# Design and Analysis of Drill-Bore Tool for Special Purpose Thrust and Radial Bearing

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**ABSTRACT**

*Conventional methods of machining use the drilling, boring and grooving operations to produce parts of desired shape to function for specific applications. There is a trend to combine two or more operations in-order to save the tool setting time and the subsequent loss in the machine idle time and labor cost lost incurred as a result of loss in time in tool change. Step drills and form tools are common examples of such tool changes adopted with the intention to save machine time. In our case the application that requires a combination tooling for the development of bearing that is used in wind operated overhead exhaust fan commonly called the wind ventilator. A certain industry are to develop the bearing for this application in Nylon-6 material with two different thrust end geometry. The project involves the design development and analysis of the tool that combines drilling, boring (counter-boring) operation in one tool to be used in the CNC machine with automatic tool changer. The theoretical design will be done for the cutting forces generated during operation, solid modelling will be done using Unigraphics NX-8 and the strength analysis will also be done using Ansys Workbench -16.*

**Keyword**: - *Drilling, Boring, Combination tool, Ball Bearing, Thrust Bearing, Radial bearing, Cycle time, Cost reduction*

## 1. Introduction

Drilled holes are distinguished by the presence of burrs on the exit side (unless they have been removed) and by their sharp edge on the entrance side. Also, the inside of the hole usually have helical feed marks. [3] Operation such as Drilling can influence the mechanical properties of the workpiece by creating lower residual stresses around the hole openings and by generating a very fine (lean) layer of highly stressed and remarkably disturbed material on the newly formed surfaces . This causes the workpiece to become more prone and sensitive to crack generation and corrosion at the stressed surfaces. A finish operation can be performed to avoid these detrimental conditions. For fluted drill bits, the chips are removed via the flutes. Depending on the material, and process parameters the chips may form like long spirals or small flakes.

Boring is a machining operation used for producing circular internal profiles on a drilled hole or hole made by any another process. It uses a single point cutting tool called as a boring bar. In boring operation, both the boring bar and the workpiece can be rotated. Machine tools which a stationary workpiece against which the boring bar rotates are known as boring machines or boring mills. Boring operations can be performed on a turning machine were a stationary boring bar is positioned in the tool post and rotating work piece held in the lathe chuck.

**Combination tools:** We all are familiar with a Center Drill used for lathe work, which is nothing but a combination drill and countersink. There are lot of combinations and sizes available, however the figure 1 shows a drive matic drill and countersink. These are most commonly used in the application where through-hole are required. Countersink collars are also available for regular twist drills that helps to set the depth of the countersink relative to the point of the twist drill.

**Fig -1:** Combination tool

## 2.Literature review

Shivani P.Raygor et, al. [1], stated that the combination of tool and work piece material has a very significant role for surface finish in turning operation, different types of tool inserts with different material and tool insert geometry which are used in turning operation are reviewed in paper and optimal procedure to select best tool insert from various tool inserts for better surface finish in turning operation. Researchers have given most of the priority for the optimum selection of combination of tool inserts and work piece for attaining the best possible results. A tool insert selection index is provided that evaluates and ranks the tool insert for good surface finish in turning operation.

Vignesh V et ,al. [2], focused on the optimization of drilling parameters using the Taguchi technique to obtain minimum surface roughness (Ra). A number of drilling experiments were conducted using the L9 orthogonal array on a radial drilling machine. 7075 alloy with carbide tool drill was used for experiments. The most significant control factors affecting the surface roughness were determined using Analysis of variance (ANOVA). Drill diameter was the most significant factor for the surface roughness in the cutting speed, feed rate and drill diameter were selected as control factors. After the nine experimental trials, it was found that the. The results of the confirmation experiments showed that the Taguchi method was notably successful in the optimization of drilling parameters for better surface roughness. Commercial software package MINITAB17 was used for performing the analysis.

