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Improving the Productivity of CNC Grinding Machines

By Reducing Set-Up Time

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Abstract: **This paper describes a method for evaluating and optimising setup time of grinding machines by focusing on few major process elements that can be easily varied and controlled. It also describes techniques for measuring the performance of the grinding machines and its evaluation process. It describes Data Collection characteristics and analysis techniques used to improve the productivity.**

Keywords: Productivity, Setup time, OEE, PICK Chart, SMED Technique, EWAG.

I. INTRODUCTION

'One of the important accomplishments and maintaining the product's price low is shortening of product cycle. The longer an articles in manufacturing process and the more moving is done the greater is its ultimate cost' Henry Ford 1926. In today's competitive market various important aspects include companies to manufacture a wide range of products for high demand. For companies of such calibre to be on top of the market by producing quality products at low prices have become one of the highest challenges in production field.

One of the methods part of Lean manufacturing is setup reduction time. Setup time can be defined as amount of time taken to change machine from last part of the production lot to first good part of the next production lot.

In some systems the amount of process repeated, considers of the lead time for majority part and the rest is usually setup time. All the companies try to minimise the setup time. Even though more companies are applying setup time reduction methods nowadays, but reduction in set up time is really an old concept.

In the following paper the focus is done on grinding machines. Of the total amount of cost 20 to 30% is standard on producing discrete components with high precision by grinding process, so it becomes necessary that the grinding process with its parameters should be learnt properly to have optimum control over productivity cost aspects and quality of the product. Determination of optimum parameters is mainly in proper selection and introduction of design of experiments that are suitable for the process at the earliest stages. Optimum grinding conditions and grinding cycle time including the price estimated for each design experiments and results were compared and analysed.

II. PROFILE GRINDING

A. Profile grinding machine:

It is mainly of two types:

1. CNC profile grinding machine
2. Optical profile grinding machine

The standard creep feed grinder provides X-travel up to 600 mm long. Spindles with variety in speeds and power ranges are available to match best application.

Purpose of profile grinder: Grinding parts for high precision dies and moulds, inserts, special tools, surface finishing products, cylinders, and rollers.

B. EWAG machine

It is able to process carbide, and CBN/PCD tools, EWAG Compact Line grinder has a number of features designed to reduce non-productive cycle times.

C. CNC Profile grinding Machine

CNC allows profiling of HM carbide and HSS cutting tools. It was designed for maximum flexibility and ease of operation. All Menu driven software allows operator to input the desired values and create a program in minutes that can be stored in the computer.

III. DIAGNOSIS

A. Spaghetti Diagram

Spaghetti diagram is a visual depiction of actual flow. The important thing is being actual. It is a snap in time, hence it might not include all what-ifs and other scenarios, but these does have discussions as the process progresses.

The idea is to make quick improvements to the Spaghetti Diagram with no tolerance for waste. The machine or station Overall Equipment Effectiveness (OEE) should be kept in mind. Longer term items are kept for positive momentum.

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It may take several readings before the final layout is fixed. Results will vary according to the changing ideas. Execute of as many changes from these with minimum cost and the best quality possible.

B. Operational Chart

Here major activities and entry points of various materials are recorded for representation of operation process graphically. It records and arranges sequence wise steps of all the operations.

In operation process charts of a single part it is in the form of a single flow line consisting of description on the top.

Each operation or inspection is numbered, while description are on the right side of the symbols. This chart is the very first step to carry the detailed analysis of the operation. Following chart shows the operations done during the set-up making. By using this we can decide the specific time for specific activities.

Operation process chart is very useful in industrial engineering for quick understanding the activities.

