

Design And Analysis of Drill Bit With Various Materials

J. PRAVEENA¹, B.SAI HARSHITHA², R. SIRICHANDANA³, B. LIKHITHA⁴

¹J. Praveena, Assistant-professor, Department of Mechanical Engineering, AU College of Engineering for Women, Visakhapatnam, Andhra Pradesh, India.

^{2,3,4}Final Year Students of Department of Mechanical Engineering, AU College of Engineering for Women, Visakhapatnam, Andhra Pradesh, India.

¹jannavarapuvena@gmail.com, ²harshithabonimanti@gmail.com, ³sirichandana6757@gmail.com,
⁴likhithabilla006@gmail.com

ABSTRACT

A significant factor in the manner of drilling is selecting the type of drill bit. While drilling, acquiring a drill bit with the required feature is crucial. We employed a twist drill made of HSS, M42 Cobalt, as a model for this research in order that we could evaluate what we discovered to identify the most effective drilling material. Drill bit simulation and evaluation are both carried out by the ANSYS2024 R2 software. Despite they have the same appearance, the input process conditions are different. As per the analysis results, M42 Cobalt Steel has shown its ability to withstand high equivalent stress and the maximum equivalent elastic strain before irreversible deformation occurs in contrast to HSS.

Keywords: Drill Bit, ANSYS 2024 R2, High Speed Steel, M42 Cobalt Steel.

1.INTRODUCTION

The method of drilling involves rotating a drill bit to create a circularly shaped hole in solid material. Usually, the drill bit is a multipoint, rotating cutting device. The bit turns at rates of rotations per minute simultaneously striking against the work piece. The angle tool is a vital feature that defines it apart from other machining activities. The Twist drill is a cutting instrument used to create holes in solid materials. The process of drilling is used to create holes, cavities, or tunnels in an abundance of materials, including concrete, metal, wood, and rock. Drilling is a crucial procedure in an enormous variety of organizations, including manufacturing, mining, oil & gas, construction, and even healthcare. Focusing on superior craftsmanship in terms of work piece dimensional precision, surface finishing, restricted wear on the cutting tools, and affordability is the challenge of the new, modern machining the manufacturing sector.

1.1 Nomenclature of Twist Drill Bit

- **Drill:** A drill is a multi-point cutting instrument used to create holes. In order to let fluids in and chips out, it features flutes and more cutting blades. The drill is made up of a body, tip, and shank.
- **Shank:** The part of the drill bit that does not cut when it is put into the spindle or drill chuck. It might have a tapered or straight shape.
- **Tang:** This flattened section at the end of the shank slides into a groove in the spindle of the drilling machine.
- **Body:** The area with the flutes, lands, and margins that lies between the drill bit's shank and point. The drill bit's cutting edge that pierces the material is called the point.
- **Margin:** The margin is a short portion of the land uncut or not cut away provide clearance. It helps to create accurate hole by burnishing the cavity.
- **Web:** The central core of the drill bit that connects the two flutes.
- **Chisel edge:** The flat central edge at the tip of the point where the two cutting edges meet.
- **Lips:** The sharp edges extending from the chisel edge to the outer diameter of the bit. These are the primary cutting surfaces that removes material as the drill rotates.
- **Neck:** A reduced -diameter section between the body and the shank, providing clearance in some designs.
- **Helix angle:** The angle made by the leading edge of the land with a plane containing the axis of the drill.
- **Point angle:** The angle included between the cutting lips projected upon a plane parallel to the drill axis and parallel to the cutting lips.
- **Lip relief angle:** The axial relief angle at the outer corner of the lip. It is measured in periphery.
- **Chisel edge angle:** The angle included between the chisel edge and the cutting lip as viewed from the end of the drill.

