Studies and Practice of Geometrical Test Procedures & Reconditioning of CNC Lathe Machine Tool

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Abstract. Machining Centres have been major production units for many decades with desired levels of accuracy, economy in costs of production and ease of control. Though new disruptive technologies such as rapid manufacturing, near net shape manufacturing technologies are replacing these machining units, still small and medium Indian Industries go with the conventional ways of large-scale production using conventional and classical machining approaches. With huge setups in place, such machines with high productivity demands, require stringent parts alignment tests frequently from time to time, referred to as Geometrical or Alignment tests to enable accurate finishing and machining of parts and smooth and uninterrupted production. This paper puts forth some basic Geometrical Tests performed on SB CNC 60 Lathe Machine Tool unit, identifying major deviations measurements and reconditioning the machine parts. The main objective of running such tests is to prevent breakdown of the machine and ensure safety working when handling older and heavier conventional machines.

Keywords: CNC Lathe, Geometrical Test, Run-out, Inspection

1. Introduction

A lathe is a machine tool that may be used to create cylindrical, conical, or flat surfaces. It may be used to drill and bore holes of various shapes, including cylindrical and conical holes. When utilised by a professional machinist, it is one of the most commonly used machine tools and is quite flexible [1-2]. Reconditioning refers to rejuvenating, recharging old systems to near first-hand and better machines. In real terms, it is a reverse engineering mechanism to identify the problems of machining inaccuracies by standard geometrical test procedures, disassemble the parts, degrease, clean and apply engineering fundamentals to renew them in totality by replenishing or by replacing and reassemble back to restore machine tool to higher performance levels. The main objective of reconditioning the machine tools is to improve/maintain machining capabilities for large production demands and to nullify the sudden breakdown of the machine tools. Reconditioning is economically viable and of low cost than replacing with new machines which are costlier at purchases and require more human skills as per technological changes made in machine tools. Nevertheless, new machines are better in features and capabilities, basic machining operations still have major roles in the metal industry and can be...
manageable by the old machines easily due to better damping capabilities, sturdy structure, and easy controlling features.

In most machine tools, major repair costs can be controlled as the structure of the machine does not need much reconditioning. Grinding and scrapping and if needed surface coatings enhance the guideways, and hence better alignment can be manageable. Other costs identified in reconditioning a machine tool are replacement of lubrication systems (oil leakages), Bearings (wear and tear problems), Drives (noisy, unnecessary heating up), Electrical fittings (short-circuiting), etc. Sometimes, retro-fittings of special accessories are recommended to increase more flexibility. Sarter et al. & Swanson [3-4] described maintenance as a collection of all technical as well as administrative operations, involving monitoring to maintain the needed functioning of the system. Wikstan and Jonansson [5] highlighted effective maintenance as a help to minimize the consequences of failure and lengthen overall life of a system. Maintenance policies, or plans of action, are used to offer direction and recommendations for carrying out additional maintenance tasks required by a system, and are referred to as "implementation of maintenance." Paz and Leigh [6] laid out corrective maintenance (CM) as a maintenance policy that involves performing maintenance activities on a system, such as repair or replacement, to restore it to its original state after it has failed. Kimura [7] indicated that Preventive Maintenance (PM) is scheduled and performed as often after a predetermined time or after the use of a particular system in the aim of reducing the probability of failure. Mechefske and Wang [8] have noted that most systems are maintained when PM techniques are applied, while a considerable portion of their useful life remains. Parida et al. [9] stated that different variables may be utilised to evaluate the effectiveness of the maintenance system. Gray et al. [10] highlighted that there li hierarchical and managerial decision-making mechanism to work on recondition old machines and to leverage them in lieu of purchasing new machineries.

