Design and Finite Element Investigation of Solid Wrench

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Abstract – *Fasteners become the essential component in our day-to-day life. These fasteners are mainly used in providing the linkage between the components, parts, members, etc. Therefore the fasteners, are fastened by the application of the wrench or spanner. Conventional Spanner is made of the typical Chromium Vanadium alloy material; later they are additionally chrome plated to resist the corrosion. So, In order to eliminate these additional operations, the material of the spanner is altered. In the paper, the material of the spanner is modified with the structural steel and Cobalt Chromium. The Spanner is modeled by the Solid works software and thereby maintain the design specifications. Then the Finite element analysis is carried out in the Abaqus software. Furthermore, the outcome is acquired, shows that the material cobalt-chromium can be utilized for the Spanner. Since it might have a high resistance to corrosion and it may have high wear resistance.*

Key Words: **CAE analysis, Finite element analysis, Solid Wrench, Stress analysis, Structural analysis, Spanner.**

1. INTRODUCTION

Wrench is a mechanical tool often used for fastening the fasteners like fasteners by applying torque on it. The word wrench is originated from the Proto-Germanic word "wrankiz" which means turning or twisting. The wrench is commonly known as a spanner. The word spanner came into existence in the 1630s, which refers to a tool used in a firearm. The word spanner is also derived from the German word spanner, which means to join, connect, or fasten. There are different types of spanner available open-ended spanner, ring spanner, open-ring spanner, scaffolder spanner, flogging spanner, shifter spanner, etc...

Historians noted the application of spanner or wrenches in the 15th century for pipe clamps, suite Armor. The late eighteen and early nineteen-century large odd-sized nuts are manufactured for a wagon wheel. For fastening these odd nuts a special adjustable coach wrench is manufactured and shipped to

The USA. In the 1950s, people started to file a patent for different types of wrench. These wrenches come in different standards, which are Standard Combination Wrenches, Metric Combination Wrenches, Standard Flare Nut Wrenches. The most commonly used standard in India is Metric Combination wrenches which start from 6, 7, 8, 9, and so on till 32.where as in the US, the commonly used standard is Standard Flare Nut Wrenches which starts from 3/8, 7/16, 1/2 and so on.

The spanner or wrench is these days utilized worldwide for fastening the fasteners. This likewise gave thoughts in making numerous different devices like church-key otherwise called a container opener(used for opening crown vessel tops of the jug), sardine can key(used for opening canned fishes), paint can opener(used for opening), window wrench, and so on.

2. METHODOLOGY

The spanner or wrench is a mechanical instrument utilized by everybody around the globe for securing the fasteners. A Metric combination wrench of M16 is structured with the specification, which is ensured by DIN 3113[1]. The above confirmation sees to that the spanner satisfies the geometrical need and resilience.

At that point as indicated by the particular, the demonstrating of the spanner or wrench is finished utilizing SOLIDWORKS. The finished model is changed over to the necessary format (igs or step).

The changed over model is inspected in SIMULIA ABAQUS which is a computer-aided engineering software suite for finite element analysis (FEA). In this product, the change over the 3D model of the spanner is imported and the material is assigned. After that, the mesh is performed.

Mesh is done so that the complex model is divided into small elements and then small elements are solved and resulting in the final value. The mesh affects the speed of simulation, accuracy, and convergence. Figure 1, shows the entire process carried out in the simulation of the wrench.

After meshing is completed, the boundary conditions are assigned to the meshed model. In addition, the problem is solved to get the results on stress distribution, deformation, and principal strain.

