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Combined Operation Boring Bar

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Abstract: ***This paper presents a new methodology for the combined operation boring bar. In normal boring operation it requires to replace the tool various operations. We cannot perform multiple operations on one machining tool. So it creates problems: Timeconsumption in changing of tool, cost of different tool, required for various operation. The focus of this research is the operation can be done on the same boring bar. It can able to perform various operation such as rough boring, finish boring, chamfering and spot facing, Which is not possible with conventional machine tool.***

Keywords: Special purpose machine, Combine operations, Boring Bar

I. INTRODUCTION

In every industry the primary object is to increase productivity by regulating different parameters. The production rate can be increased by different ways such as implementing optimization, collecting statistical data, approaching six sigma. These are the parameters which come into consideration after conducting inspection, different tests etc. But having increased rate of production is primarily depends on the cycle time of the component, which contributes a lot to increase the production rate. So in earlier days the component including different operations to be carried out are machined by using number of boring tools. So during the machining it is supposed to change the tool as the machining proceeds. One thing can be noticed that conducting such task requires lot of time to execute which is intolerable in today's competing world. This increases the cycle time for the component, resulting reduced rate of production. So the solution for this problem may be to combine the various tools on a single boring bar so that in a single pass of the tool the machining can be carried out. So 'Combined Operational Boring Bar' is the suitable title for this research paper. The analysis of problem and their solution is a preliminary step before starting any kind of project. Once the problem statement is made the necessary steps are taken to find the suitable solutions and to apply the best solution. So it's very important to make first the problem statement from which one can get easily what has to be done.

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In today's competitive world and also the demanding customer's requirement make a large scope Employed the problem can be found out, and then work can be proceeded to find the solution.

II. PROBLEM DEFINITION

The combined operation boring tool is able to perform different operation at a time such as boring, spot facing and chamfering. This otherwise would impossible with conventional boring tool to perform various operations at a same time and on the same machine. The result is fruitful by using the combined operational boring bar, it reduces the machining time, cost of procuring different tools, reduces idle time of machining during changing the tool while performing each operation. It also increases the productivity. The operations are discussed below:

III. OPERATIONS TO BE COMBINED

1. Boring: In machining, boring is the process of enlarging a hole that has already been drilled (or cast), by means of a single-point cutting tool. Boring is used to achieve greater accuracy of the diameter of a hole, and can be used to cut a tapered hole. There are various types of boring rough boring and finish boring. It can be performed on lathe and milling machine.
2. Chamfering: Chamfering is the operation of bevelling the extreme end of a work piece. This is done to remove the burrs, to protect the end of the work piece from being damaged and to have a better look. The operation may be performed after knurling, rough turning, boring, drilling. Chamfering is an essential operation before thread cutting so that the nut may pass freely on the threaded work piece.
3. Spot facing: A spot face or spot face is a machined feature in which a certain region of the work piece (a spot) is faced, providing a smooth, flat, accurately located surface.The most common application of spot facing (spot facing) is facing the area around a bolt hole where the bolt's head will sit. Other common applications of spot facing involve facing a pad onto a boss, creating planar surfaces in known locations that can orient a casting or forging into position in the assembly; allow part marking such as stamping or nameplate riveting; or offer machine-finish visual appeal in spots, without the need for finishing all over The cutters most often used to cut spot faces are counter bore cutters and end mills. Spot facing of larger planar surfaces sometimes employs face mills. 4. Combined operation boring tool: The combined operation boring tool is able to perform different operation at a time. Such as boring, spot facing and chamfering, this is not possible with conventional machine tool, to perform these operations at a same time and at a same machine.

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It will help to reduce the machining time, cost of purchasing different operational tool, Reduces the ideal time of machine during changing the tool during each operation. It also increases the productivity. The research carried out by us made an impressing task in the field of industrial and automated workshops. It is very useful for the workers to work in the industrial workshop are in the service station. This project has also reduced the cost involved in the concern. Project has been designed to perform the entire requirement task which has also been provided. The various machining process in manufacturing industries are carried out by separate machining machine. It need more space requirement and time with high expenses. But the fabrication of multi operation machine, which contains three operations in a single machine. The operations are namely boring, spot facing and chamfering. It is a new concept specially meant to reduce the work time and save the cost. It can be used for perform combined operation such as boring, spot facing and chamfering operation. It applicable for to machining the crank case of Emerson Company's compressor.