2. Literature Reviews

Prakash N. Parmar [11] in his paper found that accuracy of CNC machine tools can be judged by the components being manufactured and the degree to which they are within the necessary dimensional control. Identifying dimensional inaccuracies and maintaining accuracy can be achieved by effective reconditioning of the parts. Mayank Srivastava [12] discussed on condition-based preventive maintenance (PM) procedures for CNC machines, for reducing frequent breakdowns. Sinan Gurel and M. Selim Akturk [13] illustrated an algorithm for calculating processing time of job on CNC machine and found that preventative maintenance minimizes the overall time to a large extent. Manikandan [14] highlighted that even though a machine tool's mechanical condition is relatively good, CNC retrofitting is often the cheapest way to increase an older machine tool's overall performance. As all Flexible Manufacturing Systems use lathes, milling machines, and grinding machines as their primary machine tools. Various types of failures occur during the operation of these machine tools, and the industry must deal with them. Saravanan et al. [15] discussed how identifying the sub-system of these machine tools is critical and how a thorough analysis of such failures can enhance performance as it will be useful in determining the condition monitoring needs of the machine tools. Khandait and Vanalkar [16] emphasised that surface finish quality is a significant need. As a result, selecting the best cutting parameters is critical for achieving the desired surface quality. They employed two performance measurements to optimise the cutting parameters: machine tool vibration and work-piece surface roughness. Lande et al. [17] examined the importance of predictive maintenance in a CNC
machine and the techniques that can help in determining the condition of in-service machinery and predicting when maintenance should be conducted. Liu et al. [18] suggest that a cost-based selective maintenance decision-making method is beneficial and propose a model for determining the appropriate time interval for maintenance. In industry, maintenance is critical to system performance and reliability. Wang [19] reviewed, categorised and evaluated current maintenance policies for single-unit and multi-unit systems. In industrial environments, it is usual that systems have to carry out several tasks with finite intervals between two successive operations. However, due to limits on maintenance resources, such as maintenance budget, maintenance time duration within each break, and restricted replacements, it is often hard to undertake all the desired maintenance measures. Yu Liu and Hong-Zhong Huang [20] highlighted that during these repair situations, the decision-maker identifies the activity of a subset among a set of feasible maintenance tasks which is known as selective maintenance. Basri et al. [21] presented preventative maintenance (PM) as a review and offered detailed information on PM, its planning, and techniques utilised in industry to establish a successful maintenance system. Condition monitoring is commonly utilised on any machine tool's critical subsystem. Saravanan et al. [22] suggested number of conditioning monitoring approaches which can identify fault when failure data analysis is used. Gurel and Akturk [23] reduced the overall completion time of a series of tasks on a CNC machine and said that utilising shorter processing times would cause the CNC machine to deteriorate faster, and that a strategy to increase more frequent PM visits to the machine was needed. They presented a search algorithm that can calculate the job's processing durations, their sequence, and the PM schedule all at the same time.

3. Experimental Work

3.1 Equipments used:
Machine used was SB (Slant Bed) CNC - 60 Lathe Machine Tool, Surface Grinder for grinding Guide ways of bed. Measurements were done by Standard Vernier Callipers, Standard Outside, Dial Indicator having least count of 1 micro-metre, Dial stand. Accessories used were Test Mandrels.

3.2 Methodology Employed:
Initially, safety guards and covers are disassembled, and freeway is provided to look closer at the components. Geometric tests are carried out and the permissible limits are verified for each component. Either the component is set to repair, recondition by using coating or replacement to new components. Finally, assemble the machine components back and perform the geometrical tests again to verify the desired result.

3.3 Initial Observations:
Run-out of Turned Workpieces (upto diameters of 100 mm and length of 600 mm) was around 20-25 microns as indicated by Dial indicator.

A total of 4 batch of 3 similar components were loaded in lathe machine to find the run-out error during machining process. The process of measurement is as depicted in the Figure No. 1. and readings of the run-out is noted as shown in Table. 1.
Figure 1. Run Out checking on CNC Lathe machine

Table 1. Run-out Inspection Results

| Batch Machining (Sample Inspection) (Length 250 mm to 300 mm long) | Run-out (in Microns) |
|------------------------|---------------------|
|                        | Test 1 | Test 2 | Test 3 |
| Batch A (Small jobs upto 40 mm diameter) | 16     | 18     | 17     |
| Batch B (Medium sized jobs – 40 to 70 mm diameter) | 16     | 17     | 17     |
| Batch C (Large jobs – 70 to 100 mm diameter) | 19     | 21     | 21     |
| Batch D (Extra large jobs – more than 100 mm diameter) | 24     | 22     | 21     |

As jobs increase in size in diameter and length, the run-out errors are found to increase due to bulk of the job. The permissible limits needed to maintain was below 10 microns which shows process need inspection of mating parts, alignment checks and removal of errors such as run-outs that are affecting accuracy of jobs being machined.

3.4 Reconditioning of Bed-Ways:

Figure 2. Bed-ways (before and after) reconditioning (Courtesy: Sharpline Automations Pvt. Ltd.)

