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Process Improvement of Centreless Grinding Machine

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Abstract: The Centerless grinding machine primarily facilitates the ease of grinding processes of bulk and big mechanical component's which are difficult to axially fit and rotate on the centered grinding machine's. The preceding and early developed grinding machines were majorly manually operated, which caused accuracy and precision deviations to the payload. This paper gives a detailed improvement's of the former. A detailed study of the advanced machines and a comprehensive study in advanced process monitoring in centerless grinding technology are looked into. A collaborative study led to the following improvement's which will be further discussed: Implementation of In Process Gauging, Implementation of Flagging Unit for face cut, Implementation of Servo mechanism for Regulating Wheel Dresser, Implementation of Servo mechanism for Drive Feed. The study of improvement of the number of axis which were manually controlled and have been integrated with C.N.C Control processors have also been summarized. The merging of the above mentioned specific's and implementation to the grinding machine and the effect of these improvements have been studied.

Index Terms: Centreless grinding, Cpk index, In Process Gauging, Flagging unit.

I. INTRODUCTION

Centreless grinding is a process for continuously grinding cylindrical surfaces in which the work piece is supported not by centers or chucks but by a rest blade. The work piece is ground between two wheels. The larger grinding wheel does grinding, while the smaller regulating wheel, which is tilted at an angle some angle, regulates the velocity of the axial movement of the work piece. Centerless grinding can also be external or internal, traverse feed or plunge grinding. The most common type of centerless grinding is the external traverse feed grinding[1] .

Side-viewed, from the operator's perspective, the centerless grinder has the grinding wheel on the left, workblade in the middle and the smaller diameter regulating wheel on the right. For most applications, the centerline of the grinding wheel and regulating wheel are in the same plane, at equal heights above the machine bed. To achieve rounding action, the workblade must be set so that the centerline of the workpiece is above the centerline of the grinding and regulating wheels. This is a critical relationship for successful centerless grinding[2].

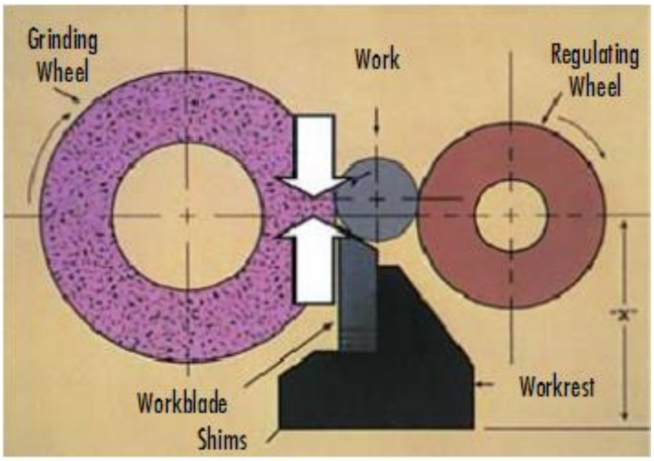

Fig 1 Centreless Grinding Principle

If the workpiece rests on a flat workblade that is on center with the regulating and grinding wheels, the contact points form three sides of a square. As the part is ground in this setup, any high spot on the workpiece will shift the work slightly on the blade, allowing the grinding wheel to cut a directly opposite low spot[2] . Over time this setup will create three lobes on the workpiece that may be dimensionally accurate but far from round.

Setting an angled workblade so it slopes toward the regulating wheel and supports the workpiece centerline above the centerline of the regulating and grinding wheels is how the centerless operation is able to generate roundness. In this setup if a high spot comes in contact with either the blade or the regulating wheel, it does not create a directly opposite low spot because of the angle created between the centerlines of the wheels and workpiece.

The angle of the workblade helps keep the workpiece in contact with and under the control of the slower rotating regulating wheel to resist any tendency to "spin up" to the speed of the grinding wheel. In some cases, a spin-up can take a workpiece from 850 rpm to near 60,000 rpm in the blink of an eye. This is not something you want to have happen[2] .