Shreedhar Bhattarai et.al. [3], discussed the impact of coating on the cutting tools. Machining is the heart of any manufacturing industry. From any small electronic component to heavy and macro size material requires machining for its production. Cutting tool is required for machining process. Engineers and scientists are working to find out the best technique for increasing the efficiency of machining process. The coating of cutting tool is one of the processes to increase the performance and productivity in machining process. The objective of this thesis work is to analyze the performance of single point cutting tool coated with metal (Nickel and Zinc) in the turning operation of Aluminium. The single point cutting tool is used for machining cylindrical shaped specimen of Aluminium. A number of tests are performed with different cutting speeds, feed rates and depth of cuts. The temperature in the chip-tool interface and surface roughness is measured and material removal rate is calculated. These data helped in analyzing the performance of cutting process. The tool used is high speed steel and are coated with Nickel and Zinc separately. Total twenty four experiments are carried out and results are tabulated. The results obtained from turning operation by coated tools are compared with uncoated tool to draw a valid conclusion.

Praveenkumar et.al. [4], discussed about increasing production capacity of manufacturing industry with minimum increase in cost is the challenge faced by the modern production industry. In this regard an attempt was made to design a rod grooving multiple spindle drilling unit to replace existing single spindle unit. Proposed design enabled 6 grooves to be drilled simultaneously and results achieved was reduced cycle time and higher productivity. The parts of this multi spindle unit have to be designed using conventional methods. Finite Element Analysis of spindle housing and gear housing was performed to analyze structural integrity using ANSYS. Results of analysis indicate that these parts are structurally sound. After implementation of the design we found that the production rate increase from 150 components per shift to 425 components per shift. Added benefits include less chance for error, less accumulated tolerance error and less tools change.

**2.1 Literature Gap**

From the study of various papers it is clear that combination tools are seldom researched and no specific tool has been designed and no analysis has been carried out for tool designed for Drilling, Boring and spot facing operation. Hence for development of a combination tool for production of combination bearing for radial and thrust loads the tool is to be designed and fabricated.

## 3. Proposed Drill-Bore combination tool for special purpose bearing

The present system of ventilators uses ball bearings and thrust bearings which are required to be replaced from two main reasons:

1. Ball bearings are costly, require special casing for mounting that increases space requirement and weight.
2. The ball bearings alone do not suffice the requirements of the balancing at the top end of the ventilator it also requires a thrust bearing.

The dust cover is required to be installed to protect the bearings from fume and dust, which increases system components. As seen below the bearing shown above has two profiles, thus the combination of drill and bore is required.

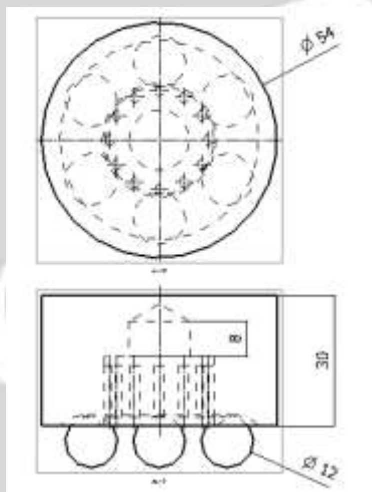


**Fig -2**: Bearing Profile

In this paper major focus has been given on the design development and analysis of critical components of the combination tool of drill and bore as shown below:

**Fig -3**: CAD model of Cutting tool

**4. Design and analysis of Tool holder considering the plain drilling and boring operation under action of maximum torque**