Table 2. Size Variation of Bed-ways

| Number of Readings taken | Thickness | Total Material Removed |
|--------------------------|-----------|------------------------|
| Number of Readings taken | Before    | After                  | Before    | After                  |
| 1                        | 54.93     | 54.72                  | 80.04     | 79.81                  |
| 2                        | 54.94     | 54.72                  | 80.04     | 79.81                  |
| 3                        | 54.93     | 54.72                  | 80.04     | 79.81                  |
| 4                        | 54.93     | 54.72                  | 80.035    | 79.81                  |
| 5                        | 54.92     | 54.72                  | 80.02     | 79.81                  |
| 6                        | 54.92     | 54.72                  | 80.035    | 79.81                  |
| 7                        | 54.92     | 54.72                  | 80.04     | 79.815                 |

Side Surface = 0.23
Top surface = 0.23
The size variations of bed was measured every 30 mm along its length by using standard vernier caliper and outside micrometer gauge and are noted in Table 2.

3.5 Alignment test of Head-Stock and Tail-stock of lathe Machine:

Alignment tests was performed by connecting to both head stock and tail stock of lathe machine tool. Using plunger dial gauge, the contact point was placed on between both the centres. It was moved from the centre towards left and then taken back. Procedure was repeated for reverse direction, readings were noted and were maintained to 10 microns. With respect to the bed-ways machined, often in tandem to each other, bed ways are checked to be parallel to the central axis of both dead and live centres. Similarly, the other mandatory tests and replacement of parts conducted on this machine are as described in the Table 3 below:

Table. 3  TailStock and HeadStock Reconditioning practice on Lathe

| Sr. No. | Part / Component | Inspection Report | Reconditioning / Modification | Permissible values |
|---------|------------------|-------------------|--------------------------------|-------------------|
|         |                  | **Before**        |                                | Run-out = 0.010, Axial play = 0.005 |
| 1       | TailStock of Lathe | Run-out = 0.035   | Replacement of Double Row Taper Roller Bearing - 133120H-A-P2 (Gammet), Oil Seal and O ring has been replaced, Cleaning of Spacer, lubrication pipes using pressurized Air | |
|         |                  | Axial play = 0.015|                                | Run-out = 0.009, Axial Play = 0.005 |
| 2       | HeadStock of Lathe | Run-out of HeadStock Centre = 0.020; Near the Nose Spindle = 0.024; At a Distance 'L' = 0.033 | Replacement of Cylindrical roller bearing - NJ2212 - E-XL-TVP2(FAG), Oil seal and O ring has been replaced, Grease is to be applied before installing new one, cleaning of spacer, lubrication pipes using pressurized air | Run-out of headstock Centre = 0.010, Near the nose spindle = 0.010, at a Distance 'L' = 0.020 |
|         |                  | **After**         |                                | Run-out = 0.009, Axial Play = 0.009 |
|         |                  | Run-out = 0.009   |                                | Run-out = 0.009, Axial Play = 0.009 |
|         |                  | Axial Play = 0.005|                                | Run-out = 0.009, Axial Play = 0.009 |

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Figure. 3 Alignment test to confirm bed ways accuracy between centres

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The size variations of bed was measured every 30 mm along its length by using standard vernier calliper and outside micrometer gauge and are noted in Table 2.

3.5 Alignment test of Head-Stock and Tail-stock of lathe Machine:
Finally, comparative evaluation of measured dimensions of different alignments of machine components before and after reconditioning is depicted in Figure 4. It is evident that reconditioning process leverages the run-out errors far below permissible levels, the blue bars show that before reconditioning, run-outs increased a lot and needed intervention to recondition the machine tool.

![Inspection Report (Before & After)](image)

**Figure. 4** Dimensional Run-outs before and after Reconditioning

4. **Conclusions**

From the experiments, we conclude that

1. Reconditioning of machine tools require careful engineering inspection and report preparation, finding deviations and repair or replace the part which is not falling within the permissible limits.
2. Training and deployment of skilled work-force for inspection and report keeping is essentially a part along with production work.
3. Deviations such as run-outs exceed due to excessive and mass bearing components based on diameter and length and need for frequent inspections are mandate to achieve good quality production.
4. Time of Repair and Re-conditioning is also yet another study research that can be worked to know the costings and thereby avoiding replacement by new machines.

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