A rule of thumb for setting the correct height for a workpiece that is up to 1 inch in diameter is to have one half of the workpiece diameter above the centerline of the grinding and regulating wheels. So, for a 1 inch diameter workpiece, the height should be a half inch above the wheel's centerline.

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Centerless grinding workblade angles range from 0 to 45 degrees. For most centerless grinding applications, a top blade angle of 30 degrees seems to provide the best results. There are limits, however. For larger diameter and longer work, a shallower blade angle is best.[2] .

Also, setting the regulating wheel slow, at about 30 rpm, is a point to begin optimizing the centerless grinding process. Obviously, this regulating wheel rotation speed is dependent on work diameter and stock removal rates required.

Angular centreless grinding

In case of Angular centreless grinding as shown in the figure we get advantage of width greater than that of the actual wheel width. The grinding wheel is inclined in a certain angle as per application need providing the increased width. Also on the other hand simultaneous grinding of End Face and Outer Diameter is possible as the wheel is inclined in certain angle[2] .

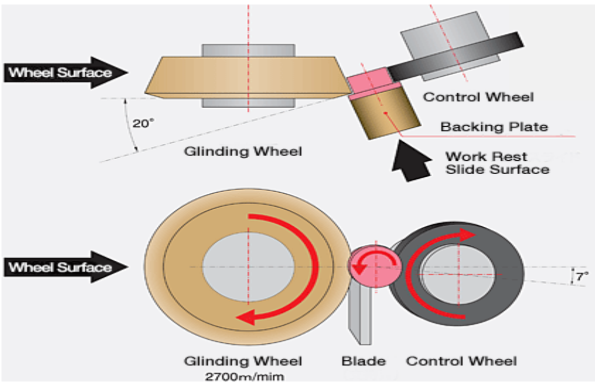

Fig 2 Angular Centreless Grinding

II. 4-AXIS ANGULAR CENTRELESS GRINDING MACHINE

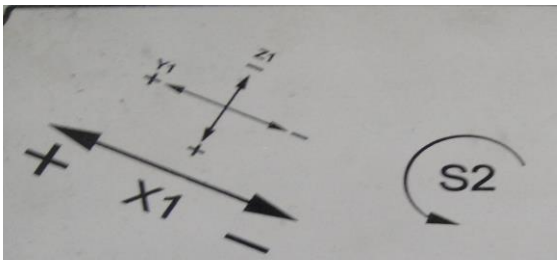

Fig 3 Axis of Angular Centreless Grinding machine

The 4-Axis Angular Centreless Grinding machine is divided mainly into four parts,namely:

1) Grinding wheel and its dresser which are CNC operated.
2) Regulating wheel and its dresser which are Hydraulically and Manually operated.
3) Feed mechansim, which is operated by using a Motor.
4) Workrest which is bolted onto the bed.

The reasons due to which this is machine is called as 4-Axis are:

1) Servo mechanism given to grinding wheel:
   a) X1(axis 1): forward and backward movement of the grinding wheel.
2) Servo mechanism given to grinding dresser:
   a) Y1(axis 2): forward and backward movement of grinding dresser.
   b) Z1(axis 3): cutttig action of grinding dresser.
3) Servomechanism given to both grinding wheel and regulating wheel:
   a) S2(axis 4): Rotational movement of grinding and regulating wheel.

*Fig of 9-Axis Angular Centreless Grinding machine is out of scope

III. BANJO

The banjo housing includes a hollow central member designed to protect your vehicle's differential unit. The central housing then extends towards each side of the vehicle, protecting the axle shafts[3] . The banjo bears the weight of your vehicle and the additional cargo or equipment you are hauling, as well as the force of acceleration or breaking.