IV. DESIGN PROCESS

A. Preliminary Design Decisions:

It is very important to design a tool which can give the best result /output throughout its life span. As the tool is going to be installed in a mass scale production, it should be designed at optimum level. In this stage the first and foremost thing is to study the component which is to be machined by using this tool. As it is required to manufacture the boring tool one should know all the dimensions of the part. And also for design purpose all the data mandatory or the basic knowledge required must be known. So the study of different machine tool related books, handbooks are necessary. As the four processes are required to be combined, all the tools needed should be mounted on the same boring bar. Now mounting of all the tools (which is also called as inserts) should be made as per the sequence of operation. The other dimensions are to be calculated by using standard formulae. Here one constraint in calculating the dimensions is the extreme diameter of boring bar, as it's supposed to enter or travel the entire depth of the component

a) Design Sketches (Rough):

Now it is necessary to develop a rough sketch in order to meet all preliminary requirements stated above. The rough sketch gives initial idea about the object, so that it becomes easier to analyze the details of that object.

b) Analysis of design:

The tool has to be drawn on the paper, now this is required to be analyzed properly from which a general outline of that tool can be imagined. The rough drawing is prepared on modeling software that is CATIA. The tool is drawn with exact and accurate dimensions. Analysis of the tool is required to be done which includes finding stresses at different cross sections, load on cutting tool, required feed and speed, rpm of the tool.

c) Modification:

The tool is designed theoretically and it's not definite that how the tool is going to behave with the component in the given condition. After conducting a trial using the prototype tool there was one problem during the machining. The problem was not certain or it varies, as the component is pure casted so there may be some changes in the castings. This causes uneven finishing of the component as the required portion of the part which is to be finished, increases or decreases. So it is necessary to design such tool which can face such problem. And the solution on this problem is to use cartridges. The inserts are attached to the cartridge by which the insert can be moved through small distance. So this was the great modification in the boring tool design.

d) Detailed Drawing:

Any component requires its proper drawing in order to interpret it accurately. So the primary objective of drawing is to clear all the ideas regarding to the component. The detailed drawing comprises of 2-D (Two Dimensional) views, which includes front view, top view and the side view. Along with the all views it is given proper necessary dimensions with tolerances. This helps in deep understanding of the component and its details. The detailed drawing also involves list of material table in which all required component names are given, material and number of quantity required. So detailed drawing helps a lot in manufacturing stage. If the drawing is made perfect then the manufacturing of component becomes accurate without any defects. Therefore proper attention has to be paid while preparing for detailed drawing.

e) CATIA Design:

As the calculations are ready now we can design the actual model of tool by using CATIA software. Here one can easily fit all necessary accessories of tool which includes Inserts and Cartridges. The tool is to be designed for four operations so that there must be four inserts present on the tool. Each insert perform its operation separately. The sequence of operations as tool approaches the component from upward to downward are:

a) Rough boring
b) Finish boring
c) Spot facing
d) Chamfering

Here first two operations will be carried out separately but the last two operations are combined so that these operations are performed at the same time.

f) Production:

After performing all the above steps precisely the production of actual component is done. The production department demands the detailed drawing of the component which includes all the necessary information regarding to the manufacturing such as all linear dimensions, inclined dimensions, diameters, chafers and their angles, tolerances etc.

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The machineries required to process the component are arranged on shop floor as per the process sequence so that there will be the smooth flow of component from one station to another without making any of machine to remain idle. So the production of the component is made as per the demand by the customer and therefore all the prerequisites are set up for production. The prerequisites mainly consist of raw material, machineries, tools, inspection devices, testing laboratories and labors. The cycle time for each operation is then calculated with the help of method time study, so that it becomes easy to recognize the optimum time taken by the worker to complete one component. The optimum MTM is applied so as to improve the production rate.

g) Testing of component:

Before the component is manufactured for the mass scale, first the prototype of the component is made which may be of reduced or of the same scale. This prototype is then processed through the actual operation so as to observe the different parameters such as its performance in actual working condition, reliability, efficiency, fatigue strength, workability etc. If any one of the mentioned parameters fails then the entire design procedure is repeated and the problems are rectified. After solving the problem if that component works satisfactorily then the component is passed further for actual mass scale production. The types of testing are destructive and non-destructive. The destructive testing involves testing of actual component after manufacturing. So there is possibility of that component may get damaged. So the cost involved in destructive testing is high, and also it does not compensate for the job being tested. The non-destructive testing includes the method of testing by which the component being tested doesn't get hampered. So there is scope for testing of all the components for testing. This system is reliable and the cost incurred can be compensated by producing the components at higher quality.

