FINITE ELEMENT ANALYSIS OF CARBIDE TOOL MACHINING LOADS AND RESPONSES ON HIGH STRENGTH MATERIALS

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Abstract:
The cutting tool material is a function of the chemical, mechanical and thermal properties of the cutting tool material to the work-piece. With the trend towards miniaturization, micro-machining has become more and more critical in fabricating micro parts. The micro-machining process involved in this study is micro-milling the conventional micro end milling, 4-flutes micro end milling. Cemented carbide is the material that has been used for this study. The main problem with the flutes micro end milling is it quickly wears in a short time. In this study, Static structural analysis of the different work-piece materials the tools will be modeller and simulated using Ansys Working with other materials such as coated Inconel 625, SS316 tools Workbench 2020R1 is well-designed software.

Key words: Micro-Machining, Carbide tool, FEA, ANSYS

1.0 Introduction:

Accuracy micromachining is the most fundamental technology for making small parts. Because of its rise in popularity in recent years, micromachining is predicted to play a key part in today's manufacturing technologies to put it simply, micro machining refers to millimetre-scale operations. It's not possible to obtain the machining result directly with standard tools, techniques, and machines [1]. When it comes to mould production, micromachining has become an increasingly popular method. It's not just for mould making anymore, since sophisticated microcavities on aluminium workpieces may now be machined utilising micromachining in bio-medical [2]. It is through micromachining that the tiniest of parts and components can be created. Consumers can benefit from space-saving and portability-enhancing nanotechnology. Electronic devices, health devices, and a slew of other industries could all profit from miniaturised technologies. By applying a spinning cutter, milling is one of the most adaptable processes for removing material from the work piece, according to Milling can be done manually or with a computerised machine, however only a computational machine can be used for micro milling [3]. Every day, the micro milling industry grows. But that doesn't mean that existing technology on the market is completely error-free. Due to the tool's small size, there are a few restrictions. The reduction of the macro milling tool is a basis for some of the tools available. When Xiang Cheng mentions two-flute micro milling in his research, the obvious example is readily available. When the cutting parameters are changed, so are the radial and axial rake angle. The tool life will be affected by the use of these little geometric tools. When a tool gets larger, its tool life gets shorter. Wear and all the processing parameters make it impossible for a tool to require replacement.

Objective of the work:
The main objective of the static analysis is to determine the deflection of end mills under milling forces. For static deflection analysis of end mills, the tip of tool cutter is assumed to be fixed and the cantilever beam principle method is used.The flutes micro end milling is the most popular tool in micro machining. Due to its size and the geometry, the failure of the conventional two flutes end milling tool is very concerning. It seems that the tool life is unpredictable. This is happening because of the downsizing of conventional end milling that can disturb the strength and also the tool life of the micro end milling tool. The result of this analysis can show the alternative to improve the conventional micro milling end-mills geometry. It also may help to increase the tool life of the tool and may increase the productivity yet may help to lower down the tool replacement cost.

2.0 Literature review:
The milling operation is a versatile operation often employed during production, which requires machining of both simple and complex geometries [5]. The modelling of the structural and geometrical design of a mill cutter is important because it determines the cutting force required for the milling operation as well as the degree of surface finish The cutting forces in milling operation results when a cutting tool come into contact with the work piece to deform and shear the material from the work piece in a form of chips During milling operations, the cutting force should be taken into consideration, as it is critical for the selection of spindle speed (N), feed rate (f) and depth of cut (d). It is also affected by chip load distribution, wear on tool cutting edges and tool length (overhang) The surface finish, rate of material removal, vibrational analysis as well as the product’s integrity can be analysed through modelling of cutting forces with respect to changes in the cutting parameters, hence, the analysis of the cutting forces is needed for process optimization and determination of critical parameters such as the power and torque required [6] The use of conventional mill cutters with inappropriate structure and geometry often result in increase in the cutting force, tool wear and breakage, production of long chips that can result in built up edge Over the years, there is need to meet the increasing demand for high quality tools to enhance high productivity and economy of machining as well as the need to meet effective machining of emerging materials coupled with the quest for the need for precision, ultra-precision, micro and nano-machining. In a bid to meet these needs, many researchers have employed numerical, experimental and analytical methods as well as combination of these methods for the analysis of machining process conditions in order to determine various causes of variation and other causes of inefficient machining operations [7]. The results from researches over years have resulted in the development of models that gives the relationship among the structural and geometric as well as cutting parameters, friction, tool angles, stress, temperature distribution, rate of material removal, surface roughness, amongst others [8,9]. This has also led to the development of special and universal cutting tools in order to improve cutting performance as well as tool and product integrity. For instance, the design and optimization of efficient layer milling cutter of layer face milling cutter has been reported with the result obtained from the design, performance evaluation and optimization indicating significant improvement in the tool’s cutting performance when compared to the

