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Theoretical Design and Analysis of Ring Spanner by using ANSYS

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Abstract: Ring spanner is an important tool in the machine industry and its demand is increasing day by day, which forces us to analyse and improve design to improve work performance and tool efficiency. The focus of this study is to determine the stress and deformations occurring in a loaded ring spanner. To analyse the spanner in detail a model is made where the geometry is simplified to a plane model. this research paper considered chrome vanadium material for ring spanner. The spanner is designed in "Catia v5" with a gauge length of 150 mm; the big end of the spanner is an internal diameter of 32 mm and a small end internal diameter of 28 mm as shown in table 1. The design file in Catia saves in an extension of .stp.

The model finally imported into Ansys software for analysis. The material selected is Chrome Vanadium with properties inserted into the 'Engineering Data Source' all parameters given in Table 2 below.

For analysis purpose, the big end 'A' is being supported as fixed and on the left side, a remote force of 500 N in an anticlockwise direction is applied in a static structural Mechanical analyzer.

The mesh of the model is fine, the number of nodes and element are 49333 and 30326, an element size of 2.5e-003 m. The overall volume and mass are 4.9667e-005 m³ and 0.38988 kg.

Keywords: Ring Spanner, 6 and 12 points, Ring big end, fixed support, Reaction force, Linear Position, Stress, Strain, Deformation

Introduction: Ring spanner is one of the categories of a wrench, used for tightening and losing the nuts of automobiles and various machine parts to assemble and disassemble. The main functions of the ring spanner (wrench) are to provide rotating motion about fixed centre and axis. Also, to provide suitable grip and applying torque to turn objects usually rotary fasteners, such as nuts and bolts or keep them from turning.

Ring Spanners are made in various shapes and sizes and are used for gripping, fastening, turning, tightening and loosening things like pipes, pipe fittings, nuts and bolts. There are two major kinds of wrenches, Ring spanner is used in plumbing for gripping round (cylindrical) things and may be adjustable to fit different sized pipes, nuts and bolts or maybe a fixed size [1].

The ring spanner is designed in a set of more standard layout, normally constructed in a single piece metallic structure that turns side onto a nut. Its connection with a fastener is very much similar to that of a box spanner set.

The ring spanner set has a head at each end are formed as a single closed loop containing a machine profile, which connects to the nut on all side and provides firm contacts simultaneously. This offers a very strong grabbing force and makes it less likely to slip.

In this research, a single piece wrench (ring spanner) is an enclosed opening at both ends that grips the lateral faces of bolt or nut. Both the enclosed ends are of an eight-point opening for use with nuts or bolt heads with a hexagonal shape. Eight-point wrenches are also made for square-shaped nuts and bolt heads. Ring spanners are often double-ended and usually with offset handles to improve access to the nut or bolt.

In a US-based system, the spanner refers to a specialized wrench with a series of pins or tabs around the circumference. (These pins or tabs fit into the holes or notches cut into the object to be turned). In UK based system, spanner is the standard term. The most common shapes are called open-ended spanner and ring spanner. The term wrench refers to

various types of adjustable spanner. In American English, the wrench is the standard term. The very most common shapes are called open-end wrench and box-end wrench [2].

Literature survey: Wrenches have existed for many centuries but saw a great blossoming of development starting in the 19th century. The first patent for a wrench was granted in 1835 to Solymon [3]
Merrick. Meanwhile, during this long period, different varieties of wrenches came into existence. Some of their descriptions are as follows [4]: -