The purpose of project methodology is to allow for controlling the entire management process through effective decision making and problem solving, while ensuring the success of specific processes, approaches, techniques, methods and technologies. Typically, a methodology provides a skeleton for describing every step in depth, so that a project manager will know what to do in order to deliver and implement the work according to the schedule, budget and client specification.

h) Hardware to be used:

- Boring bar inserts
- Chamfering tool inserts
- Spot facing tool inserts
- Cartridges
- Boring bar

V. COMPONENT TO BE MANUFACTURED

The component named as crankcase of refrigerator which is developed by Emerson ltd. the component is to be machined for three operations namely boring, spot facing, chamfering. The material for component is FG350 that is Grey cast iron having ultimate tensile strength of 350 N/mm^2

Fig. 1.Component to be machined

VI. CALCULATIONS

A. Standard data:

The standard data is collection of all results by carrying out the numerous experimentations. So the data is obtained by varying number of parameters such as temperature, pressure, humidity, loads, stresses and strains etc. So the results are Obtained by keeping some of the parameters constant and varying few of the parameters. So very large numbers of results are obtained and the results are prepared in a tabular format. So that it is easy to find out any value while calculating for different number of conditions.

B. Cutting Forces for different materials:

Chart no. 01. Cutting forces for different materials.

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Workpiece Material	Tensile Strength(MPa) and Hardness	Specifi c Cutting Force Kc (MPa)				
		0.1(mm/rev)	0.2(mm/rev)	0.3(mm/rev)	0.4(mm/rev)	0.6(mm/rev)
Mild Steel	520	3610	3100	2720	2500	2280
Medium Steel	620	3080	2700	2570	2450	2300
Hard Steel	720	4050	3600	3250	2950	2640
Tool Steel	670	3040	2800	2630	2500	2400
Tool Steel	770	3150	2850	2620	2450	2340
Chrome Manganese Steel	770	3830	3250	2900	2650	2400
Chrome Manganese Steel	630	4510	3900	3240	2900	2630
Chrome Molybdenum Steel	730	4500	3900	3400	3150	2850
Chrome Molybdenum Steel	600	3610	3200	2880	2700	2500
Nickel Chrome Molybdenum Steel	900	3070	2650	2350	2200	1980
Nickel Chrome Molybdenum Steel	352HB	3310	2900	2580	2400	2200
Hard Cast Iron	46HRC	3190	2800	2600	2450	2270
Meehanite Cast Iron	360	2300	1930	1730	1600	1450
Gray Cast Iron	200HB	2110	1800	1600	1400	1330

C. Cutting Speeds and Feeds

Workpiece material	Hardness	Cutting speed - High speed steel				Cutting speed - Carbide uncoated				Feed rate per revolution			
	[Bhn]	Vc [feet/min]		Vc [m/min]		Vc [feet/min]		Vc [m/min]		f [inch]		f [mm]	
		MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
Cast irons	190...320	16	197	5	60	33	492	10	150	0,003	0,020	0,080	0,500
Steel - plain carbon	85...200	49	394	15	120	197	919	60	280	0,003	0,020	0,080	0,500
Steel - alloys	35...50Rc	16	131	5	40	66	492	20	150	0,003	0,020	0,080	0,500
Steel - tool	50...58Rc	16	66	5	20	49	197	15	60	0,003	0,020	0,080	0,500
Steel - stainless	150...450	16	98	5	30	98	394	30	120	0,003	0,020	0,080	0,500
Aluminum alloys	30. . .150	492	1181	150	360	492	2625	150	800	0,003	0,020	0,080	0,500
Copper alloys	80...100Rb	98	591	30	180	164	1378	50	420	0,003	0,020	0,080	0,500
Nickel alloys	80. ..360	16	131	5	40	16	394	5	120	0,003	0,020	0,080	0,500
Titanium	250...375	16	98	5	30	33	328	10	100	0,003	0,020	0,080	0,500

For grey cast iron minimum and maximum cutting speeds are 5 and 60 m/min respectively. So we have selected grey cast iron.

