Design and Manufacturing of VMC Machine Tool Runout Checking Device

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Abstract— Tool runout is found in any machine and can never be 100% avoided. Runout remains an important issue in machining process. Runout is seen in the accuracy of every cutting tool, tool holder ,collet and spindle. Every added connection between a machine and the workpiece it is cutting will introduce a higher level runout. Each increase can add to the total runout further and further.

In this project work, we introduce a device to check runout and to minimize the runout for best performance, increased tool life, increase productivity and profit ,quality finished products and minimize westage of time.

Keywords—*Increasing productivity; profit; save time; minimize runout.*

I. INTRODUCTION

This project research deals with the Design and Manufacturing of VMC machine runout checking device to check the runout of tool before it is located in tool holder for operation. In manufacturing, one of the most important machine tools is the milling machine. Basically, a milling machine is used in shaping solid materials, specifically metals. More than anything else, the milling machine is used in shaping flat and irregular surfaces. Aside from this main function, the milling machine can also perform other tasks such as drilling, routing, planning, cutting gears, boring, and producing slots among others.

A vertical milling machine's spindle axis is aligned in a vertical manner to the machine's bed. That means that the cutting tool is arranged vertically to shape the metal or other material into the desired form. The vertical mill moves while the part remains stationary. The vertical mill has controlled movements, either mechanically (by hand), or through programming via a computer.

Tool runout is a given in any machine shop, and can never be 100% avoided. Thus, it is important to establish an acceptable level of runout for any project, and stay within that range to optimize productivity and prolong tool life. Smaller runout levels are always better, but choice of machine and tool holder, stick-out, tool reach, and many other factors all have an influence on the amount of runout in every setup.Tool runout is the measurement of how far a cutting tool, holder, or spindle rotates off of its true axis. Runout is seen in the accuracy of every cutting tool, collet, tool holder, and spindle. Every added connection between a machine and the workpiece it is cutting will introduce a higher level of runout. Each increase can add to the total runout further and further. Steps should be taken with every piece of tooling and equipment to minimize runout for best performance, increased tool life, and quality finished products.

Determining the runout of your system is the first step towards finding how to combat it. Runout is measured using an indicator that measures the variation of a tool's diameter as it rotates. This is done with either a dial/probe indicator or a laser measuring device. While most dial indicators are both portable and easy to use, they are not as accurate as the available laser indicators, and can also make a runout measurement worse by pushing on a tool. This is mostly a concern for miniature and micro-tooling, where lasers should be strictly used due to the tool's fragile nature. Most end mill manufacture recommend using a laser runout indicator in place of a dial indicator wherever possible.

II. LITERATURE SURVEY

A. M. Krüger & B. Denkena et al . 2012 "Model-based identification of tool run-out in end milling and estimation of surface roughness from measured cutting forces".

This paper presents a model-based approach for the identification of tool runout and the estimation of surface roughness from measured cutting forces. In the first part of the paper, the effect of tool runout on variations in the cutting forces and the effect on surface roughness generation are studied. Thereby, several influencing parameters are identified and examined systematically. Based on theoretical considerations, systematic relationships between tool runout, resultant process force variations, and surface roughness characteristics are deduced. The sensitivity of process force variation is investigated for varying runout parameters by experimental tests. In the next part, the model-based runout identification method is developed, which identifies runout parameters accurately from the measured process forces..

B Tony L. Schmitz et al 2006 " Runout effects in millingSurface finish, surface location error,and stability"

This paper investigates the effect of milling cutter teeth runout on surface topography, surface location error, and stability in end milling. Runout remains an important issue in machining because commercially-available cutter bodies often exhibit significant variation in the teeth/insert radial locations; therefore, the chip load on the individual cutting teeth varies periodically. This varying chip load influences the machining process and can lead to premature failure of the cutting edges. The effect of runout on cutting force and surface finish for proportional and non-proportional tooth spacing is isolated here by completing experiments on a precision milling machine with 0.1 mm positioning repeatability and 0.02 mm spindle error motion.