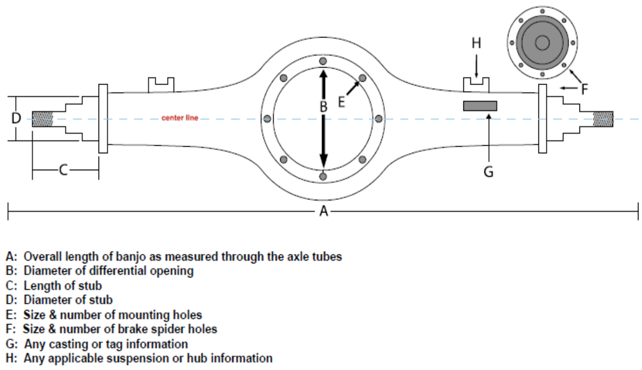

Fig 4 Banjo

IV. ISHIKAWA ANALYSIS OF 4-AXIS ANGULAR CENTRELESS GRINDING MACHINE

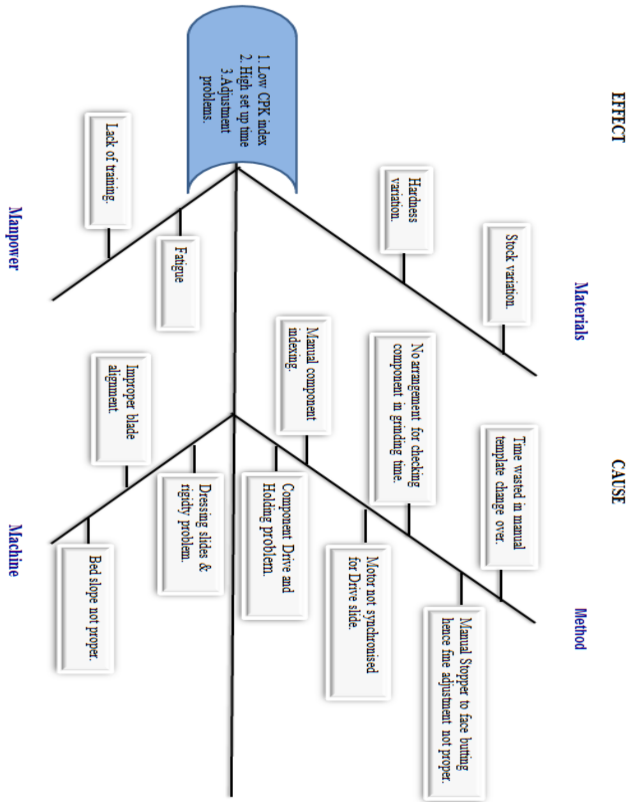

Fig 5 Ishikawa analysis of 4-Axis Angular Centreless Grinding Machine

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V. STATISTICAL ANALYSIS OF 4-AXIS ANGULAR CENTRELESS GRINDING MACHINE

A. Banjo- Spindle Machining(3 diameters)

1) Cpk of 1st Diameter
Cpk= 0.668
2) Cpk of 2nd Diameter
Cpk= 0.894

* Observations, readings and calculations are out of scope Of this paper.

Banjo-Spindle Machining (Single Diameters)

1) Cpk of Single Diameter
Cpk= 0.548

* Observations, readings and calculations are out of scope of this paper.

VI. IMPROVEMENTS

After carrying out the ishikawa analysis and as well as the statistical quality analysis of 4-axis angular centreless grinding machine, we concluded that, the following improvements need to be implemented in order to improve the process capability index of angular centreless grinding machine

Things to be done in order to achieve the required target:

1) Implementation of In Process Gauging :

In- Process Gauging is an on-line inspection of products as available during production to confirm product compliance. In-process quality control is based on the premise that most in- process physical behaviors of a manufacturing process can and should be regarded as process quality feedback. It is a new quality-control paradigm that extracts the product- and process-relevant features from the in-process manufacturing data and alerts the manufacturer of anomalous process behavior in real-time. In-process quality control is a non-destructive, in-process monitoring approach for manufacturing quality control that enhances, complements, and extends the engineering efforts that have already gone into the process.