Types of wrenches and their applications

SR. No.	Name	Purpose and Applications	Pictorial Representation
1	Double Ended Spanners	It is made from high-grade steel forged, accurately machined, Hardened and tempered to give long trouble-free service. Provided appropriate surface protection for rust prevention.	
2	Double Ended Spanners Sets	6-32 mm drop-forged chrome vanadium steel spanners. Standard set contents typically are 6 x 7, 8 x 9, 10 x 11, 12 x 13, 14 x 15, 16 x 17, 18 x 19, 20 x 22, 21 x 23, 24 x 27, 25 x 28, 30 x 32mm.	
3	Double-Ended Spanners (Ribbed)	Drop forged from suitable grade steel. Heat-treated with hardness 42 – 48 HRC to give maximum strength and wear resistance. Head at each end are of different sizes and set an angle of approximately 15 Degree. Good accessibility in confined spaces due to slim and practical design	
4	Single Ended Open Jaw Spanners	Manufactured from forged and hardened chrome vanadium steel, this range of open-ended spanners are ideal for professionals. Head angle around 15degrees, Nickel Chrome Plated finish.	
5	Ring Spanners	Drop forged from high-grade chrome vanadium steel heat treated to give maximum strength and wear resistance. Good accessibility in confined spaces due to thin-walled rings and are light and handy in use. Slightly rounded handles sandblasted fit snugly in the hand and give a comfortable grip. The non-damaging grip on the nut due to close wrench opening tolerances.	
6	Ring Spanner Sets	Highly forged polish metallic material, available in a variety of sets, like 6X7,8X9, 10X11, 12X13, 14X15, 16X17, 18X19, 20X22, 21X23, 24X26, 25X28, 30X32 Inches. Features- Stanley Ring Spanner Sets Shallow Offset Ring End Spanner - Matte Finish	
7	Slogging Open Ended Spanners	Open End Slugging Wrench Spanners are heavy-duty drop-forged open-ended slugging spanner with amendment no.1 is specially designed for very heavy-duty work. Their durable striking end gives extra utility while tightening and loosening with the hammer. Chrome-Molybdenum is used as material	

8	Slugging Ring Spanners	Drop forged from high-grade Chrome Vanadium steel. Scientifically heat-treated to give maximum strength and wear resistance. Hardness: 34 – 40 HRC. Thoroughly rust corrosion protected with black phosphate finish. Short and strong profiled handle and striking ends for heavy-duty operations in shipyards, railways, heavy industries etc.	

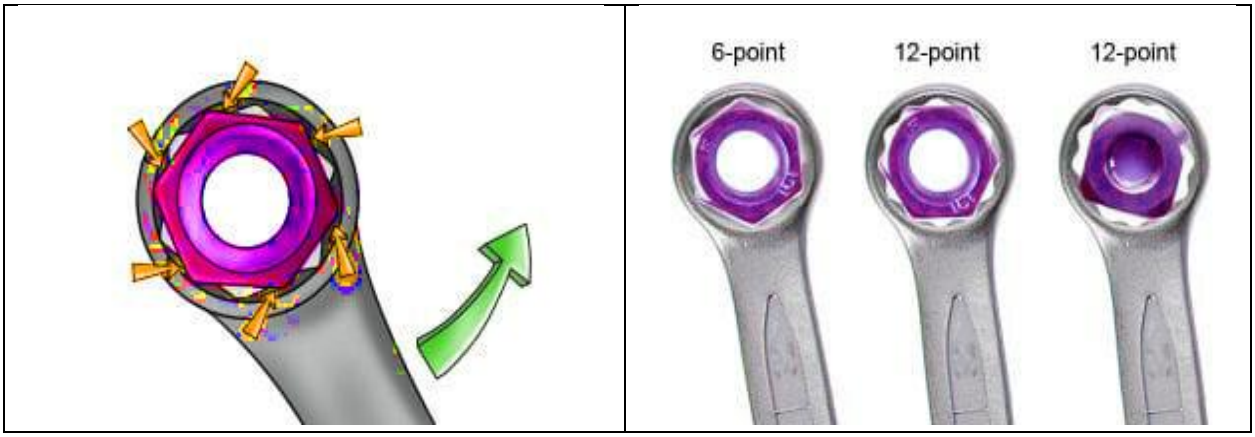
Based on the above different types of spanners mention, there is a wide scope to improve the design conditions and do analysis for more effective results. Also, a wide range of study can be performed on this under different operating and loading conditions. The analysis will help us in enhancing the service life of the tools and attain better ergonomics. Generally, we are using a box end wrench and four-way wrench for fastening and unfastening the nuts.