Chart No. 03. Power and Force Requirement

Work Material	Hardness HB	UTS Kgf/mm³	Material Factor K
Free Machining Steels	167	59.9	1.03
	183	63	1.42
Mild Steels	121	44.1	1.07
	160	56.7	1.22
Medium Carbon Steel	152	55.1	1.15
	197	67.7	1.45
Alloy Steels Tool Steels	163	58.3	1.56
	174	61.4	2.02
	229	78.8	2.1
	241	81.9	2.32
Stainless Steels	187	64.6	1.56
	269	92.6	2.41
Cast Iron: Grey, Malleable, Ductile	177	21.3	1
	198	28.4	1.5
	224	35.1	2.03
Aluminum Alloys	-	-	0.55
Copper Alloys	-	-	0.55
Magnesium Alloy	-	-	0.45

From this table we have selected material factor (k) = 1.5 of grey cast iron.

Calculation for the Combined Operational Boring Bar.

Vc = Cutting speed (m/min)

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K= material factor
KW=Power at spindle (KW)
T=Torque (N.m)
Th = Thrust (Kg.f)
P= Power (KW)

Using standard data from Central Machine Tool Institute machine design data book.

1. Cutting Speed, N = Cutting Speed = (1000 x Vc)/(Π x D) = (1000 x 60)/(Π x 67.183) =284.27 rpm = 285 rpm

2. K = Material Factor = 1.5 ... (From CMTI

3. KW = Power at Spindle

KW = $1.25D^2 \times Kn$ (0.056+1.5 S) x 10^{-5} = $1.25 \times 67.183^2 \times 1.5 \times 285(0.056+1.5\ S) \times 10^{-5}$
= 194401 Watts =19.44 KW

4. Torque:

T = 975 × (N/n) = 975×(19.44 / 285) = 66.5052Kgf.m= 66.5052×g= 66.5052 × 9.81= 652.14N.m

5. Thrust (Th): Th = 1.16 K×D $(100 \times S)^{0.85}$
= 1.16 × 1.5 × 67.183 $(100 \times 0.5)^{0.85}$= 3250.3725Kgf = 3250 Kgf

6. Power (P):
P = (2πnT)/ (60) = (2π x 285 x 652.14) = 19463.2032 Watts = 19.4632 KW

7. Force Calculations (F):
At spot facing: Force = (torque / radius) = (652.14/18) = 36.28 KN
At rough boring: Force = (torque / radius) = (652.14/30) = 21.73 KN1
At finish boring: Force = (torque / radius) = (652.14/33.59) = 19.41 KN