- Operation Process Chart.
- Task: Changing holder
- Method: Present
- Location: Profile Grinding Floor
- Change Begins: Selecting new holder
- Chart Ends: Testing of selected holder on machine

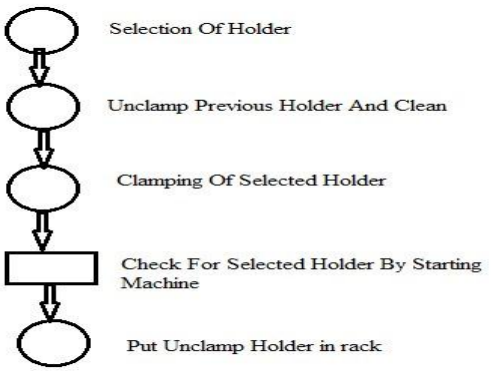


Fig. 1. Holder Change operation Chart

C. PICK Chart

(Possible, Implementation, challenges, kill out)

PICK charts are the means by which we arrange our ideas that are proposed in a way which will help us to shortlist the ones that are feasible and easy to implicate. PICK charts are mostly assisted by six sigma policy.

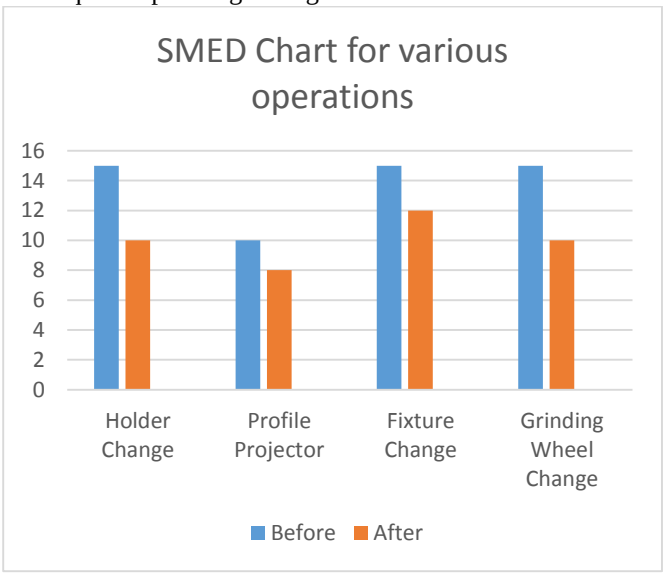
D. SMED (Single Minute Exchange of Die) Techniques

Various methodologies are used by the companies to reduce the waste. SMED technique is one of the most useful ones of many.

SMED method implies to reduce setup operations to in less than ten minutes, which is setup operations should be completed in a single digit minute viz. 1 to 9 minutes. Due to this, the production efficiency would increase and the time spent in midst of each production is less.

For EWAG RS 12-1 and EWAG RS 12-2 SMED technique is analysed for various operations like changing holder, Dimensions check on shadow profile projector, copy the standard program on one machine to another machine. These operations take less than 10 min for doing the activity.

Because of sorting the holder rack, Grinding wheel trolley, Fixture trolley as per standard article Codes various operations can done with SMED technique. And this technique is very useful for improving the productivity of grinding machine. For the reducing set-up time we use this technique for profile grinding floor.



X-Axis :Name of Operations
Y-Axis :Time Required for each operation in (min)

Fig. 2. SMED Chart for various operations

E. Time study

Time study comes under work measurement that includes recording the times of performing a certain specific job for analysing the data to acquire time necessary for an operator to carry it out a good rate of performance.

Time study is 'try and test' method of work measurement for setting basic time and therefore standard times for doing a particular work. The main aim of time study is to set a time for a qualified worker to perform a specified work under given conditions and at a given rate of working.

This is done by a qualified employee observing the work and recording what is done and then timing it while simultaneously rating the pace of working. The person performing the task should be experienced in the work, the work and the working conditions must be clearly defined.

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By changing the layout of the profile grinding floor motion or movement of workers is reduced and it is very useful for minimizing set- up time. Because of arrangement of machines and various equipment trolley time for workers movement is reduced. It helps to increasing the productivity of grinding floor.

F. Systematic planning layout

Plant layout is the best and an optimum arrangement of operating equipment, storage space, employees etc. facilitate the product. Plant layout concerns with the physical arrangement of industrial facilities. This arrangement which is either in installation or in planning phase, consists of the spaces needed for material movement, storage, labourers, and other related activities. Direct and rapid flow of material shows formation of a good layout. Idle time, idle man hours, transport cost per unit etc. things get optimized when a systematic plant layout is proposed and implemented.