For the efficient operations of machines, automobiles, manufacturing and production industries and many other sectors, ring spanners widely used. A proper design, dimensions, material selections, would be effective in handy and smooth work operations, also the service life of the handy tools gets to improve. During the operations, such as fastening and unfastening many factors need to consider depending upon the size, loads and nature of operations such as stress, residual forces, strain, deformation [5].

Design of Ring Spanner: The ring spanner is one of the wrenches used in a mechanical, electrical, automobile on a large scale with different size configuration. It is evident to assess the design and performance analysis for further augmentation in design and get rid of technical faults.

A simple tool used to establish whether something is ‘plumb’ (exactly vertical). When the string is attached to a static object and the plumb-bob weight is suspended below, the laws of gravity will ensure that the string is both vertical and perpendicular to any horizontal plane through which it passes.

The head of the fastener and spanner profile is designed in such a way that pushes against the flat sides of the fastener by placing the loop over it, and then turn the head as shown in the figure below:



In comparison with an open-ended spanner, the ring spanners are less slippery over the fastener, because ring spanners provide large contact points with the fasteners in all possible points. This implies the turning arc will be more with large action and make the task effective and quicker.

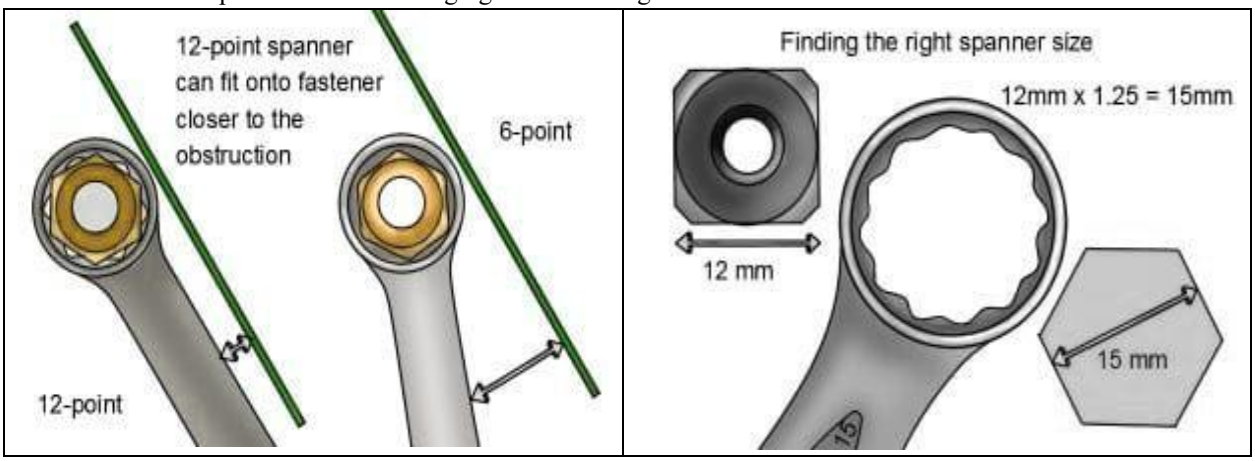
Although a wide variety of ring spanners profile are designed like 6 points, 12 points etc. for fastener shape and contact points.

The most demandable ring spanner is the 12 points (or ‘bi-hex’) profile, why it is called because it has 12 point and holders for grip.