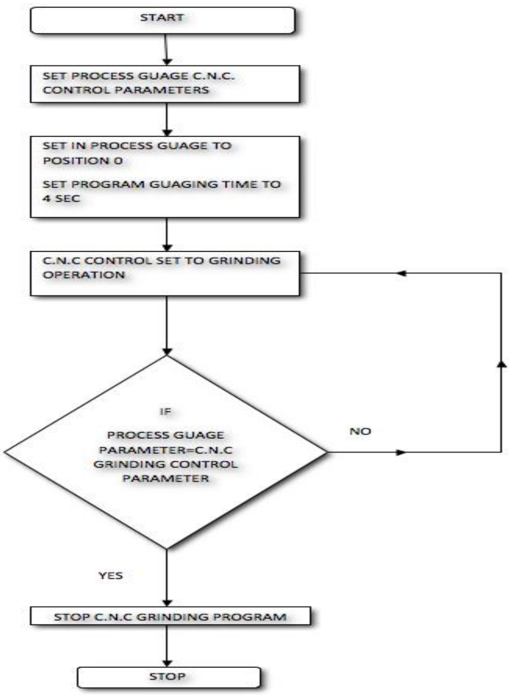

Fig 6 Working of Morposs In Process Gauging

2) Implementation of Flagging Unit for face cut :

CNC probing recognizes irregular work-piece topography and compensates for it dynamically. It does this by taking measurements along the surface of a blank and feeding that data into the machining controller. The controller automatically adjusts for uneven surfaces or work piece position. Through this process, job setup times are reduced and part rejection is minimised[3].

Flagging unit is nothing but a CNC probing technology in which probe is used for accurate positioning of the workpiece with the following benefits:

1) Precise depth machining by compensating material and clamping tolerances
2) Electronically maping & measuring of surfaces.
3) Perfect engraving without lengthy set up times.
4) Accurate measurement of work pieces in X, Y, and Z direction.
5) Lesser rejects.
6) Compensation for material variances.
7) Higher Quality machining results.

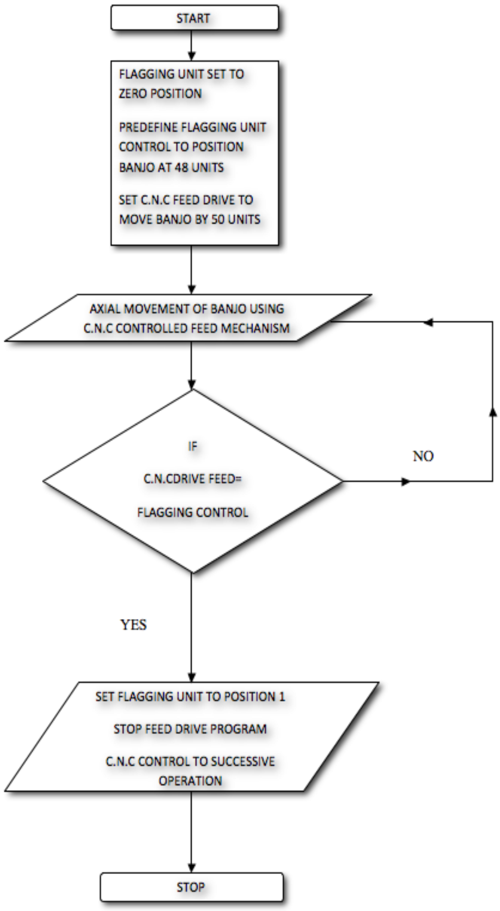

Fig 7 Working of Morposs Flagging unit

3) Implementation of Servo mechanism for Regulating Wheel Dresser :

A regulating wheel dressing system in a centerless grinder, having a dressing tool for dressing a regulating wheel, dressing tool is adapted to be feed-controlled in a direction parallel to the axis of rotation of the regulating wheel and also in a crossing direction by a feed control means, which in turn is controlled biaxially simultaneously by a control means.

