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Design of Tool Holder To Compensate Tool X-Offset For Turning Tools

KEYWORDS

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ABSTRACT *On the shop-floor of small and medium make-to-order companies, NC machining start-up still remains highly dependent on humans. There are essentially two tasks that have to be carried out before machining starts: the first is to set up the workpiece on the machine table, and the second to set up the cutting tools. When these are done manually, a significant amount of time is required for the machine operator to intervene and the flexibility and productivity of the process is adversely affected. Tool offset is important in high-precision machining, as the tool-origin can become changed by the tool replacement. The required relationship between the NC machine origins (references) can only be determined after the workpiece and tool settings have been completed. In particular, the tool setting task can be highly time consuming when small batches of complex parts are involved, mainly because frequent tool-set changes at the NC machine are required.*

In this project, a new design of tool holder is suggested for a 2-axis turning center (LMW LL20T L5) and thereby it minimizes the tool setting time for all the turning tools used in the machine. The main purpose of this work is to propose a design of tool holder where presetting of the tool is done quickly and accurately compared to the conventional method and the manual procedure of tool offset measurement can be eliminated. As the job is being changed frequently, Z-offset is not considered and only the X-offset has been taken into account for compensation. A methodology for the design of tool holder is made and analysed. Implementation details and the results of tests carried out on the machine are presented and discussed.

1. INTRODUCTION

Precision machining is a process where material is removed from a component to a very high tolerance. The tolerance held depends on the machine but most precision CNC machines will not have a problem holding a tolerance of 0.002 or 0.005 mm. Precision Machining can be classed as Milling, Turning and Jig Boring but also include other types such as laser and water cutters.

Precision machines use a cutter and can be solid cutters such as tungsten carbide, cobalt or HSS. The critical elements of manufacturing that need to be maintained from a precision manufacturing point of view are summarized as follows:

- To eliminate 'fitting' and promote assembly especially in automatic assembly (emphasis in the original)
- To improve interchangeability of components.
- To improve quality control through higher machine accuracy capabilities and thence reduce scrap, rework, and conventional inspection
- To achieve longer wear/fatigue life of components and, on the general push for improvement in precision engineering and manufacturing, he adds
- To achieve further advances in technology and science.

1.1. Tool offsets

The word 'offset' refers to the allowance made by the CNC machine for the diameter and length of the tool to cut the job. Programming on a CNC machine is always done according to the **centre point** of the cutter. The cutting tool runs along the programmed line. If the offset value of a tool is not set, the tool will move according to this centre point of the cutter rather than according to the tool being used. This means that the tool will be cutting in the wrong part of the work piece. Since the diameter and length of a tool may vary, an 'offset' value needs to be set so that the tool can be moved to the correct position for the cutting required.

After a program is written, the control has to be told where the tools are on the slide. Tool offsets are used by the control to position the tool and know where it is. There are three steps when using the offsets.

1. Establishing the offsets: This is done in the Jog mode before the program is run

2. Call the tool offset and establishes what the location is: This is done in the program that is written and used when the program is run.

3. Adjust the offset: This is done while you are running a program and find the tool is not located where you want it. Fine adjustments are available down to .001 "/diameter in X and .0005" in Z.

1.2. Reasons for tool offsets in a turning center

Offsets can be used for several purposes depending on the style of machine tool and type of compensation being used. For turning center applications, it would be very difficult for the programmer to predict the precise length of each tool and also location of the tool varies when a new tool is replaced. At the time of setup, the setup person measures the tool tip origin in jog mode and inputs the tool offset value for the corresponding station.

Generally in setting up a tool, the following problems were observed.

- Since presetting is done manually, a significant amount of time is required for the machine operator to intervene and the flexibility and productivity of the process is adversely affected.
- In particular, the tool-setting task can be highly time consuming when small batches of complex parts are involved, mainly because frequent tool-set changes at the NC machine are required.
- If the offset value of a tool is not set or if there are any incorrect measurement, the program zero changes and the tool will be cutting in the wrong part of the work piece.
- In addition to the time spent by the operator in measuring offset, typing mistakes can occur, and these can cause tool collision.