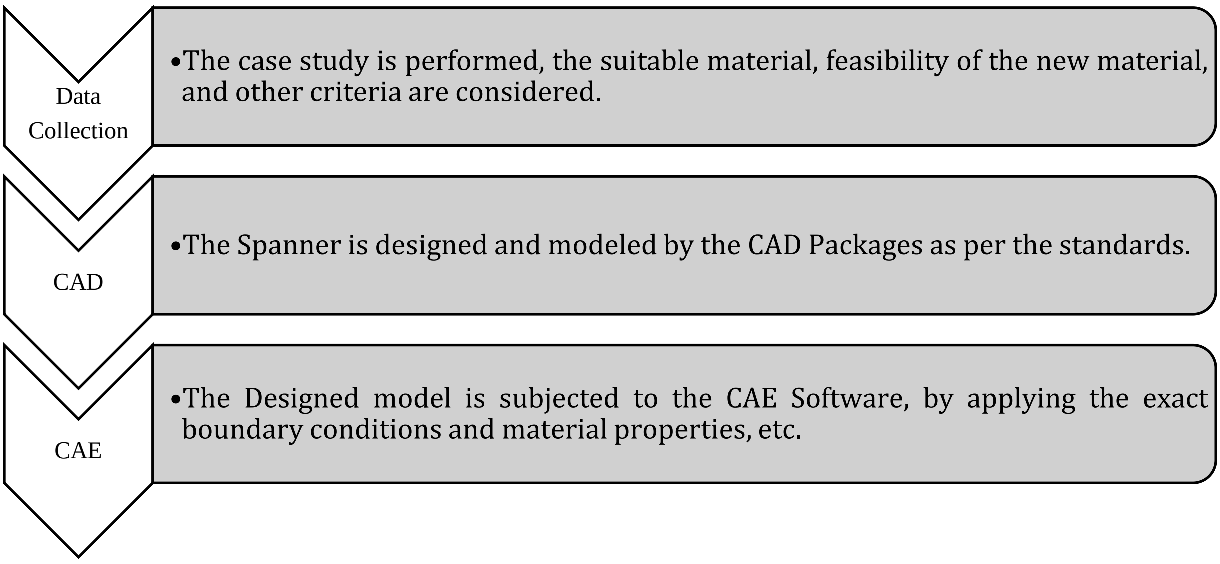

Fig-1: Process Flow of the analysis

3. SOLID MODELLING

The solid model of spanner or wrench is designed with any CAD Packages. In this article, the solid modeling was done with the help of CAD software SOLIDWORKS which is owned by Dassault Systems which is a French company. The model is created by using simple commands in SOLIDWORKS like a sketch, extrude, extrude cut. Then, the model is converted into a suitable format. Here, the SolidWorks model is converted to the step or step format. The material suggested for the manufacturing of spanner or wrench is Cobalt-chrome or Cobalt-chromium (CoCr). Cobalt-chromium has a very high specific strength. Figure 2 and 3 shows the Wrench modelled in the Solid works software.

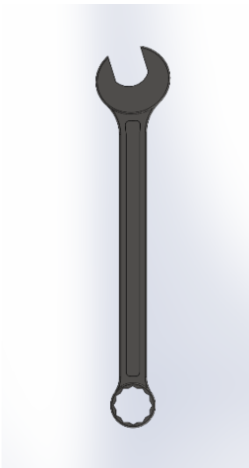

Fig-2: Top View of wrench

Fig-3: Isometric View of wrench

4. MATERIAL SELECTION

The material used for manufacturing spanner or wrench is Chromium Vanadium alloy. The structural steel is easily available, fire-resistant, and ductile. Whereas the cobalt-chromium alloy has good corrosion resistance, scratch-resistant. The CoCr material is used in dental inserts, gas turbine, orthopedic embed this material is not susceptible to people so it does not create any rashes. Table 1 shows the mechanical properties of the material.

Table -1: Mechanical Properties of Structural Steel and CoCr alloy.

Material	Structural Steel	CoCr alloy
Density	7850 kg/mm3	10000 kg/mm3
Young's Modulus	200 GPa	220 GPa
Poisson Ratio	0.26	0.29

5. ANALYSIS OF WRENCH

The model is imported to the Abaqus Software. Then, the part model is designated as the Deformable 3D model. Figure 4 shows the mode imported to the abaqus software. Then the material is assigned to the model section. In this analysis, two different materials are used. Figure 5 shows the Meshed model of Wrench.

5.1 Case 1

The Material used is Structural Steel.

Then the load conditions like, the fixed support is provided at the open end of the spanner. The load is provided at the box end of the spanner. The mesh is performed for the model. Here the tetrahedral mesh element of size 1 mm is meshed. The element is of C3D10 – A 10 noded quadratic tetrahedron, and it may contains 269880 elements.

The job is submitted for the analysis. The post-process is done for the analysis.

5.2 Case 2

The Material used is the Cobalt Chromium alloy.

The same analysis is carried out for the materials. Then the stress distribution, deformation and plastic strain is calculated and compared with each other.