conventional ones In addition, [10] performed the modelling and surface roughness of micro end milling using the hybrid approach while carried out the modelling of cutting forces in curvilinear peripheral milling process.

3.0 Materials and methods

Methodology for this research is based on analysis technique. This project required to use relevant reading materials that can be obtained by the previous researches including journals and also books. This project will be focused more on designing the micro end mill and analyse by using Finite Element Analysis (FEA) This process helps to narrow down the focus of the project. Next, is gather information about the title and construct literature review which can be achieved by collecting reading material from journals, papers and also books. This stage also will give more understanding about this project. After that is modelling the tool geometry and simulate the tool. Firstly, the tool will be modelled and simulated by using the data from previous research. This step is important for continuation with designing various type of tool geometry. The result should be evaluated before proceeding to design various tool geometries.

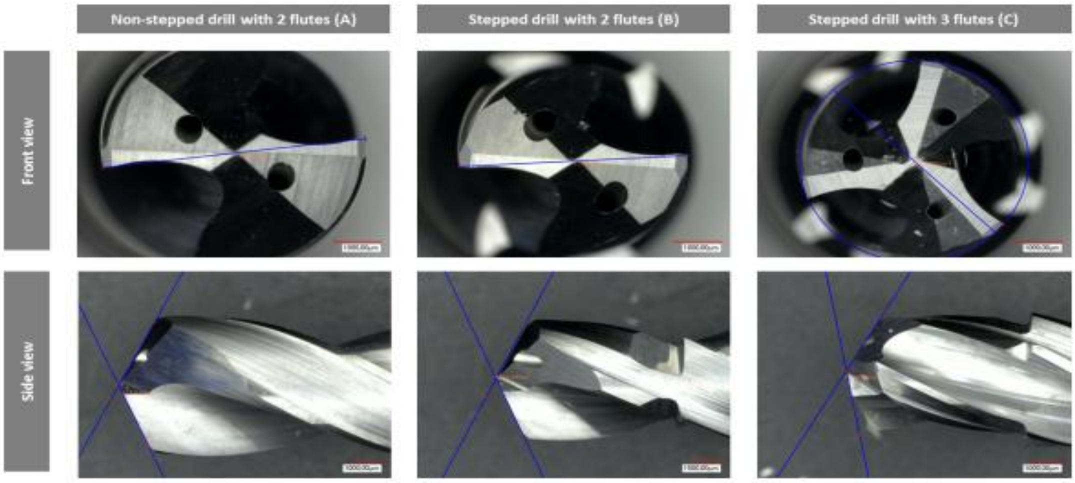


Fig. 3.1 Front and side views of the used tools. Geometries of tool.