2. METHODOLOGY

This study shall concentrate on the adaptive side of tool holders, with the ultimate aim being the investigation of how such holders can be applied to improve the end result of the manufacturing process and/or to decrease the process's cycle time and cost. In order to achieve the desired results, a structured research methodology was followed for the completion of the thesis. This methodology will be analysed in the next paragraphs.

The research methodology followed comprises three core steps. At first, a detailed literature survey was completed, which helped to identify the current state of the art in tool presetting technology and research trends in the field. Most importantly, this survey highlights the knowledge gaps which should be addressed in order to propel the research in the tool presetting system.

The second step of the methodology involves the translation of the identified knowledge gaps into clearly defined research objectives. Three are the main research objectives identified, namely

1. Develop a tool holder which compensates the tool X-offset for different tools where the offset values are predefined and the tools are clamped according to the desired overhang value.

2. The tool presetting is to be done with maximum accuracy (within ±0.01) and it should minimise the cycle time.

3. The tool holder must have capabilities for adjusting the tool to different offset lengths. The design of tool holder should be capable of holding shanks of different lengths.

The final step of the methodology involves the validation of the design. To achieve this, combination of analytical and experimental approaches will be utilised whether the designed holder caters all the requirements.

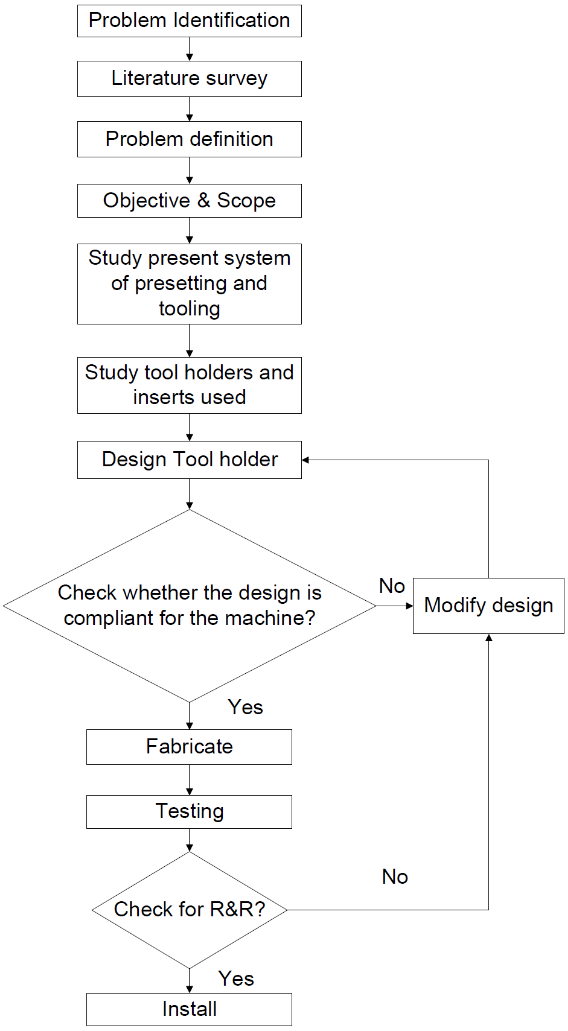

Fig 1. Research methodology

3. DESIGN OF TOOL HOLDER

In order to design a new holder, the necessity of the new design has to be clarified well before to meet the demands. Therefore to reach the objectives, certain requirements are to be met which are listed below

1. The tool holder should be capable of holding shanks of different length.
2. The tool holder design should not interfere with other parts or obstruct the movement of the turret.
3. The tool holder design should be in compliance with the turret station.
4. Dimensionally stable and should be capable of withstanding machining forces.
5. The tool holder must have capabilities for adjusting the tool to different offset lengths.