C. Xianyin Duan et al 2019 "Tool orientation optimization considering cutter deflection error caused by cutting force for multi-axis sculptured surface milling".

Multi-axis milling (especially five-axis) is in the ascendant for high precision manufacturing of a product with a sculptured surface such as ship propeller, owing to its multi-axis linkage and resulting outstanding superiorities. Needs of a faster-improving manufacturing level of sculptured surface milling are derived by higher performance requirement of complicated equipment, which makes the planning of tool orientations more significant and

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challenging. This paper builds a tool orientation optimization model with inclusion of the influence of deflection error caused by cutting force to achieve better machining precision controlling in five-axis sculptured surface milling. The basic idea of the optimization method is described firstly, followed by the prediction of cutter deflection error.

D. Sitong Xiang et al 2019 "Volumetric error compensation model for five-axis machine tools considering effects of rotation tool center point".

Conventional volumetric error compensation strategies for five-axis machines directly generate compensation values without considering the RTCP (rotation tool center point) effects, which causes additional movements of translational axes with the movement of rotary axes, so the compensation values for three linear axes need to be recalculated. In this paper, a volumetric error compensation model considering RTCP is proposed. In the model, the compensation values for translational axes totally consist of three parts, i.e., position errors caused by the volumetric error, position variations caused by the compensation of rotary axes, and caused by RTCP. Firstly, the compensation values for rotary axes are obtained based on the volumetric error model and the inverse kinematics.

E. Zhong Jiang et al 2018 "Research on detection of the linkage performance for five-axis CNC machine tools based on RTCP trajectories combination".

The five-axis machine tool has been extensively employed in complex curved surface machining area. The linkage performance of the machine tool is one of the key origins of the machining accuracy. An accuracy measurement based on RTCP (rotation tool center point) is an effective means for multi-axes motion synchronously linkage performance detection. In order to demonstrate the linkage performance more completely, an RTCP trajectory description method is presented, and some trajectories which take account of curvature and speed changes are proposed in this paper. The trajectory sensitivity analysis is applied to examine the sensitivity of RTCP measuring trajectories in mismatch parameters of the five-axis machine tool. Through comparative analysis, some RTCP measuring trajectories are more sensitive to certain error parameters than others. Therefore, the corresponding RTCP measuring trajectories are necessary for various linkage performances detection of the five-axis machine tool. For this purpose, RTCP measuring trajectory is optimized based on sensitivity analysis result.

F. XiaoJian Zhang et al 2012 "Dynamic Cutter Runout Measurement with Laser Sensor ".

The cutter runout is very common in machine milling and has a great effect on the surface accuracy. In this paper, a measurement of radial cutter runout in revolving milling tool is proposed by using the laser sensor. A laser beam is projected onto the milling tool edge and subsequently reflected. The diffuse reflection is captured by the sensor and the displacement between the cutter and the laser sensor is obtained. Based on the dynamic displacement, the cutter runout is calculated. The experimental results show that the radial cutter runout is dynamically varying in the constant rotation speed and the runout fluctuation largens with the increasing speed.

G. Jabir Z et al 2016 "Measurement of Concentricity and Runout"

This work proposes an importance of a Geometrical Dimensions and Tolerance process that is interlaced in the product development process becomes a deeply rooted philosophy. GD&T is a system for defining and communicating engineering tolerances. It uses a symbolic language on engineering drawings and computer-generated three-dimensional solid models that explicitly describes nominal geometry and its allowable variation.In our GD&T we wanted to reduce the Human error while Measuring Dimensions which can ultimately reduce the repetition of work to achieve desired shape and sizes with accuracy up to micron level.The instrumentation system that we have made is isolated from human error and external vibration while measuring or determining tolerances of a work job so that we can achieve a high precision work job for industries.The findings of this work show that Dimensional Engineering is a profitable activity since many companies have integrated this process in their work and the Dimensional Engineering field is expanding rapidly. It is an activity that has shown to decrease time to market, enhance product functionality and decrease product development costs. In addition, it stimulates the mind-set of employees to think proactively and it boosts organizational awareness.