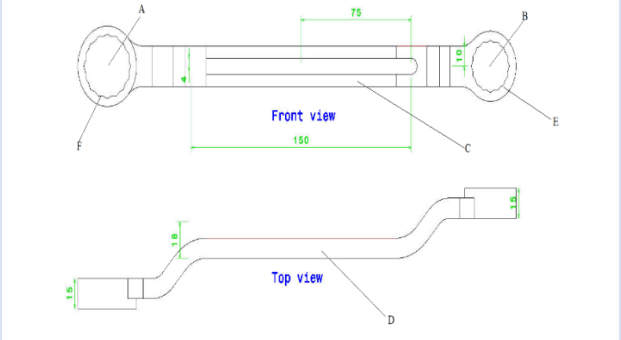
The major differences between the 12 points and 6 point profile ring spanners are 1. 12-point spanners lock the fastener in smaller space than 6 points, 2. 12 points allow to turn more degrees of rotation than the 6 points always

require to readjust, 3. 6-points spanners only restricted to apply on hexagonal fasteners while 12-point profiles can be used on hexagonal or square fasteners.
The spanners profile and design are referred to as 'OGV' of Alti-Slip 'AS' because the shape of the profile varies slightly between manufacturers and some have designs that are less likely to damage the fastener due to its better contact with the fastener side.
In a standard design, most of the heads of the ring spanner are at a 15-degree angle with the shaft and gives suitable access into some retreats, and allow the users to hold the spanner in much easier to save fingers and flawlessly turning the fastener on a flat surface.

A case which means the head is offset from the shaft also referred to as cranked which help us to retreats and make it easier to turn the spanner without damaging the user's fingers.



Ring spanner sizes are given as the size of a head of a hexagonal fastener the spanner can be used on. Ring spanner profile sizes are available to fit hexagonal fastener head sizes ranging from 4mm to 50mm or 5/32″ to 2″. The spanner length increases with the size of the spanner head, from about 100mm (4″) to 500mm (19½").
To choose a size of ring spanner for square fastener heads, increase the fastener head size by 25% to find the approximate size of a suitable 12-point ring spanner. For example, a square fastener that has a 12mm head requires a 12-point ring spanner with a given size of (12×1.25=) 15mm.
In a present paper, we extent a 6-point and 12 point study on 16 points double-ended ring spanner design and drafting in Catia.

SR No.	Drawing/View	Description
1. Orthpgraphic Projection		A. Big Ring End B. Small Ring End C. Spanner Length D. Spanner side face E. Bid end inner section F. Small end inner section

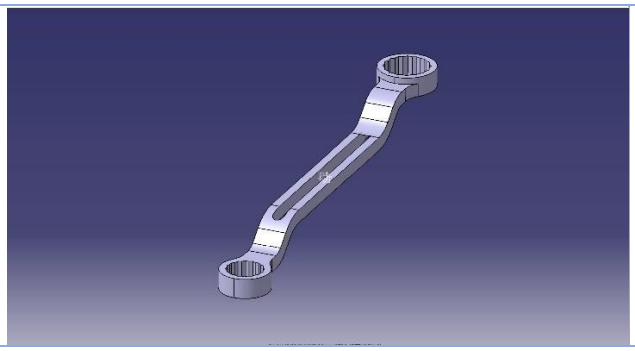
2. Isometric View		`Model designed in Catia