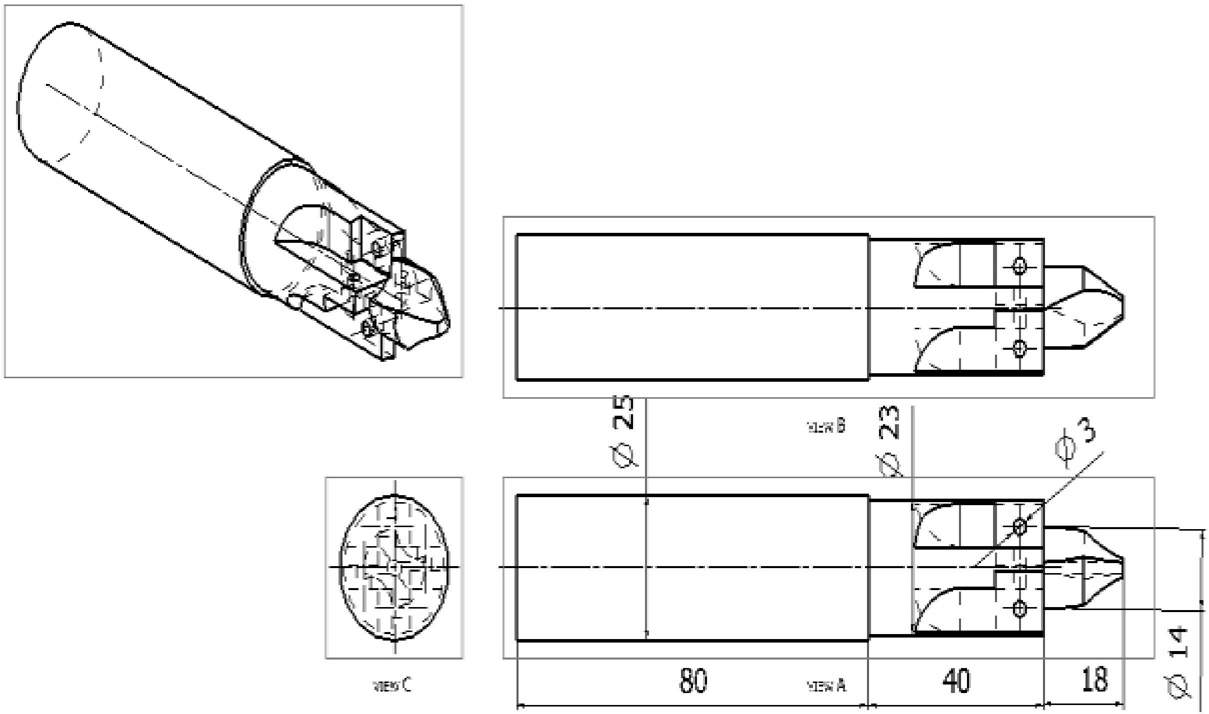


**Fig -4**: Detailed layout of Cutting tool holder

**Table-1**: Material Selection: - PSG (1.10 & 1.12) + (1.17)

| Designation | Ultimate tensile strength ($N/mm^2$) | Yield Strength ($N/mm^2$) |
|---|---|---|
| En9 | 600 | 480 |

$$f_s = \frac{uts}{fos} = \frac{600}{2} = 300\ N/mm^2$$

This is the allowable valve of shear stress that can be induced in the shaft material for safe operation.

Assuming 100 % efficiency of transmission

$$T_d = 8.743\ N - m$$

Considering the torsion failure of the hollow portion of the coupling shaft:

$$T_d = \frac{\pi}{16} \times \left(\frac{D^4 - d^4}{D}\right) \times f_{s\,act}$$

$$fs_{act} = \frac{16 \times Td}{\pi \times \left(\frac{D^4 - d^4}{D}\right)}$$

Diameter of Shank for cutting tool = 23 mm

Inside diameter of drum boss =14 mm

$$fs_{act} = \frac{16 \times 8.743 \times 10^3}{\pi \times (\frac{23^4 - 14^4}{23})}$$

$$f_{s\,act} = 4.24 \ N/mm^2$$

$$f_{s\,act} < f_{s\,all}$$

Tool shank is safe under torsional load.