III. PROBLEM STATEMENT

In industries, the operator can check the runout with the help of dial indicator.If the runout is present then he stop the machine and corrected the runout this method can take more time and due to this the sometimes the operator have a stress problem and product accuracy is more. Because of this their is a decrease in productivity, profit and performance also.

IV. CONSTRUCTIONAL DETAILS

Mechanization is broadly defined of runout measuring device with less time and less cost. The runout measuring device contains following components,

A. Circular Plate

There are three circular plates are used.Two of them having 300mm diameter and 20mm deep.Out of two circular plate one is having a BT40 tool taper. Both circular plates having a hole of 68.2mm at a centre in which bearing is placed.The tool holder is placed between the two big size plates.One small circular plate having a 150mm diameter upto 10mm height and 64mm diameter upto another 10mm height.These small plate is placed in the top circular plate having 68.2mm hole.These small plate having two rectangular slot of 15mm*6mm in which two magnetic rods are placed.

B. Bearings

Bearings are one of the most commonly used machine parts because their rolling motion make almost all movements easier and they help to reduce friction. Bearings have two key functions they transfer motion i.e they support and guide components which turn relative to one another.There are two bearings are used to fit the tool holder in between the two plates.The bearings are used for the proper press fit between plate and tool holder and because of the bearing the tool holder can easily rotate. We use the ball bearing because it is suitable for low torque and high speed application.They also have superior acoustic characteristics.and load capacity is lower for ball bearing.

C. Electromagnet

When an electric current flows in a wire, it creates magnetic field around the wire.This effect can be used to make an electromagnet.A simple electromagnet comprises a length of wire turned into a coil and connected to a battery or power supply. Electromagnets have some advantages over permanent magnets

1)They can be turned on and off.
2)The strength of the magnetic field can be varied

A tool holder is the machining components which is used to hold the tool in place as precisely and firmly as possible. As we see the most of

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the times the reasons of runout is due to the pull stud i.e pull stud pressure and pull stud angle.If the pull stud is not placed correctly then there is the chances of runout.So to obtain the pressure of pull stud as same as in the machine,we use the electromagnet.Due to the electromagnet the pull stud is firmly placed as it is placed in the machine.

D. Magnetic Rod

Standard PML Magnetic Rods

- Low-intensity magnetic rods are ideal for catching materials such as Nuts, Bolts, Screws, broken washers, etc. These rods are designed to attract larger iron pieces from relatively larger distances.
- High-intensity magnetic rods are capable of catching contamination particles as small as 1 micron. These rods have been designed to attract super fine particles from the carrier material.
- Magnetic rods are long circular magnets where the length is equal to or greater than the diameter.They are ideal for recessing into a drilled hole in a holding or sensing application.

E. Square Plate

The square plate is a base plate upon which the whole assembly is mounted.The base plate is made up of mild steel because it has a high strength.It is 300mm wide and 300mm long in size.