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Coordinate values of plural points on a rotated hyperboloid of one sheet of revolution to be formed on the regulating wheel are calculated and the dressing tool is feed-controlled for coordinate interpolation between the plural points with those coordinate values as target points. The regulating wheel can be dressed to the rotated hyperboloid of one sheet of revolution in high accuracy independently of changes of its diameter and even where it is stepped for supporting a stepped work[4].

4) Implementation of Servo mechanism for Drive Feed :

A feed drive consists of a Chuck with feed servomotor and an electronic controller. Unlike a spindle motor, the feed motor has certain special characteristics, like constant torque and positioning. The above drive feed assembly is provided with certain guide way, so that it can move forward and as well as backward with ease.

A. REQUIREMENTS OF CNC FEED DRIVE[6]

(a) The required constant torque for overcoming frictional and working forces must be provided (during machining),
(b) The drive speed should be infinitely variable with a speed range of at least 1:20,000 which means that both at a maximum speed, say of 2000 rpm, and at a minimum, speed of 0.1 rpm, the feed motor must run smoothly and without noticeable waviness.
(c) Positioning of smallest position increments like 1-2 µm should be possible. For a feed motor this represents an angular rotation of approximately 2-5 angular minutes.
(d) Maximum speeds of up to 3000 rpm.
(f) Low electrical and mechanical time constants.
(g) Integral mounting feedback devices.
(i) Low armature or rotor inertia,

VII. 9-AXIS ANGULAR CENTRELESS GRINDING MACHINE

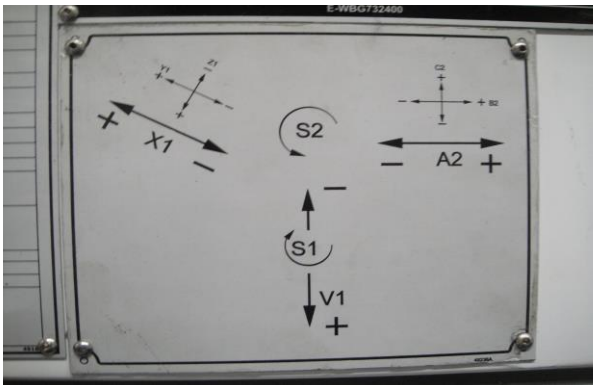

Fig 8 9-Axis of Anuglar Centreless Grinding Machine

The above figure shows new and improved Angular Centreless Grinding Machine with 9-Axis,namely

1) X1(axis 1): forward and backward movement of Grinding wheel
2) Z1(axis 2): cutting action of Grinding wheel dresser
3) Y1(axis 3):forward and backward movement of Grinding wheel dresser
4) A2(axis 4): forward and backward movement of Regulating wheel
5) C2(axis 5): cutting action of Regulating wheel dresser
6) B2(axis 6): forward and backward movement of Regulating wheel dresser
7) V1(axis 7): forward and backward movement of drive
8) S1(axis 8): Rotational movement of drive feed
9) S2(axis 9): Rotational movement of Grinding and Regulating wheel

*Fig of 9-Axis Angular Centreless Grinding machine is out of scope

VIII. STATISTICAL ANALYSIS OF 9-AXIS ANGULAR CENTRELESS GRINDING MACHINE

A. Banjo-Spindle Machining (3 Diameters)

1) Cpk of 1st Diameter
Cpk= 1.846
2) Cpk of 2nd Diameter
Cpk= 1.6

* Observations, readings and calculations are out of scope of this paper.

B. Banjo-Spindle Machining(Single Diameter)

1) Cpk of Single Diameter
Cpk=1.3

* Observations, readings and calculations are out of scope of this paper.

IX. CONCLUSION

From the above improvements and Validation process carried out , it can be see that Cpk of old machine which was around 0.75 earlier is been improved to 1.33 and higher.

X. ACKNOWLEDGMENT

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