>
<thead>
<tr>
<th>Date of Observation</th>
<th>Hydraulic Pressure Value</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>25th December,16</td>
<td>36.2</td>
<td>None</td>
</tr>
<tr>
<td>25th January,17</td>
<td>35.8</td>
<td>None</td>
</tr>
<tr>
<td>25th February,17</td>
<td>35.6</td>
<td>None</td>
</tr>
</tbody>
</table>