V. CAD MODELING

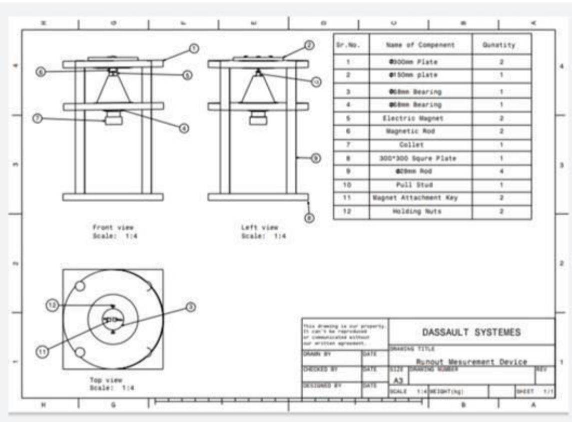


Figure 1. 2D View of Device

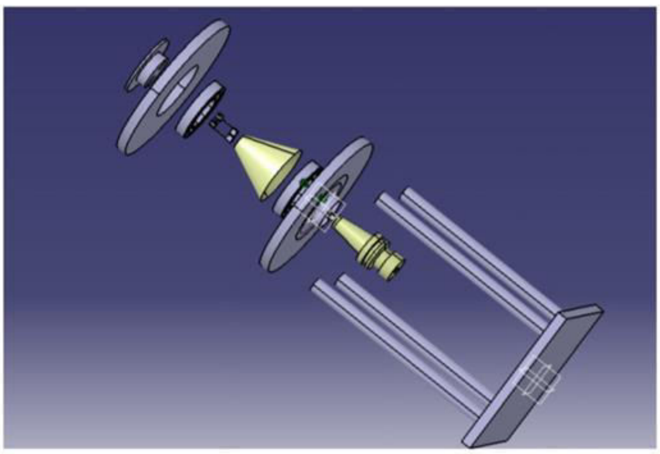


Figure 2. Disassembly of Device

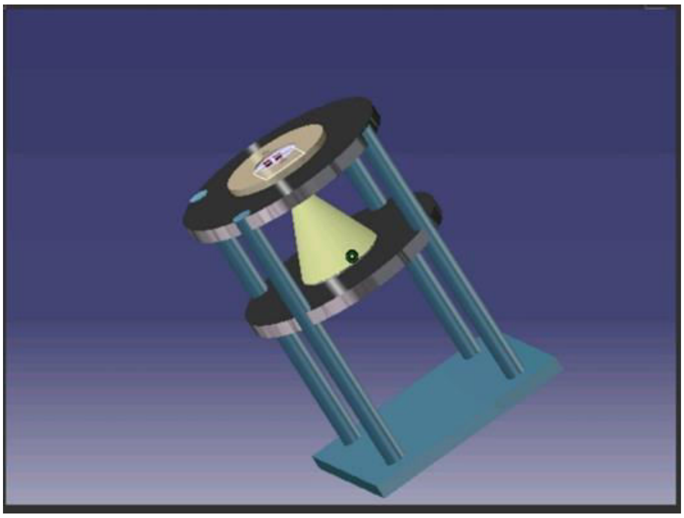


Figure 3. Assembly of Device

VI. TESTING

After fabrication and assembly the testing of runout measuring device is carried out. The main thing which we have to reduce with our device is the time required for the runout measuring and increase the productivity. Because of electromagnet we create a same pressure as it is in the machine spindle.So because of these same pressure there is nothing a issue of any error regarding to the pressure.So we can adjust the tool holder as same as the we adjust in our device and measure the runout and correct it.

The minimum time required to measure runout is 3 min approx. There are total 9 machines in the company so total time required to measure the runout of the 9 machines at a one time is 27 minutes. If we consider that in a day they were check the runout of a one machine at a 3 times. So for 9 machines 81minutes are required. Means they lost around 1 hour per day.

Because of our device we can check the runout of a tool when the previous operation is carried out.Means the operator of machine knows what is the next operation will be carried out so the operator can check the runout of that tool before the operation is carried out hence in that way we can reduce the time required for checking the runout.Means we can save the 81 minutes per day and because of these we increase the productivity and also increase the profit and also the performance of the company.It may lead to reduce the stress of operator and also product accuracy is more.

VII. RESULT AND DISCUSSION

In this chapter determining runout of our system is the first step towards finding how to combat it. Runout is measured using an a indicator that measures the variation of tool's diameter as it rotates. This is done with either dial or problem indicator while most dial indicators are portable & easy to use. The runout should be measured at the point where a tool will be cutting. typically at the end of the tools ,or along a portion of the length of cut . A dial indicator may not be plausible in these instances due to the inconsistent shape of tool's fluets and these will overcome by our device. It will give more accurate result than manual method.