After exploring a number of models, a final design was made which satisfies all the requirements and fulfils the objective of the work. The model consists of two setups, one is an offline fixture and the other is an external tool holder which fits into the turret slot.The offline fixture is for presetting the tool to the desired overhang and thereby the offset is fixed for that particular overhang value.The presetted tool is directly placed onto the external tool holder which maintains the overhang.Therefore for the fixed overhang, the offset value is manually entered into

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the controller and the offset value is set.The offset values for a set of overhang lengths viz. 40,50,60,70 was initially determined in manual presetting and was recorded. Therefore for a particular overhang (say 50) which was presetted in offline fixture, the offset value corresponding to that which was manually calculated earlier is then entered into the controller.

S.No	Overhang (mm)	X-offset (mm)
1	40	226.350
2	50	236.350
3	60	246.350
4	70	256.350

Table-01 Overhang values

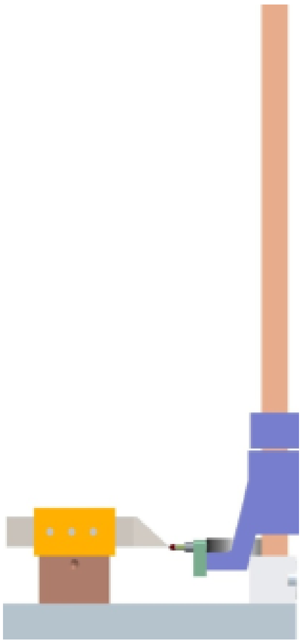

Fig 2. i) Offline fixture

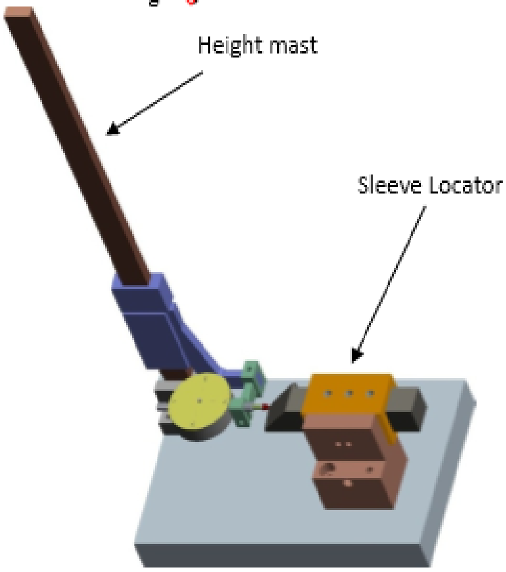

Fig 2. ii) Offline tool setting fixture

An external tool holder is modelled so that it fits into the turret slot. The tool holder has dowel holes which help in locating the tool to the presetted overhang.

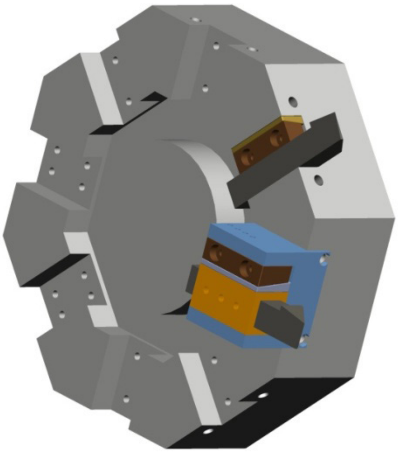

Fig 3. i) Turret with new holder and tool

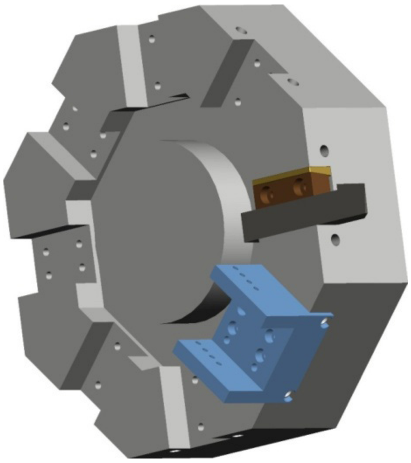

Fig 3. ii) Turret with new holder without tool

Components were modeled by employing 3D Geometry Software (Pro/Engineer). 3D Solid Model of the component created for the purpose is shown in Fig. 2.1 is used to determine for checking its compliance with the machine, analysed for structural stability and machining forces. The 3D model also helps in raising the standard operating procedure for assembling the new holder.