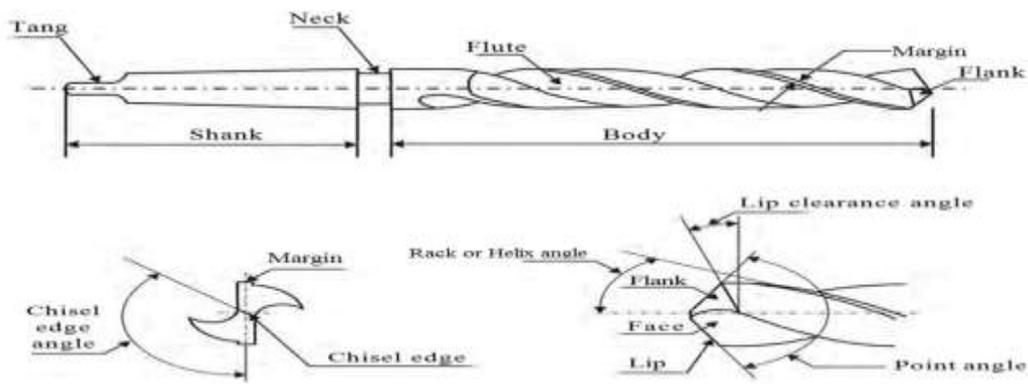


Fig No: 1 Twist drill bit geometry.

2. LITERATURE REVIEW

An indispensable tool to use when set to drill holes employing various materials is a drill bit. The structural performance of drill bits comprised of alpha titanium alloy, beta titanium alloy, and high-speed steel (HSS) was studied by Shivani et al. (2019). The study uses ANSYS Workbench for simulation and SOLIDWORKS for modelling. According to the results, beta titanium alloy is a potential replacement for alpha titanium in terms of improved performance and durability because it shows lower equivalent stress but higher effective strain. Using ANSYS simulations, (Madan et al., 2021) compare drill bits made of titanium, structural steel, and high-strength steel. The study assesses strain, deformation, and stress distribution under varied loading scenarios. Effects indicate that titanium drill bits are less stressed and deformed, which makes them appropriate for high-performance applications. Choudhary et al. (2021) use finite element analysis (FEA) to investigate that drill bit geometry impacts stress distribution. When evaluating alpha and beta titanium alloys with HSS, the study comes to the conclusion that beta titanium alloy offers a superior balance between deformation and stress resistance. The study highlights how crucial point angle optimization is to reducing stress and extending tool life. The purpose of this study, according to Dr. Ing (2020), is to determine the HSS and Co-HSS cutting tool's wear-out value within the machining variation. Consequently, it could lead to the evaluation of the numerous machining parameters that have the greatest impact on the accuracy of the hole and the worn-out cutting tool that results from drilling and machining into S50C workpieces. Compared to a Co-HSS drill, an HSS drill's edges wear out more quickly. Dhanraj Patel (2015) Analysing the deformation brought on by variations in drilling tool material allows us to improve the drilling forces and tool shape while also examining the impact of these changes on the drilled work piece. At last, we are able to examine the deformation in the drilling tool life and geometry. (Ashutosh Singh, AbdulGani (2024) Finite element method is programming is implemented to analyze the stress behavior of drill tool while drilling operation. The modular investigation and static fundamental modules are treasured for the exam. The study considered the structural steel materials and structural analysis on ANSYS. This finds the stress behavior on different tool bits.

3. MATERIAL & METHOD

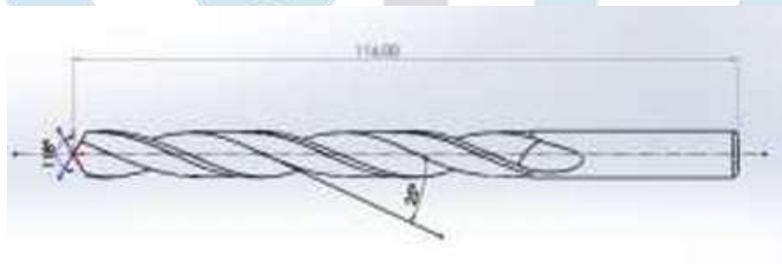
- Bit selection is the procedure that involves estimating the bit's weight; RPM focuses on the operation's prerequisites; and there are no particular ways to select the best bit for the formation that has to be drilled. Any drill bit selection program's aim is to eliminate trial and error. There are a lot of stipulated bit selection techniques, and before adopting the ultimate decision, several are frequently employed. Among the techniques for bit selection are:
- Material analysis Drill bit material evaluation should enhance tool life and performance, and it also involves assessing the work piece's hardness and abrasiveness.
- Cost analysis: While considering materials, cost is a significant criterion. Although M42 cobalt alloy is more expensive than M35 cobalt steel, it performs better than both HSS and M35cobaltsteel.
- Ensuring the drill bit is compatible with the machine tool in terms of stability, cooling lubrication, drill chuck capacity, and spindle speed and torque.
- Evaluation of dull bits entails tracking wear accumulation and identifying performance losses via visual inspection, and requirements for replacement or reshaping when a bit becomes, ineffective.
- IADC bit coding is primarily used in rotary drilling involving oil and gas. The premise that can be altered here is establishing a drill coding or categorization system that takes performance, geometry, and materials into account. aids in rapid identification and inventory management.
- Evaluating drill bit documentation: Assessing past performance and usage aids in tool improvement and predictive maintenance.
- Manufacturer's guides: Materialspecific charts, sharpening, coating, and storage instructions, as well as manufacturer recommendations on speeds, feed, and coolant consumption