By Mannual Or Old Method :

- ➢ Total no.of machines - 9 VMC Machine
- ➢ Minute time required to check runout for all 9 machine - 45 Minutes

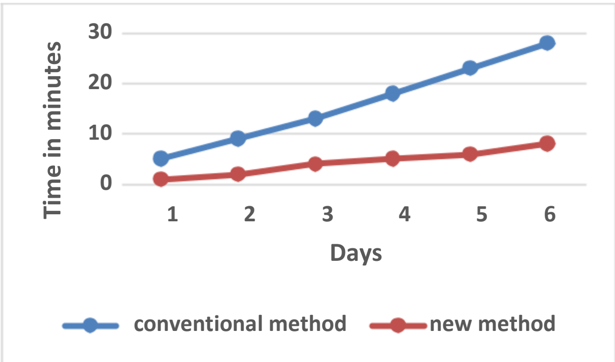
Therefore, 9 machine*5 min for every machine = 45

- For Every machine in one day- 5 Minutes
- For 1 month ,Time required (except holidays) – 45*26=1170 Minutes(20 hours)
- For 1 Year ,Time required = 12*20 =240 hours (10 days)

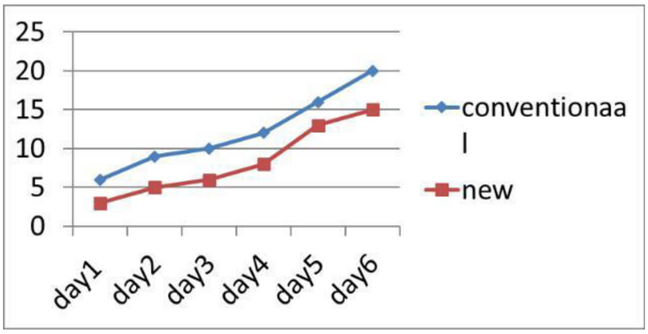
By Modified Method :

- Total no. of Machines – 9VMC Machine
- Minute time required – 2 Minute per machine
  Therefore, 2*9 =18 Minute
  Similarly,
- For 1 Month (required time) - 18*26 =468 Minutes (8 hours)
- For 1 Year, (required time) – 8*12 = 96 hours (4 days)