SLP is an organized way to layout planning. It involves procedures that are based on identifying, rating, and visualizing of the elements that are involved in planning of a layout.

In many industry's floor, plant layouts take more time to transport any equipment like fixture, grinding wheel, holders, work orders etc.. So because of changing the layout of grinding floor, workers movement is smoothened and energy is saved.

IV. PROPOSAL

These are some proposals and techniques used which are identified for reducing setup time:

Solutions	
i.	Standardization Of Process (SOP)
ii.	Layout Change
iii.	Holder Accessibility
iv.	Easy Availability of Raw Material Creating Groups and shift leaders.
v.	Double-Pocket Holder
vi.	Grinding and Dressing Wheel Identification.
vii.	Left hand right hand operations
viii.	Distribution of Work
ix.	Program Training
x.	Continuous Utilization of Machine

Table No.1 Various solutions and techniques used to reduce setup time.

A. Standardization of processes (SOP)

It means setting a standard order or fixing the order of operations to be carried out for setup of an insert. It also includes assigning an optimum (minimum possible) time for each step of setup. This helps to create a sense of discipline in the worker and prevent him from being lethargic during the setup.

B. Layout Change

As mentioned above, a worker has to go to a profile projector to check for various dimensions and their accuracy. Hence, distance between the machine and the profile projector should be as low as possible. If it's not, then certain changes need to be carried out in the layout of the shop floor for better plant area utilization and increasing the productivity. Changing the layout helps to minimize the material handling time, labour cost, and transportation cost for some operations.

C. Holder Accessibility

Holder must be easily accessible to workers (new or old). For a particular job a specific holder is required. Most of the times workers do not use a proper holder and use sim on a different holder. Also holders must be properly arranged in the trolley with reference to product code and order number so that time required for searching the appropriate holder would be minimized. Detail process of this proposal is explained later.

D. Availability Of raw material

Raw material should be available before starting the setup so that workers are not left idle during their shift. Previously, workers used to bring raw material from raw material storage machine, which is on other shop floor. But now raw material is provided on a trolley placed adjacent to the machine as shown in layout chart. This reduces time required to bring the raw material to the machine.

E. Grinding and Dressing Wheel Identification

Grinding wheel is chosen depending on movement of fixture and depth of cut of grinding operation. As thickness of grinding wheel increases, its diameter also increases. Thus grinding wheels are arranged and labelled according to the diameter to reduce time needed for searching them.

V. FEASIBILITY CHECK AND IMPLEMENTATION

Out of all solutions we were use only feasible solutions or these are only accepted rest are rejected. Implement only feasible solutions. Detail of some of them is given below.

A. Standard Operating Procedure (SOP)

Do the procedure as per the following procedure:

a) Fixture Change

i. Identifying and selecting the new fixture according to new order.
ii. Removing the previous fixture from the machine, cleaning it and keeping it on the trolley.
iii. Fitting of the selected fixture from the trolley on the machine.
iv. Checking if fixture is placed properly.

b) Holder change

i. Identifying and selection of proper holder according to article code (if available).
ii. Getting the holder from trolley according to its designed position.
iii. Attaching it to the fixture according to requirements.
iv. Cleaning and keeping the previous holders in its given location.

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c) Grinding wheel change

i. Selecting of grinding wheel as per grinding operation requirement.
ii. On the portion of the insert to be grinding or movement of fixture during process, grinding wheel is selected (larger or smaller diameter).

d) IK axis setup

i. Setting of datum (i.e. point on grinding wheel) with reference to which the fixture will move.
ii. It acts as a reference with respect to which operation is carried out.

e) Program setting

i. Taking a program from computer into the machine unit.
ii. Making changes in the program according to the drawing provided
iii. Dressing of grinding wheel should be done during this step.

f) Shadow –graph setting

i. Placing the tracing sheet on shadow graph as per co-ordinate axes.
ii. Selecting of master piece and measuring plate according to article code.
iii. Tracing sheet placement and dimension are recorded according to master piece and used further during pilot job.

g) Pilot job

i. Performing the requirement operation on raw material.
ii. Checking of work piece on profile projector and changes in program as per dimension.