- The term "geophysical interpretation" refers to more conventional geological drilling, but it can also include analyzing the structure of the work piece or the layers of material, and modifying bit selection depending on variations in hardness or homogeneity of material.
- General considerations: Considers a variety of aspects, including operator skill level, logistics, safety, and ergonomic

The drill bit model which is used in this present analysis is of twist drill bit. The standard diameter of this type of material drill bit used in this analysis is 10.31mm. The point angle is 135° and flute length 87mm.

Tool Specifications	Values
Diameter of drill bit	13/32 in [10.318mm]
Length of drill bit	133 mm
Point angle	135°
Flute length	87
Helix angle	30°
Shank length	46

Table -1 Drill Bit specification



FigNo 2: Dimensions of drill bit

3.1 Design of Drill Bit using ANSYS Software

A 3D model of the twist drill bit with given specification was drawn using ANSYS workbench with the dimensions shown in Table 1.

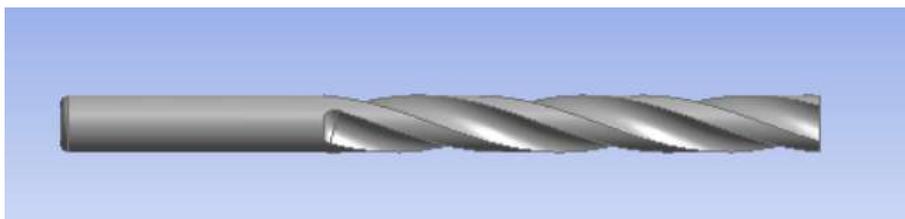


Fig No 3: Horizontal View of Drill Bit

A workbench software called ANSYS 2024 R2 was employed to simulate equivalent stress (von-mises stress), equivalent elastic strain, and equivalent deformation. Force data is needed for the analysis of stress and deformation in drill bits. For the twist drill bit, force values were taken from the reference. The model is loaded with the Force value in order to simulate it. Following the definition of the material qualities and the tool material (the necessary material is assigned), meshing was done. After that, the model was solved to provide the necessary output data.

MATERIALS	COMPOSITION
HIGHSPEED STEEL	18%tungsten,4%chromium and 1% vanadium along with carbon and iron
M42COBALT STEEL	Cobalt steel alloy (M42) 8% of cobalt is present

Table 2: Materials

3.2 Meshing the Model:

Meshing is most important part in any of the simulations, because It can show the changes in results you get. Meshing means creating a mesh grid- points called nodes. It done with various tools and applications available in the software.Meshing is the partial finite element analysis of model which shows the nodes and elements of the model.

The results are calculated by solving the each nodes of the mesh. The solutions are relatively poistioning of the nodes also affect the solution, the computational efficiency and time.

STRUCTURAL ANALYSIS

The fixed support is added to the 2 faces for Drill Bit and as well as the Force is added to in a definition of component which show the directions, the initial force is 0 N and maximum force applied in Y direction is 500 N for 4 geometry faces.

Structural Analysis Reports

The study of a drill bit's behaviour under different mechanical stresses, strains, and loading conditions while drilling is known as structural analysis. It evaluates if the drill bit is robust, long-lasting, and safe for a certain application. Three parameters are added to the solution information: total deformation, equivalent stresses [Von Misses], and equivalent elastic strain. ANSYS software is commonly utilized for Finite Element analysis (FEA) in order to achieve these results.

