Improvement of Tops Spinning Manufacturing with CNC Lathe

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Abstract

This paper presents an increasing demand of Top-Spinning (T-S) has resulted in the production of high quantity of T-S. Currently, the production of T-S is very low and not up to the required demand. This is due to the old machine used as well as an old method in the manufacturing of T-S, which lead to the longer time taken compared to the new technology found in this project. The cardinal purpose of this project is to identify the machining sequence with the selection of a suitable tool and reducing machining cycle time with the use of CNC Lathe for manufacturing T-S. In ensuring a successful and optimum result of the project, manufacturing T-S with CNC Lathe will be assisted by Mathematisch Technische software Entwicklung (MTS) and Master CAM simulation to determine machining sequence, cutting tools, technology parameters and machining cycle time. The data extracted from MTS, and CAD/CAM simulation process will then be used for manufacturing T-S on CNC Lathe technology. This project emphasizes on the importance of determining machining sequence, cutting tools to manufacture T-S in any shape available and also resolving machining cycle time. The result from MTS and CAD/CAM with three analyses of machining sequence, cutting tool and technology parameters will be used to proceed on CNC Lathe. Finally, with the utilization of the data extracted from MTS software, and CAD/CAM simulation has successfully impacted the reduction on overall machining cycle time while producing T-S.

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Keywords: Simulation; Turning process; Machining parameters; Method of Machining

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1. Introduction

The tradition of Top-Spinning (T-S) is becoming revitalized by the Malaysian government who are now organizing T-S competitions around the nation in various categories ranging from primary school to the professional clubs (see Table 1). The competitions are usually being held at large shopping malls and popular open areas to attract tourists [1,2,3]. Because of that ministry youth and sport encourage T-S game become a co-curriculum at school level. In this case, there is a need to manufacture T-S in high quantities. Currently, the production of T-S is very low and not up to the required demand. This is due to the old machine used as well as old method in the manufacturing of T-S, which lead to the longer time taken compared to the new technology found in this project (refer to Figure 1).

Table 1. T-S Characteristic.

| Open   | Min     | Max     |
|--------|---------|---------|
| Weigh  | 600gm   | 800gm   |
| Diameter | 120mm | 150mm   |
| Height | 90mm    | 120mm   |

The purpose of utilized Mathematisch Technische software- Entwicklung (MTS) and CAD/CAM for this project is to reduce cost of materials, cutting tools and avoid from machine collision when tested to produce products. CNC Lathe is to manufacture actual T-S where the machining sequence and machine parameters get from analysis of MTS and CAD/CAM have been used in this process to manufacture T-S.

The research aims is to develop a methodology for manufacturing T-S with CNC Lathe and the specific objectives are as follow.

1. To determine a suitable cutting tool and machining sequence to manufacture T-S by using MTS simulation software.
2. To reduce machining cycle time by using Master CAM simulation software involving machining parameter.
3. To gain an acceptable and accurate overall Machining cycle time with CNC Lathe.

2. Literature review

T-S is a traditional game popular among Malay (Native people). Especially amongst the villagers in the State of Pahang, Kelantan and Melaka. Each season after the rice harvest, several villagers will come together to challenge each other in an ultimate test of skill. The villagers believed that the spinning tops would help bring good harvest. Both adults and children can play the game. But bigger or giant T-S is more of games for adult than children. The one used by adults are much bigger in size and can spin for a
period of time whereas the one played by kids are much smaller. T-S is split into two (2) categories. One is for ornamental purposes and while the other is for playing [16]. T-S maker is a talented person in the art of carving will use woods to produce T-S. Woods selected are from the type of keranji, tembusu, sepan, penaga, leban tanduk, merbau, bakau, johol, and keradah which are found in the jungle or the edge of forest. Below stated the sequence of traditional method of process preparing Tops Spinning [4,5]. According to Jones [3], Computer Numerical Control (CNC) retains the fundamental concepts of Numerical Control (NC) but utilizes a dedicated stores-program computer within the machine control unit. Valentino et al. [9] defined the Computer Numerical Control (CNC) machine is an NC machine with the added feature of an on-board computer. The on-board computer is often referred to as the machine control unit or MCU. Valentino et al. [9] defined the Numerical Control (NC) is a method of automatically operating a manufacturing machine based on a code of letter, numbers, and special characters. Amic [1,6], mentioned that when numerical control is performed under computer supervision, it is called Computer Numerical Control. Computers are the controls units of CNC machines. They are built in or linked to the machines via communications channels [1,7]. Since its introduction, NC technology has found in many including lathes and turning centers, milling machines and machining centers, punchers, electrical discharge machines (EDM), flame cutters, grinders, and testing and inspection equipment [1,8,9].

3. Methodology

Methodology shows the direction on how the project was conducted. Several techniques have been used to determine the best solution for producing product, which has been derived from the project methodology and project Tools. first stage is to design T-S shape according to the size required by using any type of CAD software. Second stage, by using MTS software technology as a virtual CNC Lathe to predict the suitable cutting tools and performance of a real CNC Lathe during part turning. In this stage, there are three types of machining sequence that need to be analyzed, to determine the best possible machining sequence as a method to be used for the next stage of analysis. By using CAD /CAM to predict cycle time. The parameters should be considered in Turning of a cylindrical stock with constant finished final diameter (Df), length (L), and initial diameter (Do). The cutting parameters in turning process include the spindle speed (N) in rpm, the feed rate (f) in mm/rev, and the depth of cut (d) in mm. Figure 2 illustrate the machinist selects cutting parameters from their specified ranges in machining handbooks, mainly based on experience, in order to satisfy the required accuracy of the final product. Lastly, is to manufacture T-S on CNC Lathe. This process will require the actual time to be taken for analysis purposes in the processing of work piece set-up, Tool length setting, and set work piece zero point and machining time.