**4.1 Analysis of the Tool holder**

**Table-2**. Details of meshing in ANSYS

| Statistics | | |
|---|---|---|
| Nodes | Elements | Mesh Metric |
| 3479 | 1817 | None |

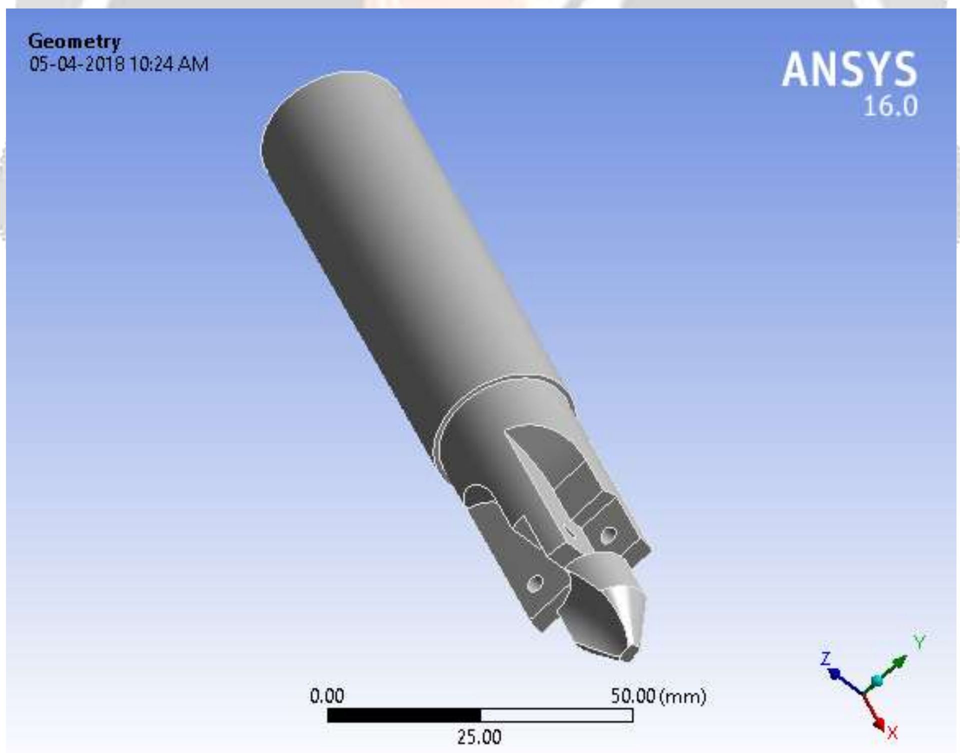


**Fig -5:** CAD model in ANSYS

Figure 5, shows the CAD model of the cutting tool in the ANSYS environment. Once the model is in the ANSYS, material is assigned to the CAD model. In our case the material is En9 which is hardened steel.