TOTALDEFORMATION: This assesses the drill bit's physical distortion or bending under load.

VONMISSES-STRESS:

Vonmisses stress forecasts yielding or failure by demonstrating the analogous stress a materialThe material may fail or undergo plastic deformation if this value is greater than its yield strength.

EQUIVALENTELASTICSTRAIN:

This is the strain energy that the material accumulates as a consequence of elastic deformation, or deformation that reduces when the load is removed. The simulation is then solved and the results are obtained.

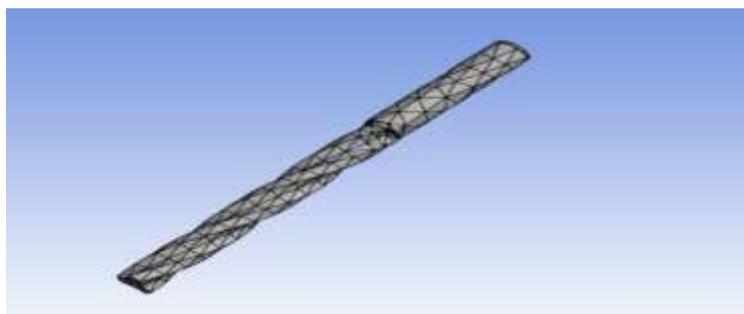


Fig No:4 Meshing of Drill Bit for HSS

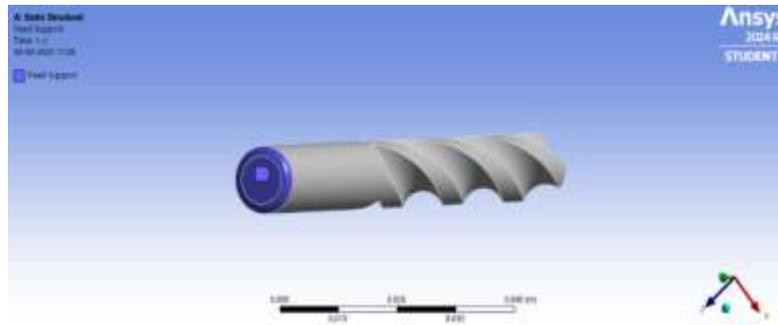


Fig No:5 Fixed Support of Drill Bit for HSS

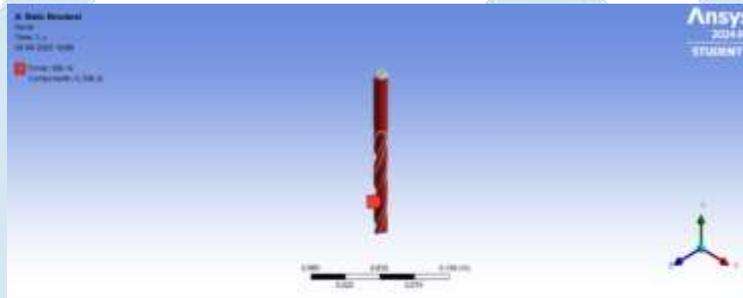
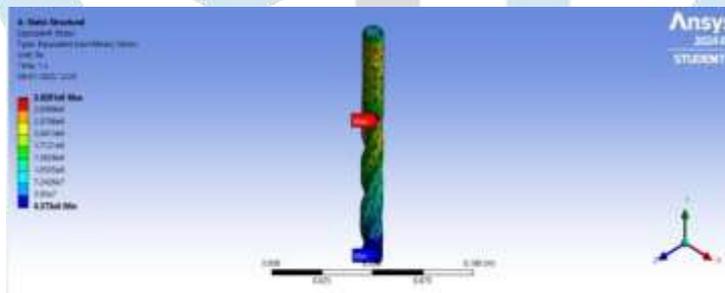