The simulation will require the parameters for Center drill, Drilling and Finishing process, the same as parameters indicated in first Simulation. In this case it will define estimate time on roughing process the parameters such as Feed rate 0.1 mm/rev, Plunge feed rate 0.2 mm/rev, Spindle speed 800 up to 2500rpm, Depth of cut 2mm, min Depth of cut 1.

![Fig. 2. (a) Machining process](image-url)
4. Result and Discussion

There are three methods of machining sequence that have been analyzed and considered about machining process such as set-up workpiece, set-up tools, no of tools, datum setting Generate NC program, NC Program verification and machining process. For the first machining sequence it needs about 22 processes to complete one T-S where for the second sequence involves 25 processes and last machining sequence requires 14 processes. Refer to table 2 that showed the lowest percentage of process is the best machining sequence.

Table 2 shown the detail process involved for each machining sequence and it’s was converted to percentage

| Job sequence/Disc | Set-up W/piece | Set-up Tools | No of Tools | Datum setting | Generate NC Program | NC prog Verification | Machining process | Total of process | Percentage of Process |
|-------------------|----------------|--------------|-------------|---------------|---------------------|---------------------|-------------------|-------------------|------------------------|
| Sequence 1        | 2              | 4            | 4           | 2             | 2                   | 2                   | 6                 | 22                | 36%                    |
| Sequence 2        | 1              | 7            | 7           | 1             | 1                   | 1                   | 7                 | 25                | 41%                    |
| Sequence 3        | 1              | 3            | 3           | 1             | 1                   | 1                   | 4                 | 14                | 23%                    |
| Total             | 4              | 14           | 14          | 4             | 4                   | 4                   | 17                | 61                | 100                    |

From the analysis, a suitable machining technology had been identified for predicting a cycle time where it can be used for actual turning process with CNC Lathe. This analysis was based on three (3) different possibilities of machining parameters used. Each simulation with Master CAM has four (4) processes such as center drill, drilling, Roughing and Finishing. Machining process for center drill, drilling and Finishing have used the same data from simulation one to simulation three. This is because of that process took less than one (1) min and having very slight different. The roughing process analysis was done on different Feed rate, Plunge rate, spindle speed and depth of cut. It can predict a cycle time where we can use the parameters on actual machining process with CNC Lathe. Table 3 defined the total machining cycle time produced by CAD/CAM analysis. Through the analyses, the lowest cycle time can be taken as reference parameters for actual CNC Turning process. Process no 3 has shown the lowest cycle time of about 18 minutes 26 seconds to complete the manufacturing of T-S with CNC Lathe.

Table 3. Total machining cycle time from Master CAM.

| No | Center drill | Drilling | Roughing | Finishing | Total |
|----|--------------|----------|----------|-----------|-------|
| 1  | 9 s          | 37 s     | 21min 10s | 42 s      | 22min 38s |
| 2  | 9 s          | 37 s     | 17min 2s | 42 s      | 18min 30s |
| 3  | 9 s          | 37 s     | 16min 58s | 42 s      | 18min 26s |

This machining process and selection of tools have been taken from Third machining sequence that was being done by MTS software. To ensure successful process of manufacturing T-S with a less cycle time, there is a need to analyze for necessary task such as Verify program upon editing or transfer program data to controller, Mounting position at tools turret position, Tool length setting, Set workpiece zero point, Machining processes and assemble T-S. From the task, it stated only one time to set up but for the task of clamping workpiece, set workpiece zero point and execute program needs to set up each of time when started to manufacture T-S with CNC Lathe. Lastly, is to execute the program for machining process to control the spindle speed by using spindle speed override. This is due to the constant cutting speed which means that the smaller diameter, the higher spindle speeds. Based on work piece profile, the end size of profile is only Ø16mm so that the spindle speed becomes higher and might cause the product to shake. In this case, it needs to be controlled with spindle speed override to avoid from the product being
shaken. In order to get a real cycle time to produce T-S with CNC Lathe, it needs to analyze a cycle time for necessary process involves with set up and machining processes.

5. Conclusion

Based on the fact findings and analysis done, it could be concluded that after conducting a series of analysis, all of the objective elements are met and up to the expectation. The conclusion could be segregated in accordance to the objective elements as stated below:

Determination of a suitable cutting tool and machining sequence to manufacture T-S by using MTS simulation software. Analysis showed that determination of suitable cutting tool and machining sequence has been achieved in such a way that the data from MTS software has successfully been used for proceeding manufacture T-S according to size and shape or another available shape of T-S. Reduction on machining cycle time by using Master CAM simulation software involving machining parameter. Through the analysis, it has shown the success of reducing cycle time with the used of main elements such as machining sequence, cutting tools and machine technology. To gain an acceptable and accurate overall Machining cycle time with CNC Lathe. Based on the fact of the analysis conducted, it is clearly showed that there is an improvement of T-S Manufacturing utilizing CNC Lathe technology with focusing on methodological aspect as shown in the process of manufacturing of T-S. Based on those reasons, the formability result between actual try out and virtual try out can be investigated, verified, measured and evaluated. Finally, the result was determined with actual manufacture T-S with CNC Lathe and managed to determine a suitable cutting tools, machining sequence for purpose of optimizing cycle time. Based on the project analysis, further aggressive studies need to be conducted to ensure the project is really worthwhile and meaningful to the organization. Looking at the successful achievement of the project, it is recommended that, action on consideration of mass production is to be initiated for commercial purposes. Decision on whether to manufacture T-S with machining process or Injection molding must be painstakingly looked into for ensuring the success of producing mass production in term of cost, time and quality, if need be.

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