B. Holder Accessibility

Tailstock of the machine contains a fixture and a holder or just a fixture. At the start of every setup worker removes previous holder and fixture and attaches new ones as required by the order. Earlier the worker somewhat used his knowledge and selected a holder based on the shape of the insert to be grinded. He needed time to search the holder and if even after some time he couldn't find the appropriate holder, he used to take a similar holder and use Sims to ensure that insert stays fixed during grinding. This process required more time and it would affect the accuracy of grinding operation.

To avoid this wastage of time, what we did during our study period is that we noted down the holders with holder numbers used for different article and order numbers on different machines for 3 days.

The observations were in following format:

Machine name:
Date:
Shift:
Operator name:
Article number:
Order number:
Holder number:

Table No. 2 Record Sheet of Holders

From above observations we found that for a certain type of article number having similar pattern of numbers in it, holder number also had a corresponding similar pattern. For example orders having article number beginning with N151.2 had holder having number 151.2. Article numbers having 20-4G up to 50-4G at the end had holders having number 40-50 at the end. Using such observations, we proposed the workers to enter the holder number used for that particular job in the program so that when same job is repeated, other worker would know which holder was used. There are around five hundred holders available. So even after the worker knew the holder number, he would have had to search that holder from those many holders which would take considerable amount of time. Now the workers can easily find the appropriate holders by looking at the article number and the list or in the program if same job has been done before. Earlier time required for selecting and searching the holder was about 12 15 minutes. Now the same job is done in 5 minutes.

Fig. 3. Holder trolley modification

C. Grinding and Dressing Wheel Identification

The grinding wheel used is composed of an abrasive compound. It is used for various grinding (abrasive cutting) and abrasive machining operations in both manually operated and automatic machines. The manufacture of these wheels is a precise and tightly controlled process, due not only to the inherent safety risks of a spinning disc, but also the composition and uniformity required to prevent that disc from exploding due to the high stresses produced on rotation.

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To use the grinding wheel it is first be clamped to the grinding machine. The wheel type (e.g. cup or plain wheel below) is fit freely on their supporting arbours, the necessary clamping force to transfer the rotary motion being applied to the wheels side by identically sized flanges (metal discs).

The paper blotter shown in the images is intended to distribute this clamping force evenly across the wheels surface. From the job process sheet, worker gets to know the depth of material to be removed from the insert. Also part of the profile to be grinded is known. From these two criteria, worker selects the thickness and diameter of grinding wheel. Greater the thickness, greater is the diameter of grinding wheel. Grinding wheels are available in 2mm, 6mm, 10mm, and 12mm thickness and in 180mm, 200mm, and 250mm diameters.

Initially Grinding wheels were just kept on a table and were randomly placed. Hence the worker required time to select the wheel by measuring its thickness and diameter. The initial arrangement looked like this,

Fig. 4. Grinding wheel modification before and after in many company

G. Double-Pocket Holder

Let us consider that insert is triangular shaped. Earlier only single pocket holders were used. During grinding operation of setup process, after a side or profile is grinded, worker needs to unclamp, change the side and clamp the insert. Thus for triangular inserts this had to be done twice. But due to the use of double-pocket holders, when one side of insert is grinded, fixture rotates through 180^{o} and corresponding side of other insert is grinded. The worker now unclamps, changes the side and clamps both the inserts at the same time. Thus the process of unclamping and clamping is done twice only for triangular inserts but instead of one, two inserts are grinded at a time.

VI. RESULT AND CONCLUSION:

i. The problems that were diagnosed were reduced as minimum as possible in given time frame.

ii. The productivity can be increased with a considerable amount (by about 20.7%)

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