Fig No:6 Force applied to HSS Drill bit



FigNo:8 Equivalent Stress (Von-misses stress) for HSS

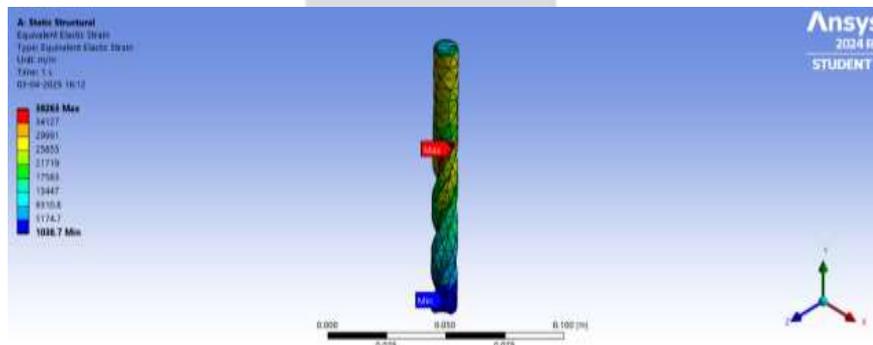
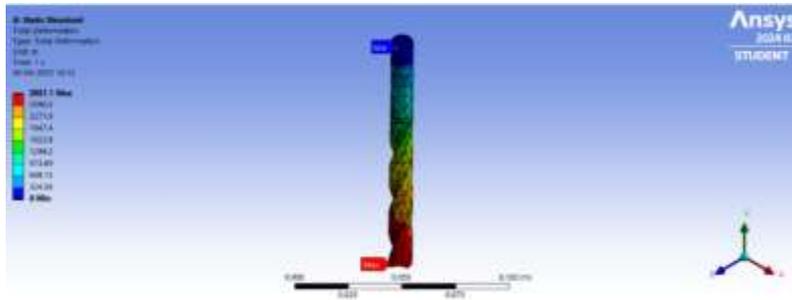


Fig No:9 Equivalent Elastic Strain for HSS



FigNo:10 TotalDeformationFor HSS



Fig No:11 Meshing of Drill Bit for M42 Cobalt Steel

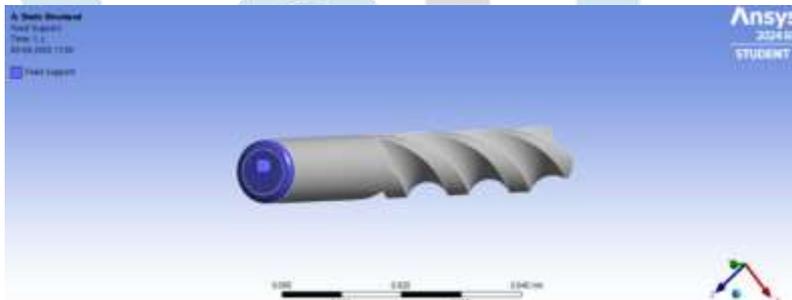


Fig No:12 Fixed Support of Drill Bit forM42 Cobalt Steel

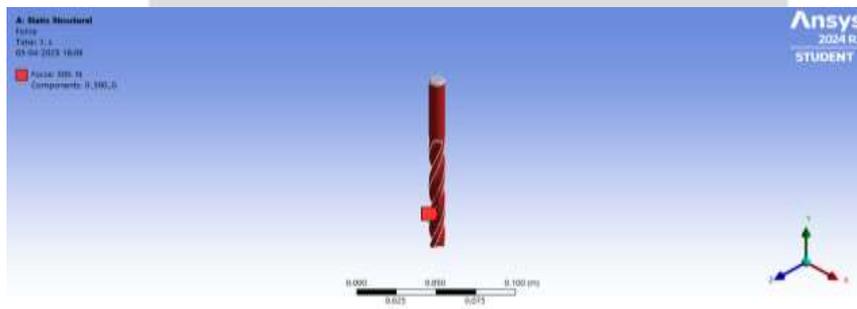
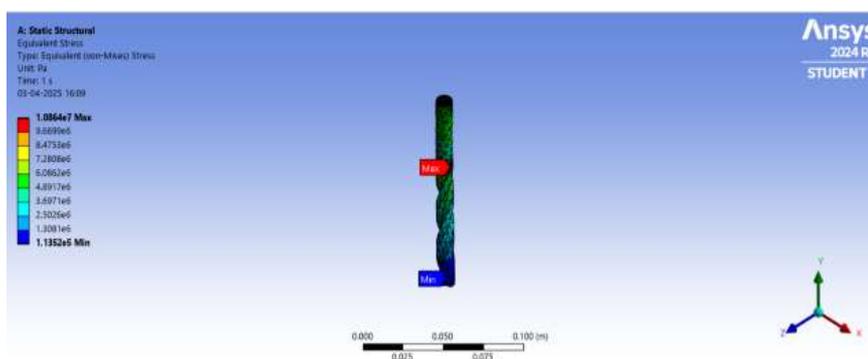
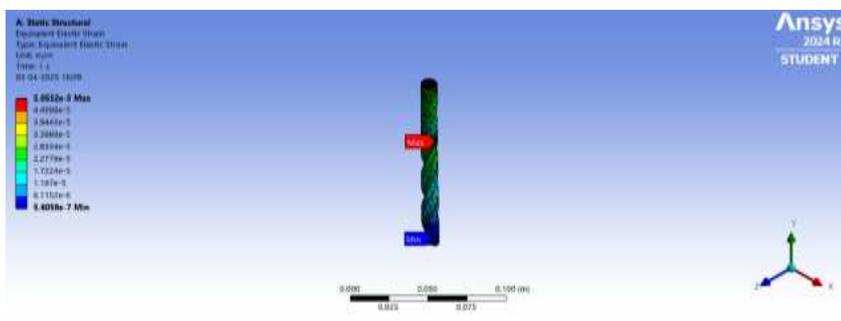