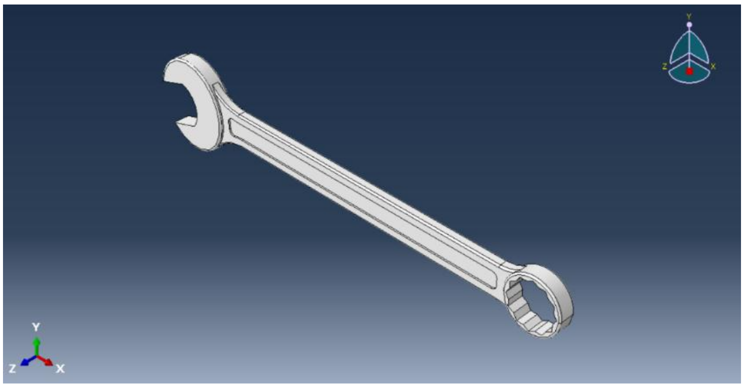

Fig- 4: Imported model in the abaqus software

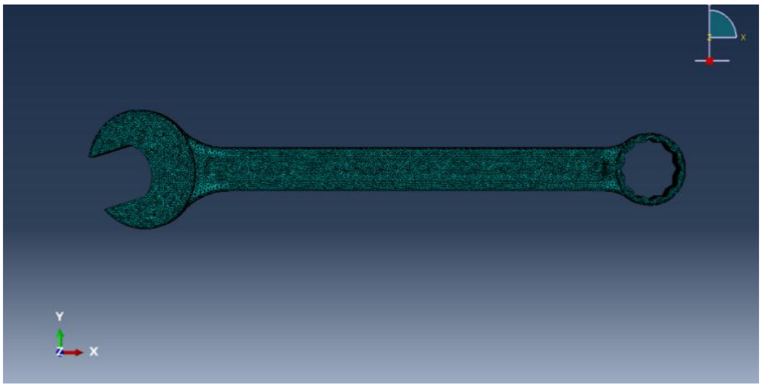

Fig- 5: Meshed model with 269880 elements

6. RESULT AND DISCUSSION

After the analysis is completed, post processing is done. The output values are obtained compared with each other. Table 2 shows the comparison between the values.

6.1 Stress Distribution

Figure 6 and 7 shows the stress distribution on the wrench for the Structural steel and the CoCr alloy. Due to the application of the load in the box end of the spanner. And it shows that the stress produced in both the material are same.

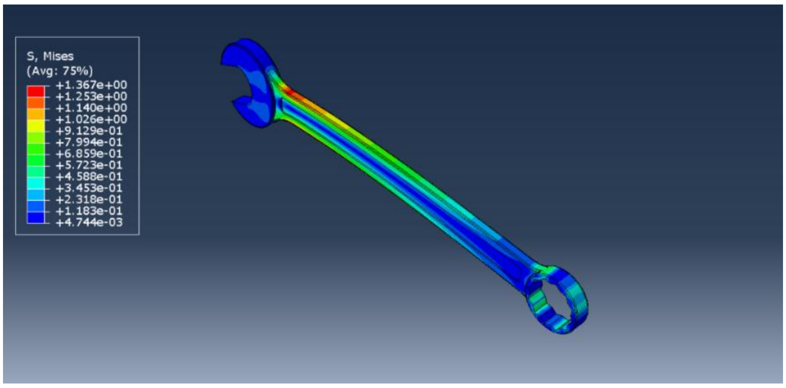

Fig - 6: Stress distribution in the structural steel

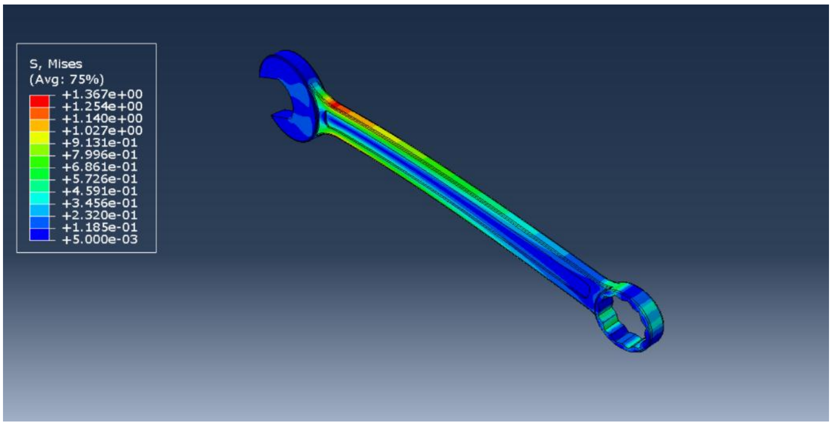

Fig - 7: Stress distribution in the CoCr alloy

6.2 Deformation

Figure 8 and 9 shows the total deformation obtained in the structural steel and CoCr alloy. It is obvious that the deformation produced in the CoCr is comparatively less than the Structural Steel.