Design of tool:

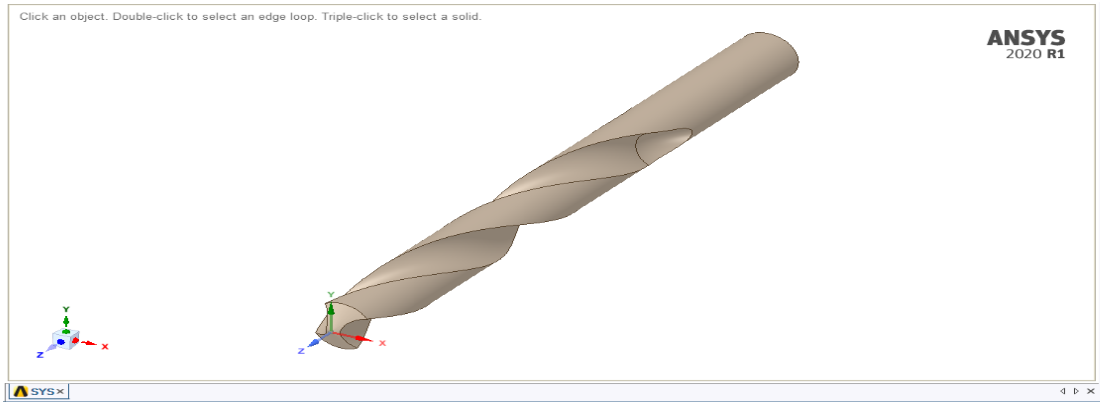


Figure: 3.2 Tool Designed model

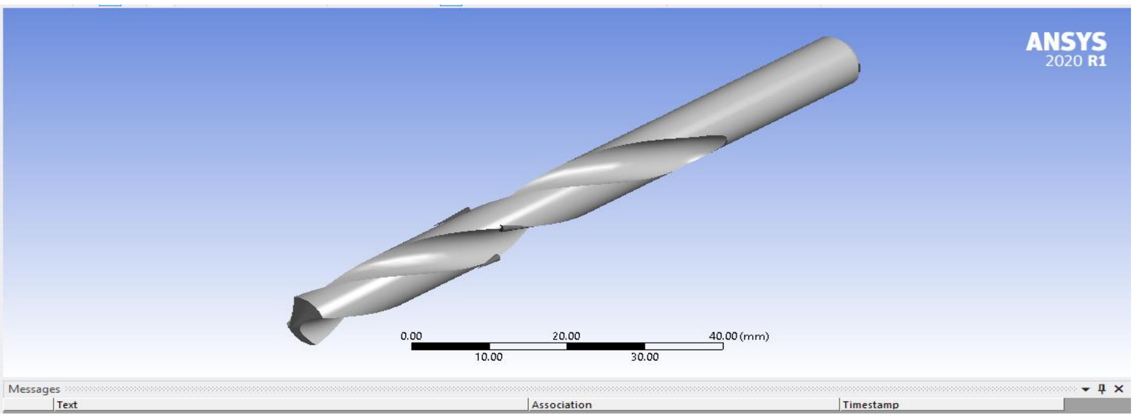


Figure 3.3 : Imported model

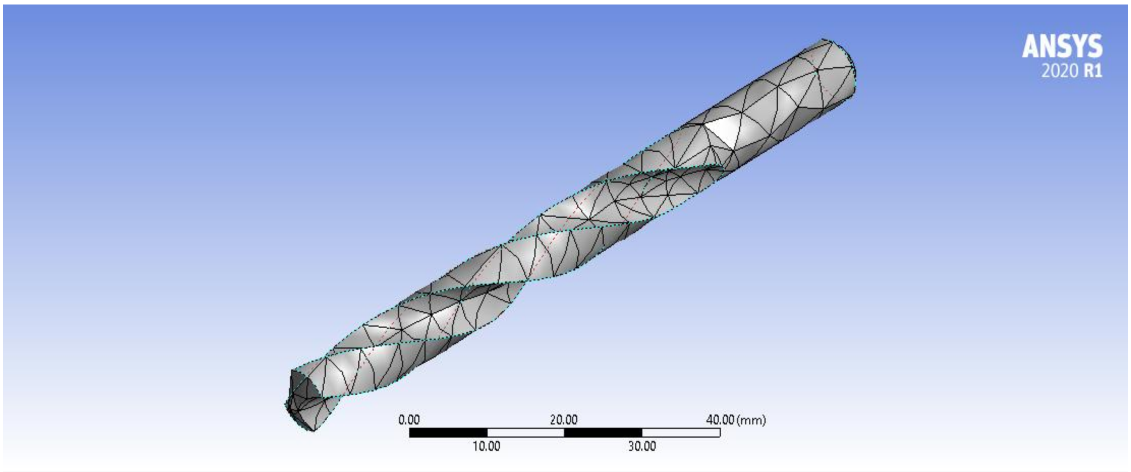


Figure 3.4 : Meshed model

Tetrahedral elements can be used for meshing, as can tetrahedral ones for meshing. With a larger number of nodes in an element type, the findings are more accurate. Tetrahedral meshing is a reliable process for meshing, and it's also a simpler method. When dealing with plasticity, almost viscous fluid materials, and sharp bending, linear tetrahedral components probably fail. Tetrahedral components also take several approximations into account, especially in complex structures. In formation, hexahedral components provide more accurate results than tetrahedral ones. They also take into account a smaller number of approximations as well. Hexahedral elements, on the other hand, run into issues when trying to fit them into corners of other sections or pieces. Additionally, for many three-dimensional hexahedral meshes, automated mesh generation is not viable.

4.0 Results and discussions

It was decided to use a meshed model, total and directional displacements, and equivalent stress and strain as factors in the investigation. The flywheel under consideration was part of a device used to measure how much speed can be slowed down. Working with different materials such as Income 625, SS316, Material alloys Workbench 2020R1 is well-designed software.