4. MATERIAL SELECTION

As the tool holder is subjected to high machining forces, hardenable alloys of iron made with high level quality control may be suitable. Since the tool holder is frequently subjected to wear due to clamping and unclamping, the material for consideration shoud have high tensile and high wear resistance properties. So considering all these factors the material chosen here is EN24. It is a popular and commonly used grade of through-hardening alloy steel due to its excellent machinability. It has Machinability index of 29%.EN24 can be further surface-hardened to create components with enhanced wear resistance by induction or nitriding processing.EN24 is a high tensile alloy steel renowned for its wear resistance properties and also where high strength properties are required.

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EN24 Mechanical properties

Size	Yield strength (N/ mm^2)	Elongation (%)	Hardness HB
63 to 150	680 min	13%	248/302
150 to 250	654 min	13%	248/302

5. PROPOSED METHOD

The offline tool setting fixture consists of a sleeve locator where dowel holes are provided for fixing the reference from where the overhang is measured. Initially a master block of desired length is fixed and the micron dial probe is made to touch the parallel face and coiled to about 0.1mm.

Then the master block is replaced by a sleeve with a single point tool in it. The sleeve is located onto the dowel holes. The tool is slightly moved until the tool tip touches the probe of dial and it is further moved till the fixed length is reached. After then the tool is clamped in the sleeve.

Now the clamped tool is fixed on to the holder where dowel holes are provided for precise positioning. The tool is fixed to the corresponding dowel hole for the fixed overhang and the X-offset is manually entered into the controller.

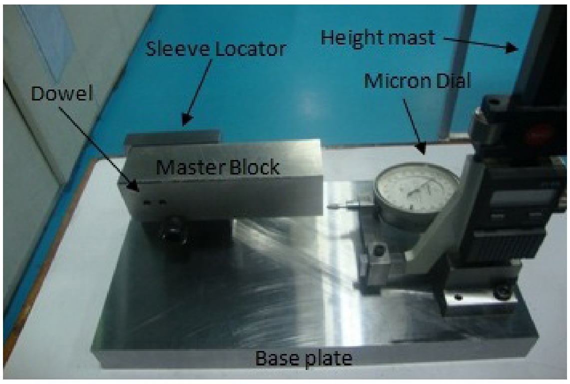

Fig 4. The required overhang is fixed by means of a master block of standard length

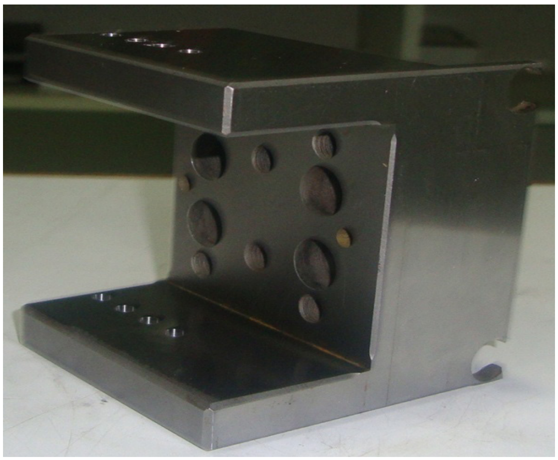

Fig 5. External Holder on turret

6. CONCLUSION

The proposed tool holder model was designed to meet the design requirements. This model gives a basic idea in designing a tool holder to compensate tool length offset. The drawbacks of this model trigger the need to refine the project work for further improvement and expand its capability. Moreover, the proposed model is analysed for further development by getting feedback from the operators and service engineers.

7. FUTURE WORK

The model and the design methodology that was proposed in this thesis can be further enriched and expanded by the following ways,

- The application of the developed methodology to a more generic, real-life industrial component could help emphasise further the capabilities and benefits of the proposed tool holder system.
- The incorporation of vibration damping capabilities could lead to an additional improvement in performance.
- The machining force could be obtained experimentally and simulated to obtain accurate machining-force prediction models.

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