CATIA MODELING

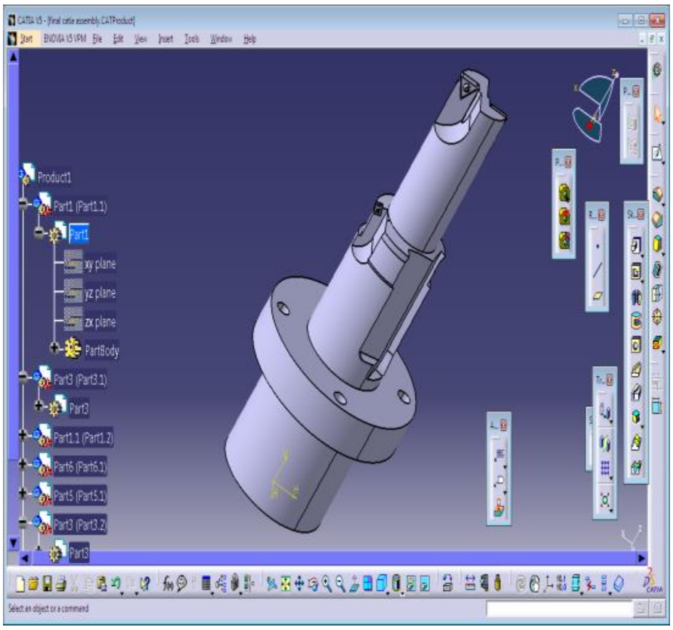

Fig. 02.Combined operational boring bar

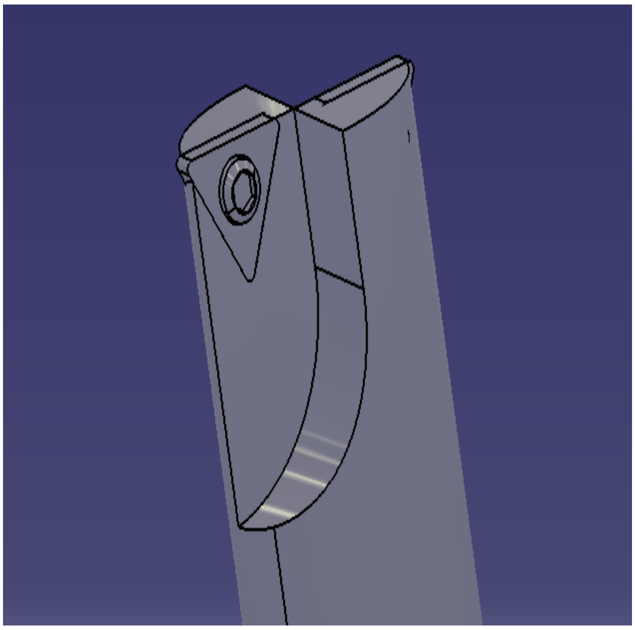

Fig.03.InsertFor Spot Facing

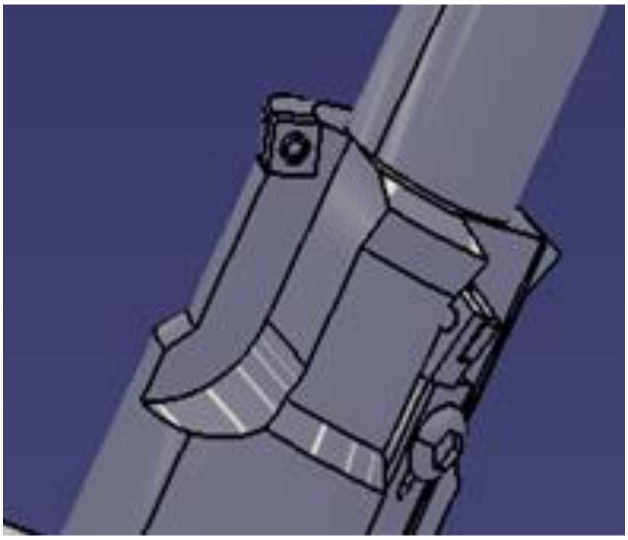