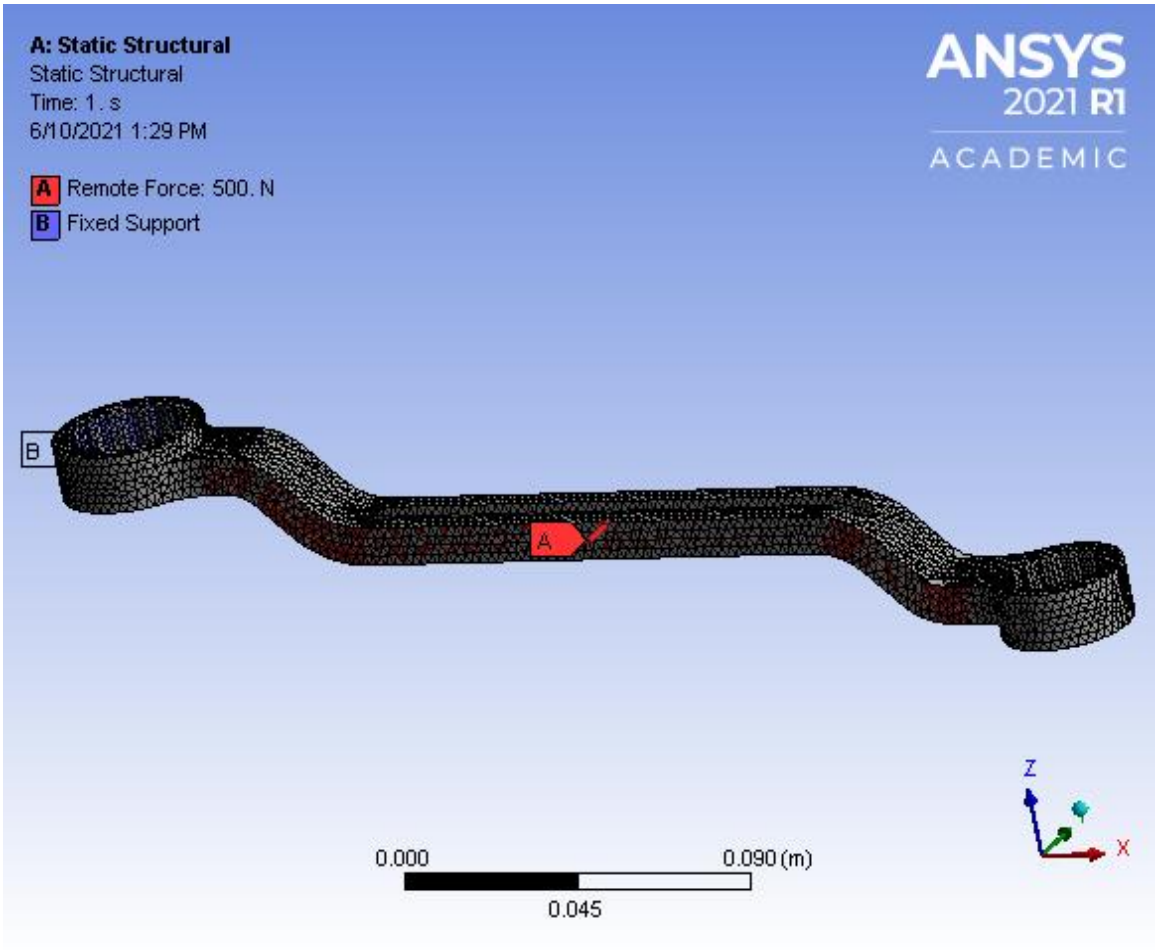
Table: 1: Detailed description

The design of a double-ended ring spanner on Catia.

A. **Big Ring End:** Outer diameter is 40 mm, the centre of the ring from the edge is 17 mm and inter circular section diameter of 32 mm and creates octagon with help of 'rotate command' generate 16 points ring.
B. **Small Ring End:** Outer diameter is 35 mm, the centre of the ring from the edge is 14 mm and inter circular section diameter of 26 mm and creates octagon with help of 'rotate command' generate 16 points ring.
C. **Spanner Length:** The length of the spanner is considered as 150 mm.
D. **Spanner side face:** The remote force one of the boundary condition is used to apply a force to the face of an element from a remote joint. The is an analogous boundary condition for the forces
E. **Bid end inner section:** All the point are being fixed firmly allow zero degrees of an angular rotation
F. Small end inner section: All the point are being fixed firmly allow zero degrees of an angular rotation

Result: By using the Ansys workbench, the ring spanner gets stress analysis with safety factors for a big end ring spanner. The Big end is fixed and the left side is subjected to a remote force of 500N. The remote force like a boundary condition that is used to apply a force on the face of the ring spanner from a remote point. This boundary condition is analogous to displacement that occurred while analysis.

The remote force boundary condition has some advantages such as deformation behaviour can be added, moment load can also be imposed. Simultaneously has some limitations like it's valid for small displacement and angular rotation occur for the small number of the entity.