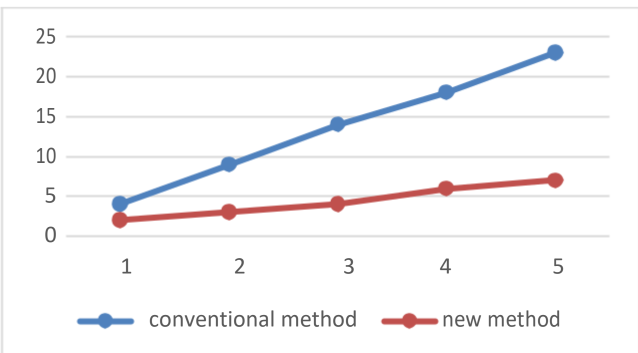
For 1st VMC



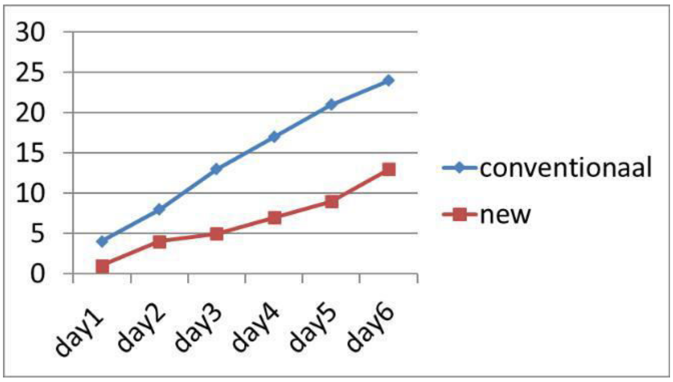
For 2nd VMC



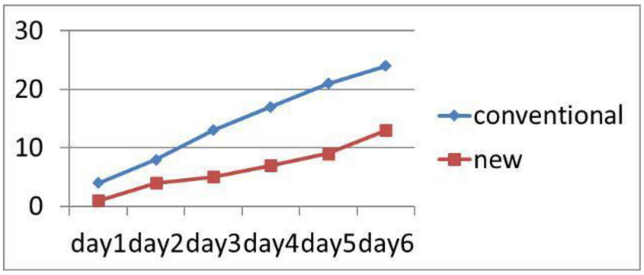
For 3rd VMC



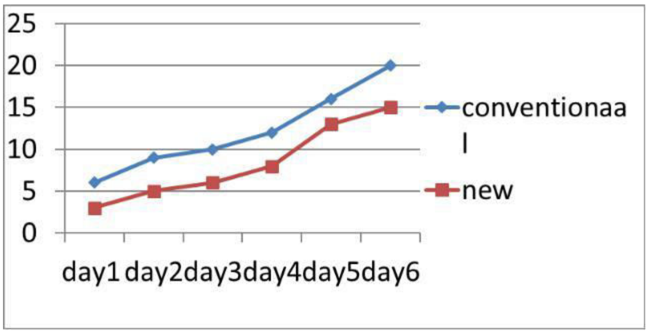
For 4th VMC



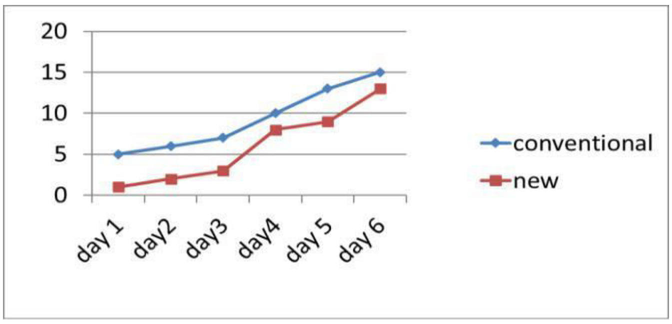
For 5th VMC



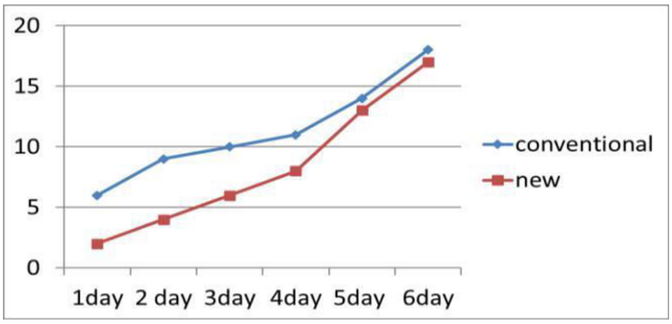
For 6th VMC



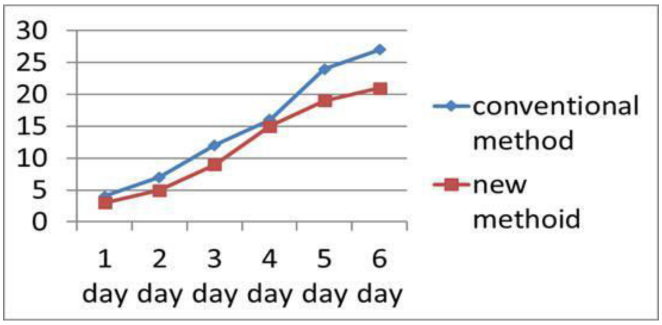
For 7th VMC



For 8th VMC



For 9th VMC



VIII. FUTURE SCOPE

1) The present work is limited due to main requirement of the company is less cost and Simple construction.
2) We can use the automated inspection system for fast and high precision runout measurement
3) We can also use the capacitive and eddy current sensors useful for non contact measurements.

CONCLUSION

The present project work is concerned with Design and development of runout measuring device. Our goal was to build a system which is efficient to check the runout of the tool manually. Very least work has been done in this type of problem. With the scope of the improvement, the project is done to fulfil the demands of the company. The main objective of our project was to fulfil the needs of the company suffering from the problem of wastage of time for checking the runout and also the less productivity. The time required to check the runout is more. Because to check the runout operator stop the machine and then check the runout and corrected it if required. As we mentioned above the time waste to check the runout per day is 81 minutes. With this device, percentage reduction in time required to check the runout is 10%.

We solved the problem in a very simple way. This device is economical as compared to other. The advantages of this device is it required less time and it increase the productivity and also profit.This device will be the great boon for any small and large scale industry.The device is effective with low cost and reduction of time when it is used to check runout.

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