Fig. 04. Insert for Rough Boring

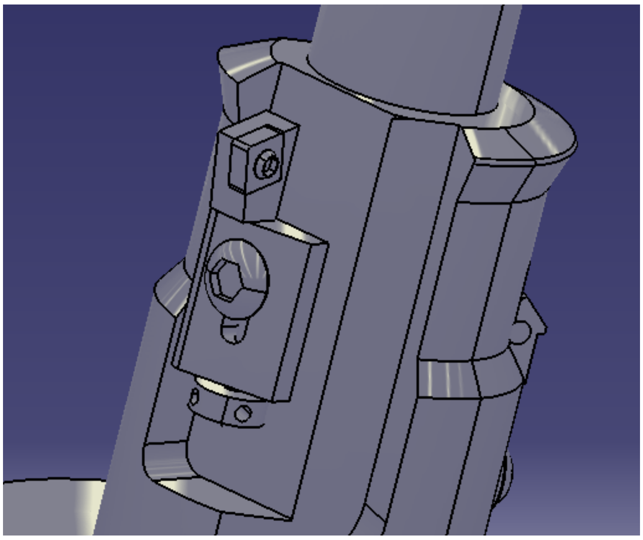

Fig.05. Insert For Finish Boring

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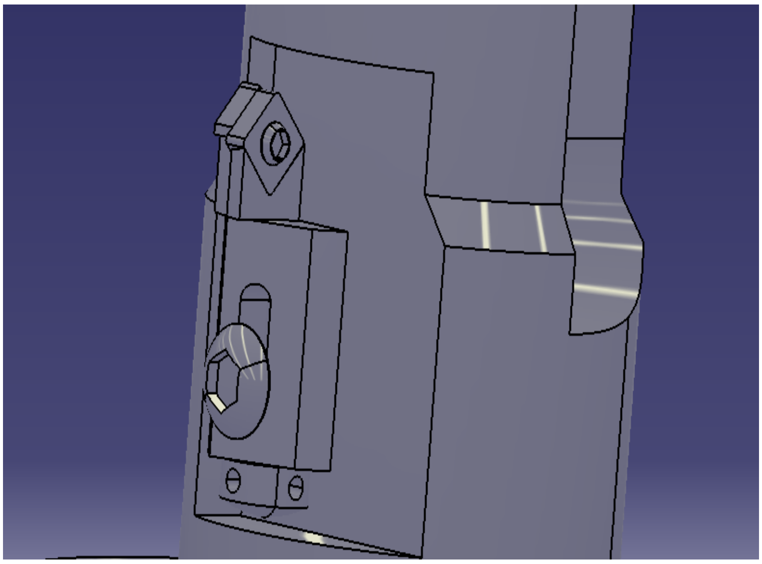
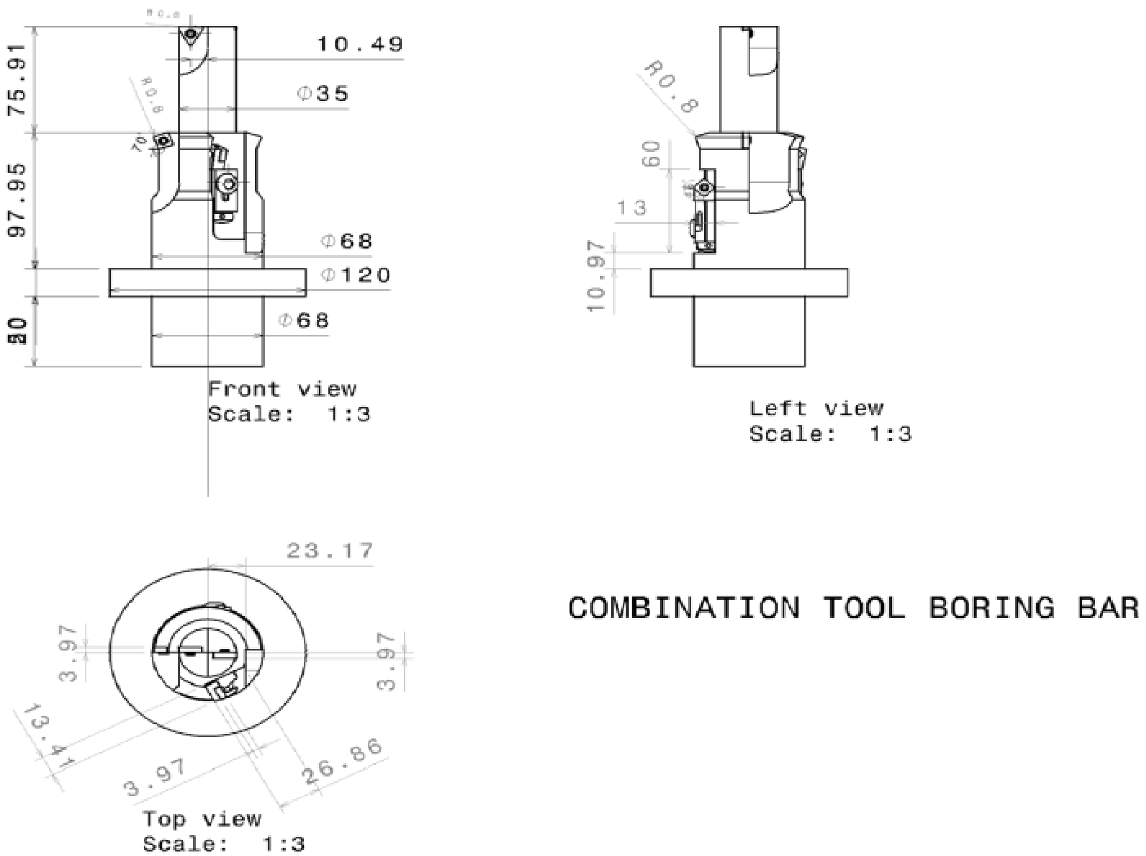