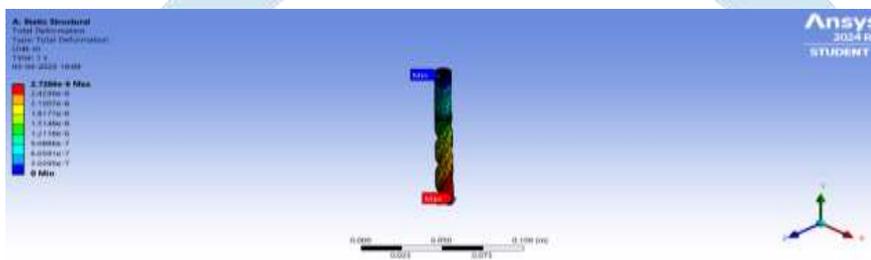
Fig No:13 Force applied to M42 Cobalt steel



FigNo:14Equivalent Stress (von-misses stress) for M42 Cobalt steel.



FigNo:15 Equivalent Elastic Strain for M42 Cobalt Steel

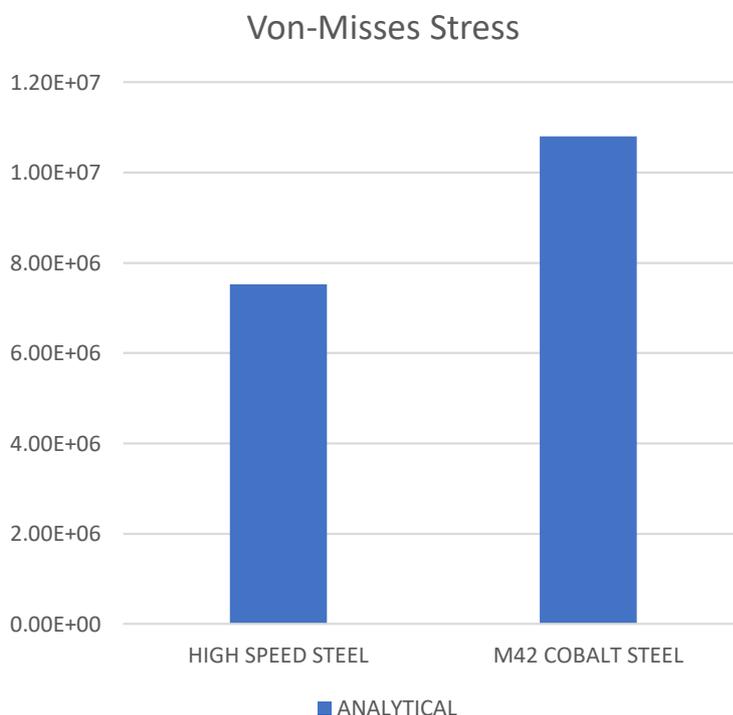


FigNo:16 Total Deformation for M42 Cobalt Steel

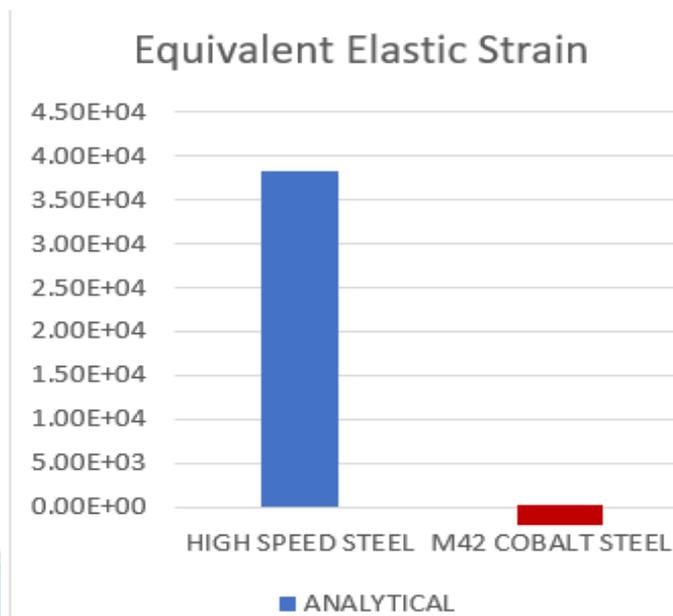
4. RESULT & DISCUSSION

As demonstrated by the data above, two materials—High Speed Steel and M42 Cobalt Stress—were employed in total for the analysis. Conclusions vary depending on the parameters, with M42 Cobalt Steel accomplishing far better than HSS. Both materials are typically used in drilling, however the M42 cobalt stress has a high stress resist capability, meaning it can bear the most strain before substantially deforming. We may infer from this that M42 cobalt stresses are resistant to wear and heat. Therefore, we have employed several materials for the drill bit's overall design in order to examine the von Misses stress and total deformation under the same force and fixed support conditions.