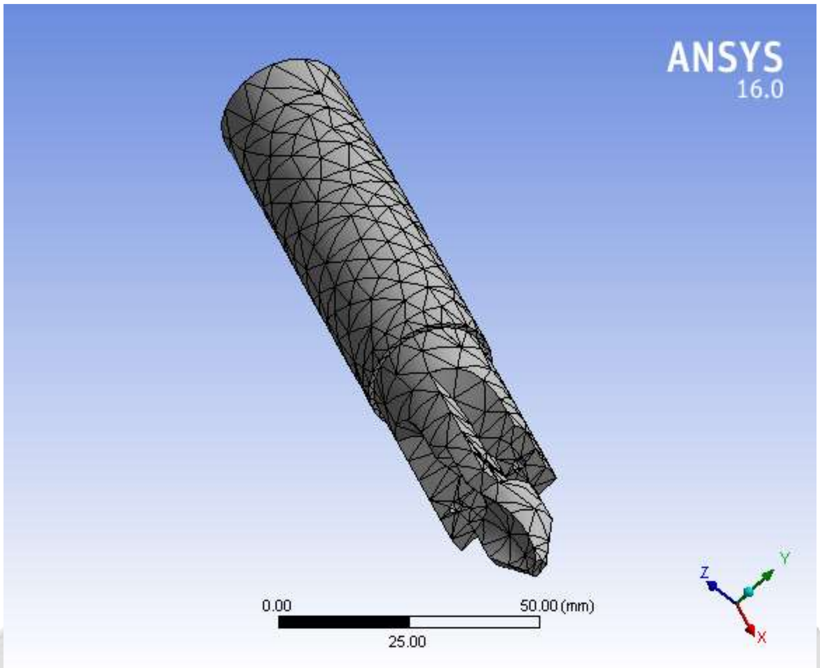


**Fig -6**: Meshed model of Cutting Tool in ANSYS

Figure 6, provides the details of the meshing used on the CAD model in ANSYS environment. Table no -2 provides the details of the nodes and elements generated while meshing in ANSYS.

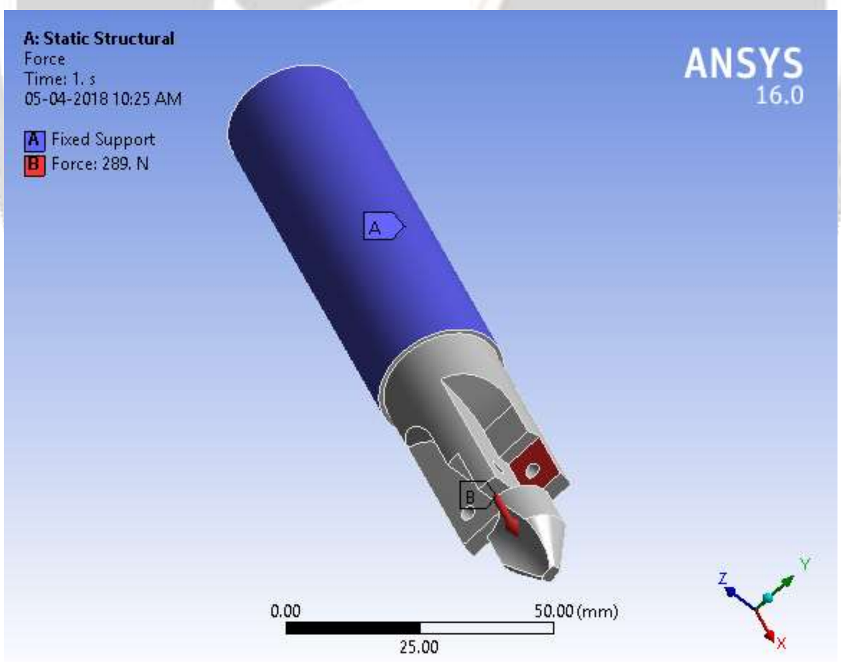


**Fig -7**: CAD model of Cutting tool with applied force

After meshing, force and constrained region are defined on the meshed model in ANSYS environment. Figure 7, shows the applied force and the constrained area.