Fig.06.Insert for Chamfering

DRAFTING OF TOOL



VII. TIME STUDY MEASUREMENT

The time study is carried out in order to find out the variation in the cycle time when the operations are performed by using the conventional machines and the newly developed combined operational boring tool. So the time study helps in determining the optimum time required to complete a unit job.

Time study on conventional machine: The time study includes the collection of time required which may be productive or unproductive (idle). It involves the stepwise procedure as follows:

For rough and finish boring:

- Clamping of job on lathe machine = 10 sec.
- Declamping of job = 5 sec
- Cutting tool adjustment = 9 sec
- Rough boring time = 65 sec
- Finish boring time = 45 sec
- Tool adjustment for chamfering = 3 sec

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- Chamfering operation = 6 sec
- For Spot facing:
- Job clamping on drilling machine = 8 sec
- Job Declamping = 4 sec
- Tool mounting = 7 sec
- Spot facing operation = 8 sec

  From the above time study the total time required is the summation of time taken on all the machines for different operations. The above time study also includes the idle time which is clamping and Declamping.

  Idle time is 46 sec.

  Actual operation time is 124 sec.

  Total time is 2 min 50 sec.

  Now the time study by using combined operational boring tool on the special purpose machine includes:
- Job clamping = 3 sec
- Job Declamping = 2 sec
- Tool adjustment = 12 sec
- Operation time = 48 sec
- Total time = 65 sec.

  So from conducting time study on both the operation facility we have come to result that total time taken for completing a single job on the conventional machine is 2 min 50 sec and by using combined operational boring tool the cycle time is 65 sec

VIII. CONCLUSION

The various machining process in manufacturing industries are carried out by separate machine tools. It needs more space requirement and time with high expenses. But the fabrication of multi operation tool, which contains three operations in a single tool. The operations are namely boring, spot facing and chamfering. It is a new concept specially meant to reduce the work time and save the cost. In combined operation boring bar we combine three operations, so we can save the investment cost of exceed milling and drilling machine in the industries. Hence exactly we can carry out three operations by using a single tool on the single machine, namely boring, spot facing and chamfering. It is a simple in construction and easy to operate. The separate adjustable inserts with cartridges are used for different operations and those are SCMT09T308 for rough boring, finish boring and chamfering. And TCMT16T308 for spot facing operation.

The cycle time for the component using conventional machines such as milling, drilling and lathe machine was 2 minute 12 seconds. The reason behind the high cycle time was the use of different machines for different operations and also the idle time taken for changing the tool, movement through station to station and clamping- unclamping at each machine. Therefore it is needed to reduce the cycle time for the component. This is achieved by using combined operational boring bar which includes insets for the different operations. The result is lower the cycle time. By using combined operational boring bar the cycle time is reduced considerably from 2 min 50 sec to 65 sec.

The costing has also influenced by using the combined operational boring bar. Previously, manufacturing of the same component was carried out on three different machines so the cost associated are: purchasing cost of machines, labor assigned to each machine, material handling cost, electricity required for the machines and space required. These parameters add a lot in the final product cost, so ultimately the product becomes expensive.

However, after using the combined operational boring bar with special purpose machine the cost parameter has decreased very much. This reduces the costs of three machines by having a single SPM, a single labor is sufficient to carry out the operation, lessen the material handling as the entire component is processed on a single work station, the energy consumption is reduced and at the last, space for installing the machine is reduced. So privilege in the terms of reduced cycle time which increases productivity and the cost effective process using the combined operational boring bar.

The project carried out by us made an impressing task in the field of industrial and automated workshops. It is very useful for the workers to work in the industrial workshop at better ease of operation. This project has also reduced the cost involved in the concern. Project has been designed to perform the entire requirement task which has also been provided.

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