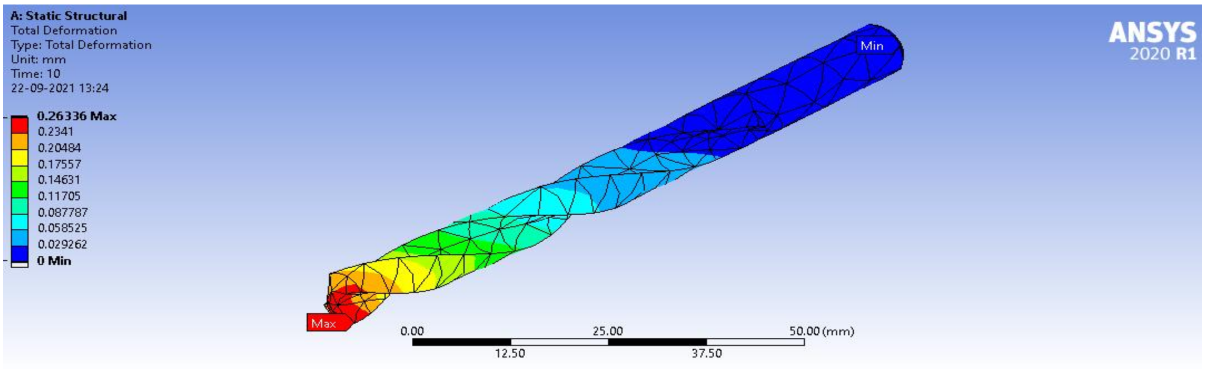


Figure 4.1 : Total deformation

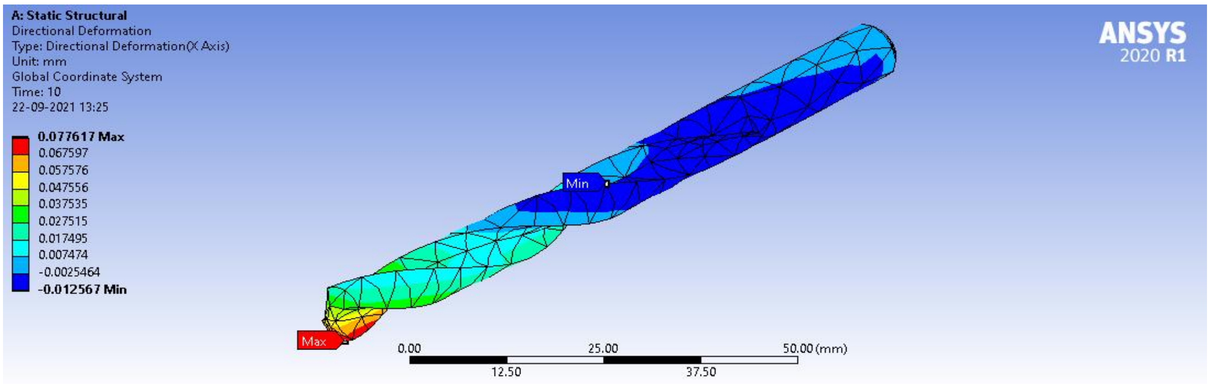


Figure 4.2: Directional deformation

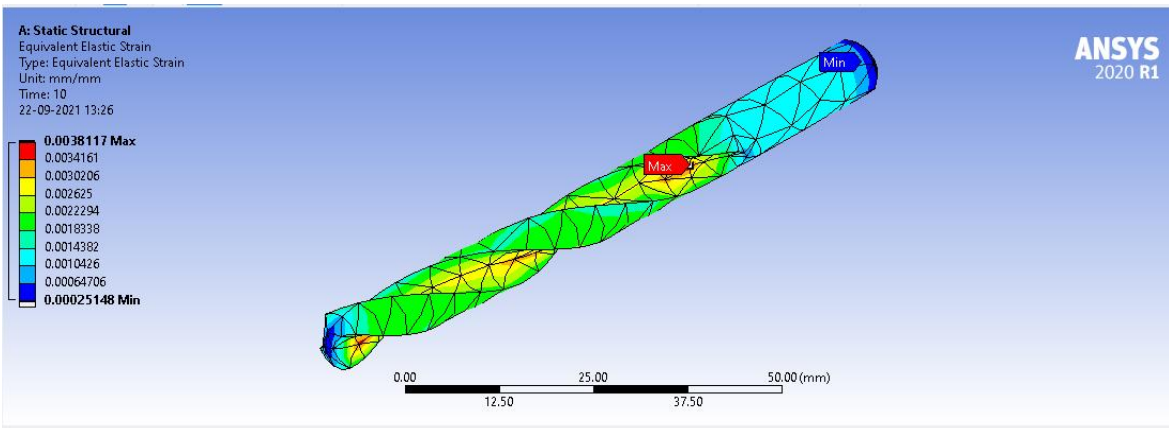


Figure 4.3: Equivalent elastic strain

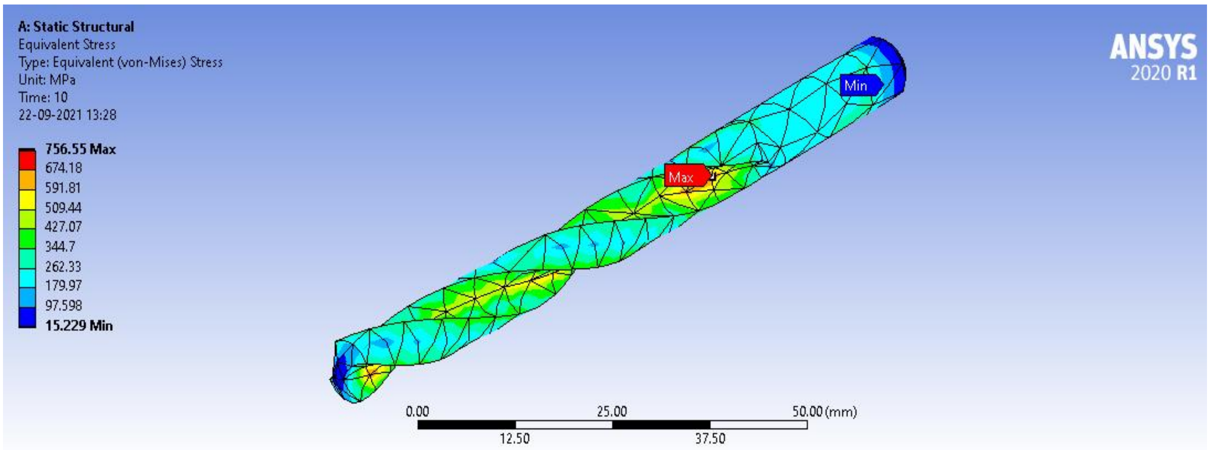
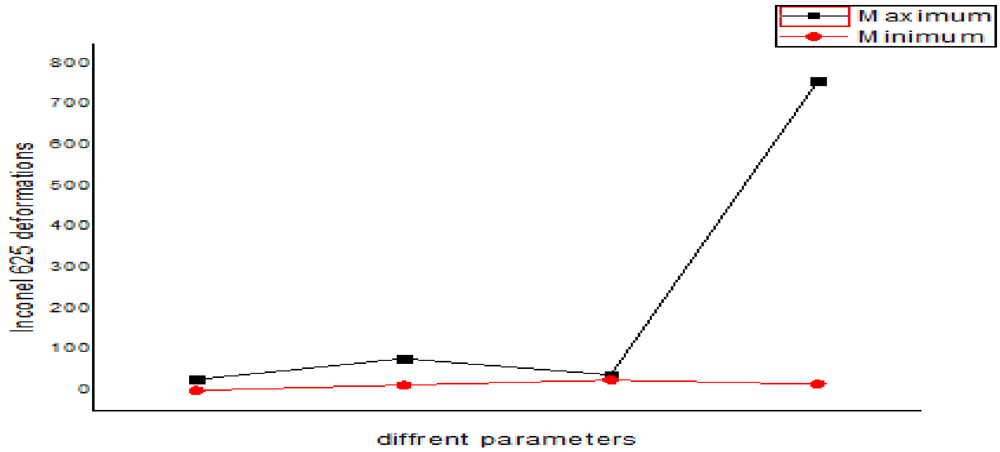


Figure 4.4: Equivalent stress

Table 4.1: Structural analysis of Tool using with Inconel 625 Material

Parameters	**Maximum**	**Minimum**
Total deformation	26.336	0
Directional deformation	77.617	12.567
Equivalent elastic strain	38.117	25.148
Equivalent stress	756.55	15.229



Graph 4.1: Structural analysis of Tool using with Inconel 625 Material different variations

Structural analysis of Tool bit using with SS316:

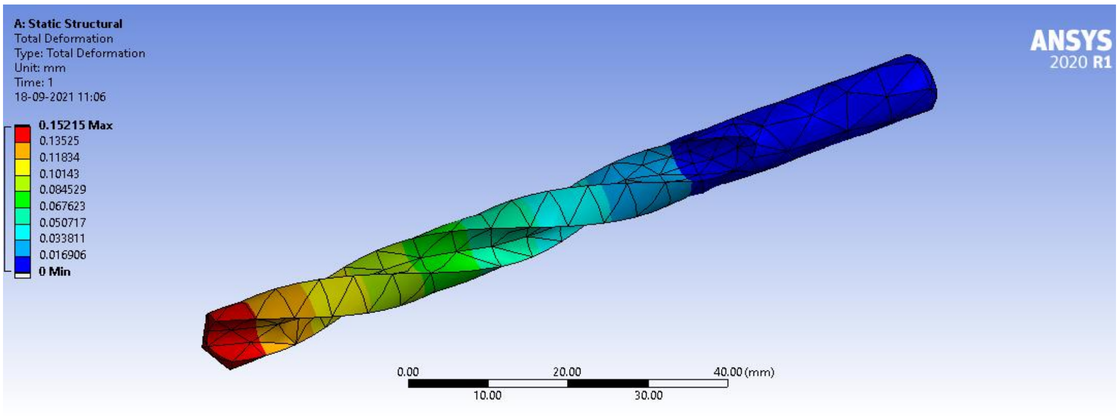


Figure 4.5: Total deformation

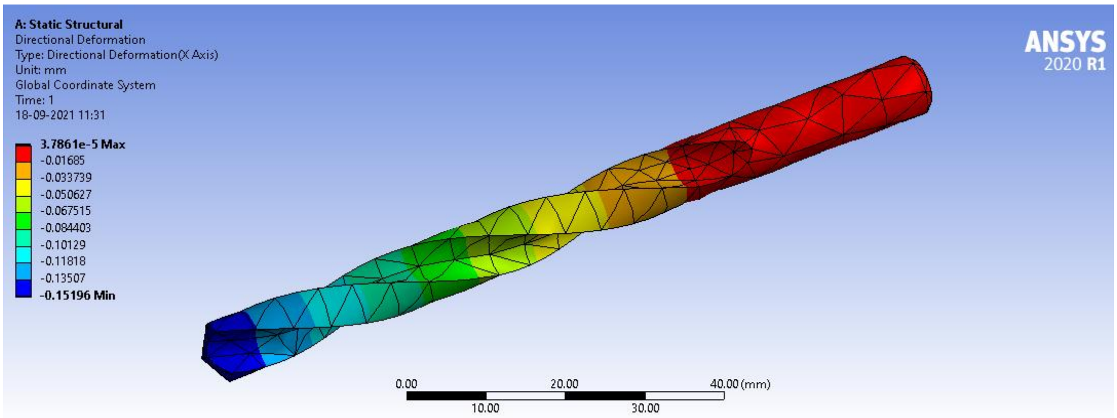


Figure 4.6: directional deformation

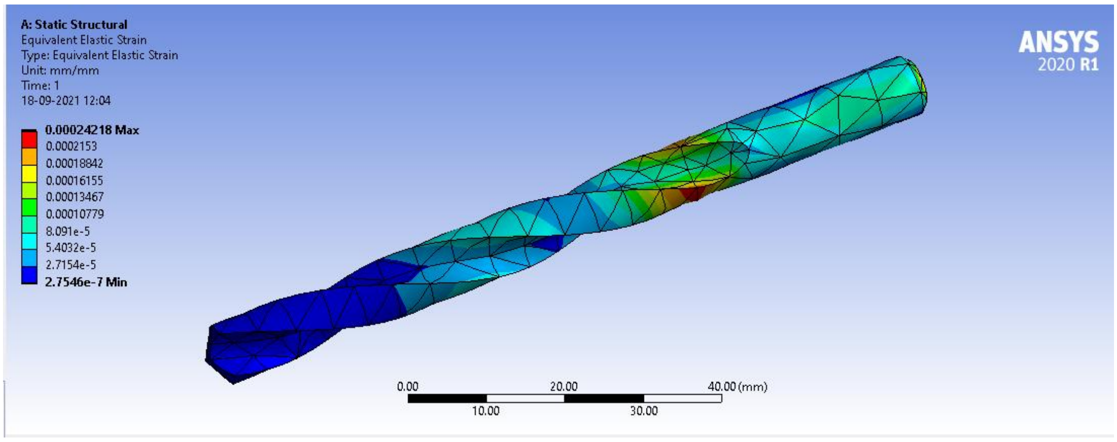


Figure 4.7: Equivalent elastic strain

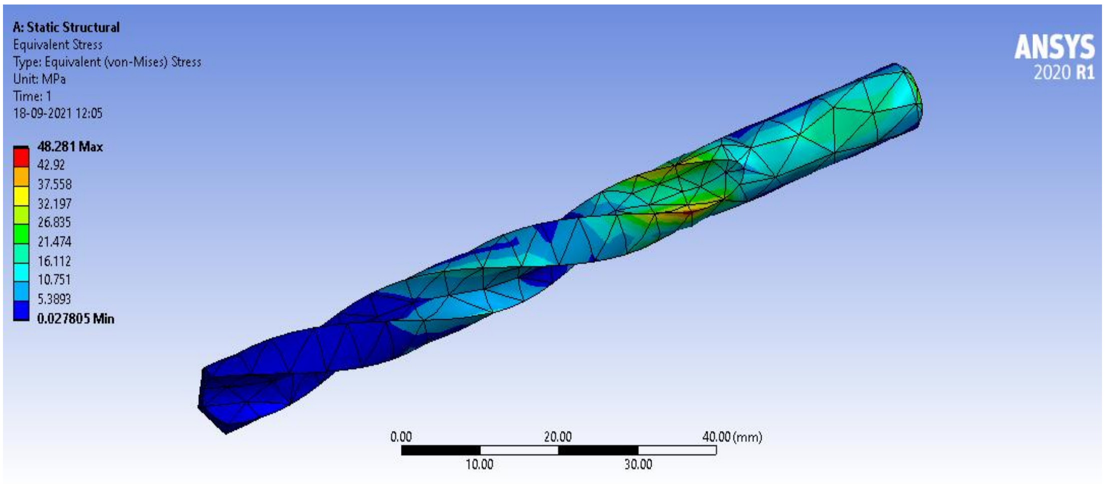
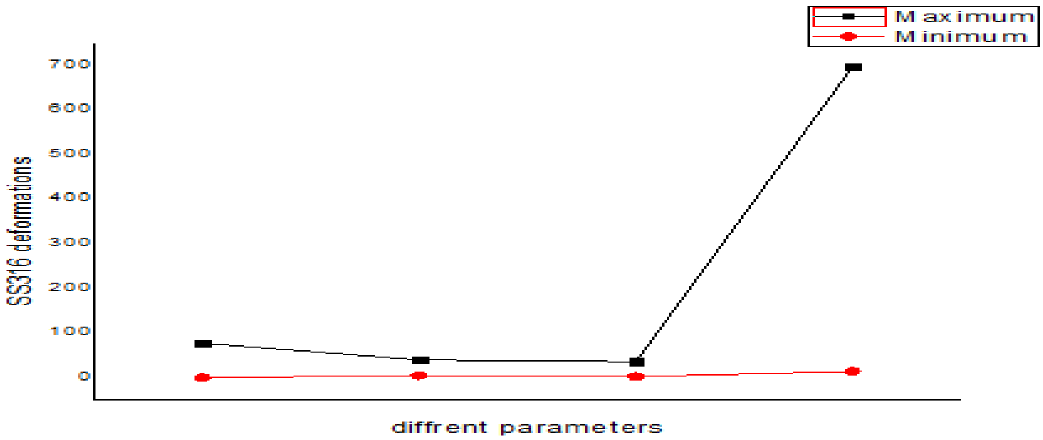


Figure 4.8: Equivalent stress

Table 4.2: Structural analysis of Tool using with stain less steel 316 Material

Parameters	Maximum	Minimum
Total deformation	152.15	0
Directional deformation	37.861	1.5196
Equivalent elastic strain	24.218	2.7546
Equivalent stress	48.281	2.7805



Graph 4.2; Structural analysis of Tool using with stain less steel 316 Material Variations

Conclusion:

In conclusion, this project has been successfully accomplished by fulfil all of the objectives using static structural analysis (Ansys) software that is Ansys from the result achieved, it clearly shows that lower helix angle will reduce the tool life of the micro end mill. It also proves that the numbers of flutes play a big role in the tool life The higher the depth of cut the higher the cutting force as compared to speed and feed rate hence, the cutting force depends on milling parameters defined from experimental cutting data The permissible values of the surface roughness indicates that the developed cutting tool can effectively to a high degree of surface finish form both SS316 and Inconel 625 coted material. Finally, comparison of both materials Inconel 625 materials wear is more than to SS316 Material. The successful completion of this work provides a design framework as well as the design data for the development of cutting tools, which finds application in the production industries

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