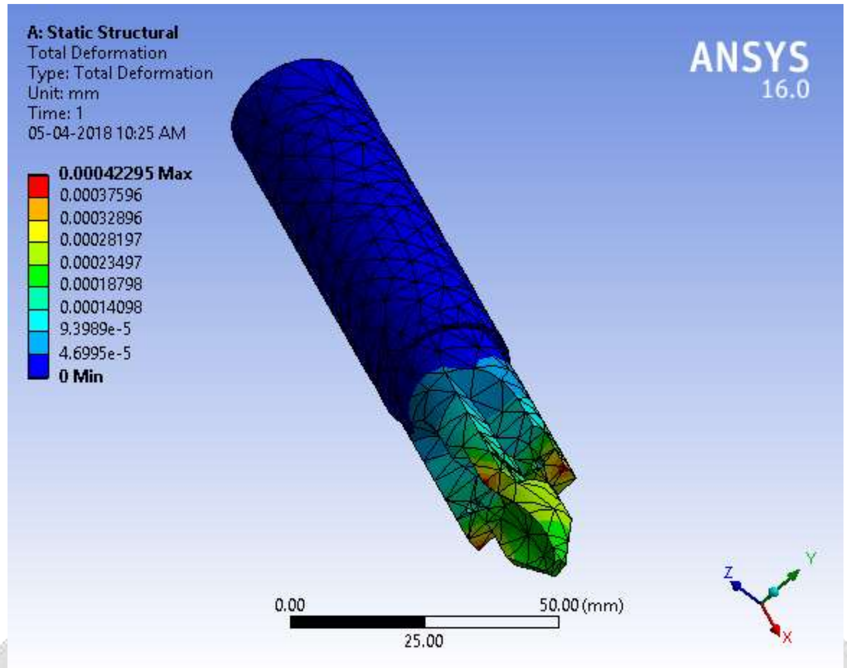


**Fig -8**: Impact of Force on CAD model of Cutting tool

Once the force and constrains were applied analysis run took place. Figure 8, shows the deformation of the cutting tool under the influence of the applied force and constrains. It was observed that the deformation is very negligible hence it was concluded that the tool is safe.

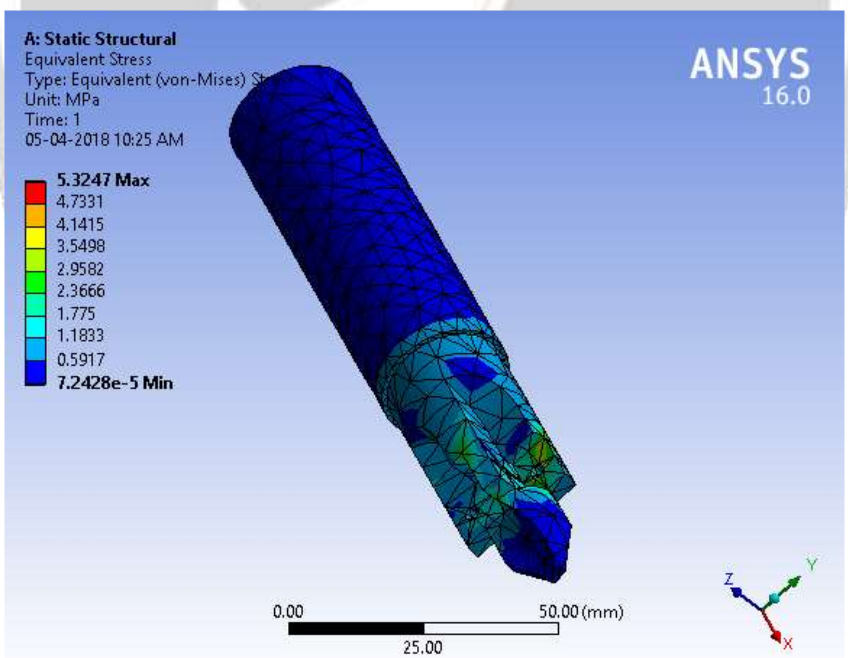


**Fig -9**: Impact of Stress on CAD model of Cutting tool

Another analysis run was applied to understand the impact of equivalent stress (Von-Mises Stress) on the cutting tool. It was observed that the maximum stress induced is 5.3247 MPa which is well below the permissible limit hence it was concluded that the tool is safe. Figure 9, shows the CAD model of cutting tool in ANSYS environment under the influence of force and showing the equivalent stress (Von-Mises Stress).

## 5. CONCLUSION

1) The cutting tool holder shows stresses well below permissible limit. Hence it is concluded that the cutting tool holder is safe.
2) The deformation in the cutting tool holder was observed as negligible. Hence the cutting tool holder is safe.
3) Maximum error of 1 percent is observed in the drilling process and the percentage error reduces with increase in speed.
4) Maximum error of 0.32 percent is observed in the boring process and the percentage error reduces with increase in speed.
5) Maximum reduction of 40 percent is observed in the cycle time and the percentage reduction in cycle time increases with increase in speed.

## 6. REFERENCES

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