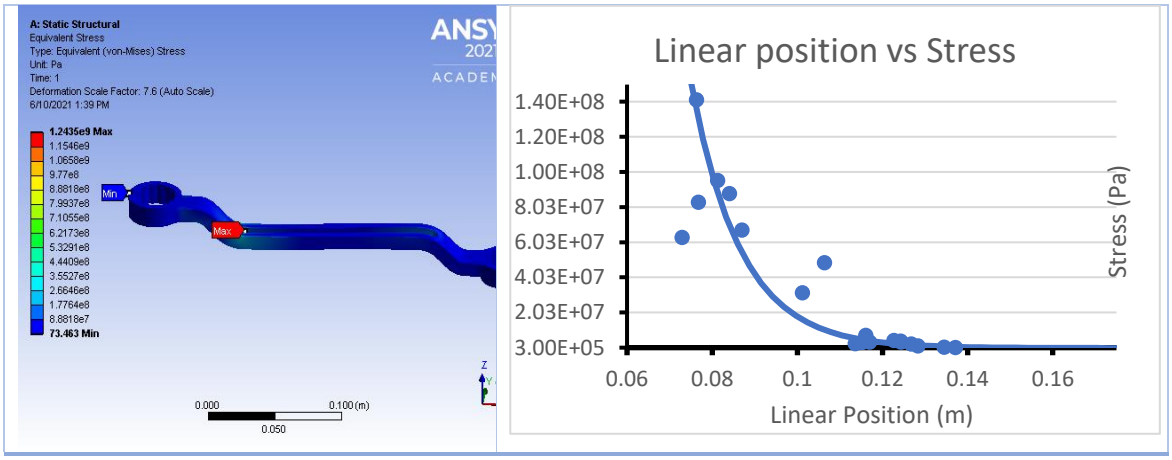
The material used for manufacturing spanner or wrench is Chromium Vanadium alloy. The structural steel is easily available, fire-resistant, and ductile. Table 2 shows the mechanical properties of the material.

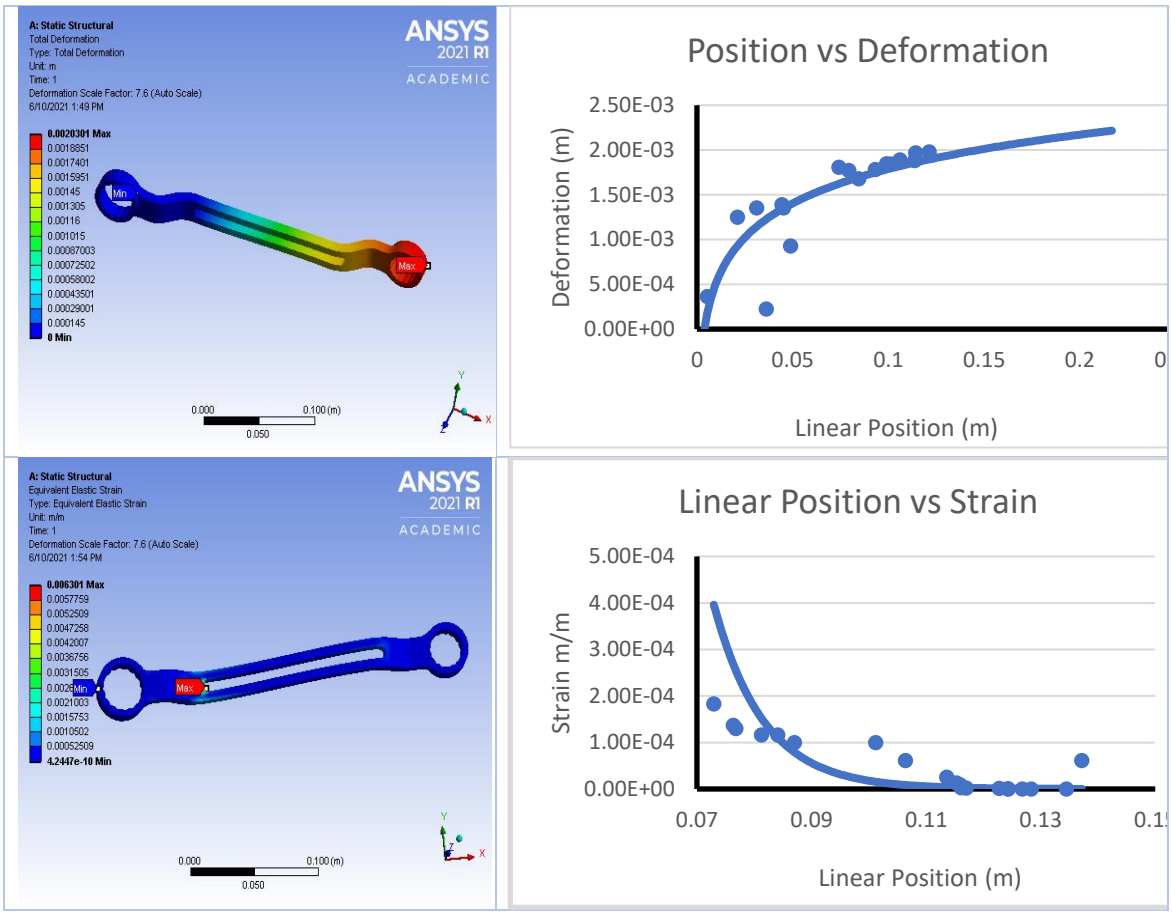
Chrome Vanadium: Ring Spanner Data	
Density	7800 kg/m^3
Structural Properties	
Young's Modulus	2.1 E+11 Pa
Poisson's Ratio	0.29
Bulk Modulus	1.6667 E+11 Pa
Shear Modulus	8.1395 E+10 Pa
Isotropic Instantaneous Coefficient of Thermal Expansion	12 1/ ºC
Tensile Ultimate Strength	9.4 E+8 Pa