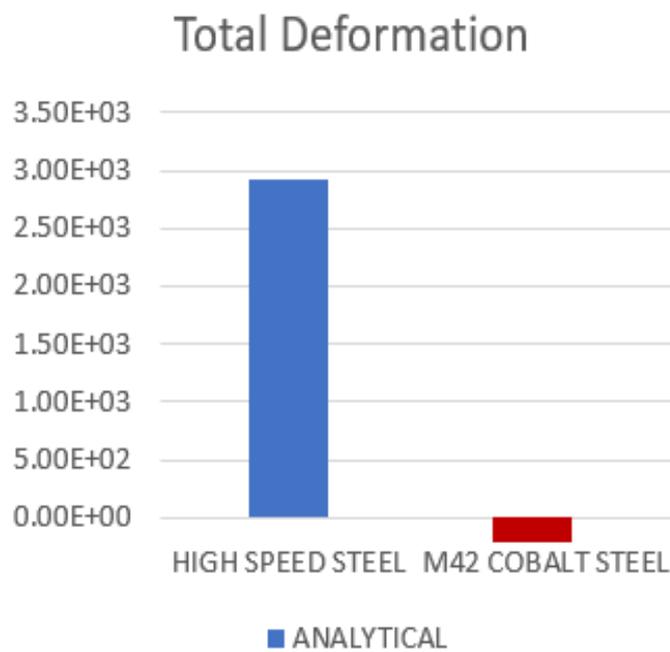
GRAPHS



Graph:1 Comparison between High-speed steel and M42 Cobalt Stress on the basis of their von-misses stress.



Graph:2 Comparison between High- speed steel and M42 Cobalt Stress on the basis of their equivalent elastic strain.



Graph:3 Comparison between High- speed steel and M42 Cobalt Steel on the basis of their deformation.

5.CONCLUSION

The current research shows the analysis of Twist Drill Bit made from High-speed steel and M42 Cobalt Steel using Static structural analysis on ANSYS WORKBENCH 2024R2. The boundary conditions assumed as 2000N as a force with one end fixed has applied to all materials, whereas the total geometry is same for all. Finally, it can be concluded that from cobalt is safer than HSS. The resultant values for M42 cobalt steel are: Maximum elastic strain is $5.05e-5$ and maximum equivalent stress is $1.08e7$ Pa with total deformation of about $2.72e-6$ mm. however the equivalent stress withstand capacity is low for HSS and withstand capacity is high for M42 Cobalt Steel.