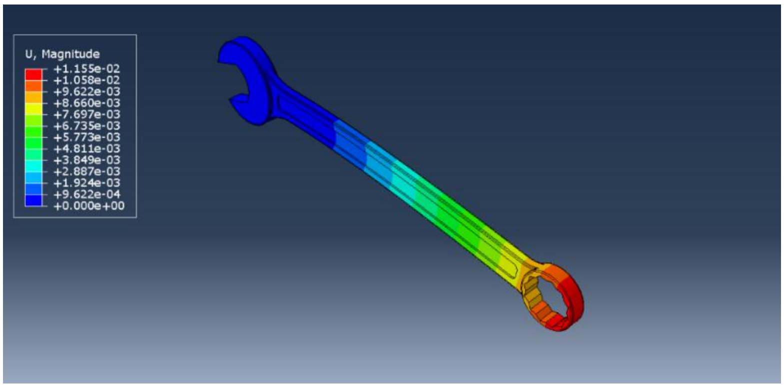

Fig - 8: Total Deformation in the structural steel

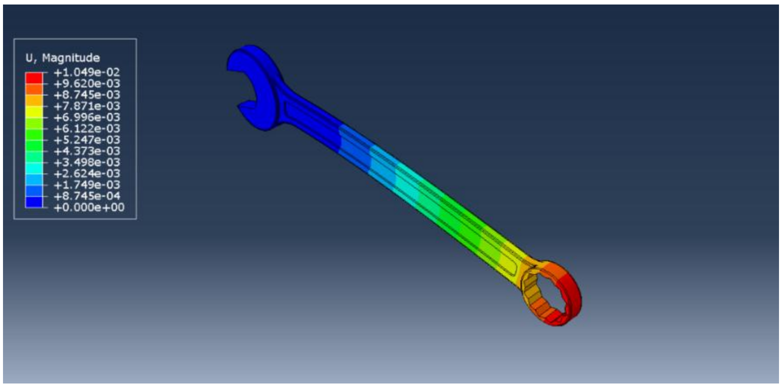

Fig - 9: Total Deformation in the CoCr alloy

6.3 Principal Stress

Figure 10 and 11 shows the maximum Principal strain obtained for the structural steel and the CoCr alloy. Here, the maximum principal strain for the CoCr alloy is comparatively less than the structural steel.

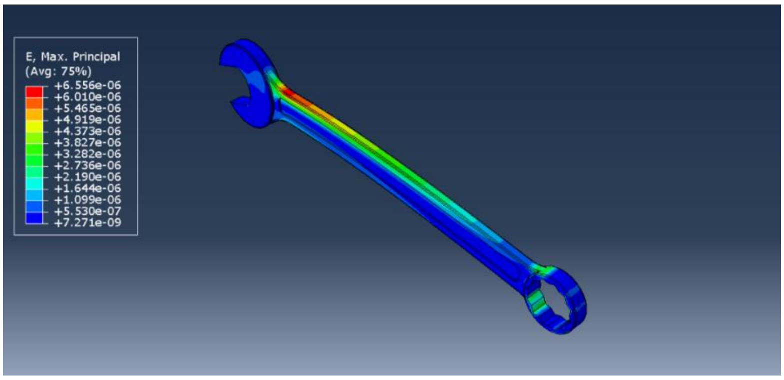

Fig - 10: Maximum Principal Strain for the Structural steel.

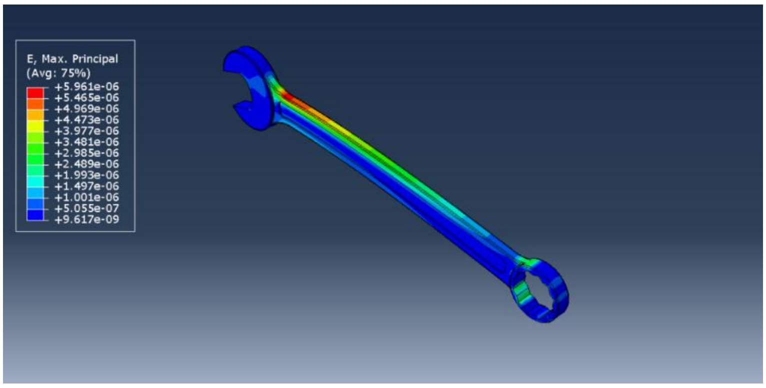

Fig -11: Maximum Principal Strain for the CoCr alloy.

Table 2: Comparison of Structural Steel and CoCr alloy.

Material	**Structural Steel**	**CoCr alloy**
Von – Mises Stress	1.367 N/mm2	1.367 N/mm2
Total Deformation	1.155E-02 mm	1.0149E-02 mm
Maximum Principal Strain	6.556E-06	5.961E-06

7. CONCLUSION

From the above investigation, the outcome acquired is evident that the Cobalt-Chromium material may have low deformation when contrasted with structural steel. The Von Mises Stress Distribution is nearly the equivalent in the two cases. The Maximum Principal Strain is nearly low in the Cobalt-Chromium than the structural steel. Thus the Cobalt-Chromium might be utilized in the Spanner, due to its low deformation, scratch-proof, high erosion resistance.

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