Table 2: Mechanical Properties of Structural Steel and CoCr alloy.

Position (m)	Stress (Pa)	Deformation (m)	Strain (m/m)
0.137198	3.00E+05	3.65E-04	6.14E-05
0.134534	4.49E+05	1.25E-03	9.06E-09
0.1284	1.23E+06	1.35E-03	3.55E-08
0.126785	2.23E+06	2.24E-04	7.30E-08
0.124357	3.36E+06	1.43E-04	2.28E-07
0.124315	4.03E+06	1.39E-03	4.41E-07
0.122767	4.23E+06	1.35E-03	1.20E-06
0.117014	3.33E+06	9.28E-04	2.09E-06
0.116122	7.26E+06	1.81E-03	2.61E-06
0.116001	4.32E+06	1.77E-03	9.26E-06
0.115322	3.18E+06	1.68E-03	1.31E-05
0.113624	2.42E+06	1.72E-03	2.57E-05
0.106414	4.86E+07	1.69E-03	6.14E-05
0.101241	3.14E+07	1.72E-03	9.97E-05
0.087049	6.72E+07	1.78E-03	9.97E-05
0.084124	8.79E+07	1.85E-03	1.16E-04
0.081314	9.54E+07	1.84E-03	1.16E-04
0.076819	8.30E+07	1.86E-03	1.30E-04
0.07637	1.41E+08	1.89E-03	1.37E-04
0.072944	6.29E+07	1.91E-03	1.83E-04

Table 3: Readings from ANSYS workbench





Conclusion: In this design and analysis, the result shows that chrome vanadium steel offered a small deformation around 2.03E-3 m; when fixed the bid end with the surface condition as a remote force of 500N. The maximum deformation at another end (small ringside). The maximum stress concentration occurs at the offset section, caused the localized stress to develop around 1.249E+9 Pa. Stress distributed exponentially after the offset section and get normalize by the end of the spanner.

The maximum principal strain is nearly low in the chrome-vanadium compare to other structural steel. The chrome-vanadium is the suitable material for manufacturing ring spanner, particularly for small size structure due to maximum strain develop at an offset position of the order of 0.00603 after that strain decreases and get stabilized.

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