By this research analysis we can say that it is good for thermal resistance and wear resistance of Drill bit and achieves good accuracy. By observing the analysis of M42 Cobalt steel possesses high-performance on heavy duty and tough material due to its superior mechanical properties. When we observe the analysis of the drill bit M42 Cobalt drill bit offers enhanced durability and heat resistance compared to HSS.

SCOPE OF FUTURE RESEARCH:

- The present research introduces a number of possibilities for additional investigation and practical use. The following portion discusses some intriguing research topics that this study has raised and that future researchers may pursue.
- The simulation results can be further validated by doing advanced materials characterization studies, such as investigating nano-composites, ceramics, or super alloys.
- In addition, dependent on past data, machine learning algorithms can be used for drill bit performance optimization and predictive modelling.
- To improve tool life and performance, particularly in harsh operating environments, future research can concentrate on hybrid materials and surface coatings.
- Further investigation is required into the use of smart technology, such as embedded sensors, to monitor cutting forces, temperature, and wear in real time.

REFERENCES:

- 1) G. Manoj Reddy, D. pinakapani Reddy, K. jagadeesh, M. eswar sai, Y. V. Hanumanth Rao, "Finite Element Stress Analysis of Drill Bit in Ansys", International Journal of Innovative Technology and Exploring Engineering (IJITEE), Vol. 8 Issue 7, May 2019.
- 2) Ganesh Malayath, Jayachandran KN, Ajay M Sidpara and Sankha Deb, "Experimental and theoretical investigation into simultaneous deburring of microchannel and cleaning of the cutting tool in micro milling", Journal of Engineering Manufacture, 5 August 2018
- 3) V Srinivas, "Design and Analysis of drill bit with various materials using ANSYS", Journal of Engineering and Applied Sciences, Vol. 13 Issue 6, 2018.
- 4) Pathak, S. S.; Kagade, V. R; and Kadam, M. S. (2011) "Experimental Analysis of Coated and Uncoated Twist Drill; Review," International Journal of Mechanical and Industrial Engineering: Vol. 1: Issue. 1, Article 7.
- 5) B. Suresh kumar, V. Vijayan, N. Baskar, "Comparison of coated and uncoated carbide drill bits for drilling titanium grade 2 material", MECHANIKA. Vol. 22(6): 571 – 575, 2016.
- 6) Puneeth H V, Smitha B S, "Studies on Tool Life and Cutting forces for drilling operation using Uncoated and coated HSS tool", International Research Journal of Engineering and Technology (IRJET), Volume 4 Issue 6, June - 2017.
- 7) Pravin Pawar, Raj Ballav, Amaresh Kumar, "Modeling and Simulation of Drilling Process in Ti-6Al-4V, Al6061 Using Deform-3D Software", International Journal of ChemTech Research, Vol. 10 No.3, pp 137-142, 2017.
- 8) https://www.researchgate.net/publication/351359052_STRUCTURAL_ANALYSIS_OF_DRILL_BIT_HAVING_DIFFERENT_MATERIAL_USING_ANSYS
- 9) <https://doi.org/10.17762/turcomat.v12i13.8909>
- 10) https://www.researchgate.net/publication/385630993_Analysis_of_stress_behavior_of_drill_tool_by_using_ANSYS-2020_R2
- 11) Tushar Gundarneeeya, Hilesh Chaudhari, "Analysis of performance parameter for the drilling of INCONEL 625", Journal of Emerging Technologies and Innovative Research (JETIR), Vol. 2 Issue 1, January 2015.
- 12) <https://doi.org/10.1007/s41872-024-00286-2>
- 13) https://www.researchgate.net/publication/366657743_FABRICATION_AND_WORKING_PERFORMANCE_ANALYSIS_OF_DRILL_BIT_TOOL
- 14) <https://www.ijitee.org/wp-content/uploads/papers/v8i7/G5536058719.pdf>
- 15) <https://turcomat.org/index.php/turkbilmart/article/download/8909/6930/15968>