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Design Optimization of Special Tool for Commercial Vehicle

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ABSTRACT: Optimization of special workshop tool is included in this paper. For service and maintenance purpose, brake drums need to be removed from vehicle axle. Often brake drums get jammed on axle due to various reasons. Some of the reasons for brake drum jamming includes corrosion, rust, unused mechanical parts for long time, getting stuck due to dust, dirt causing brake drum to get stuck on the vehicle axle. In this research, use of special tool is mentioned to remove such brake drum from the vehicle axle. Targeted tool is a special tool used for brake drum removal from vehicle axle for maintenance and service purpose. Forces are found out for pulling brake drum. Different alloys of steel with different hardness are studied and tested to find out their mechanical properties. For optimization, iterations are performed using PROE CREO and the optimization analysis performed in ANSYS Workbench

KEYWORDS: 3D model, analysis, force, optimization

I. INTRODUCTION

There are number of special tools which are made for different purposes for each vehicle aggregate. Further each tool has variants in terms of shape and size depending on accessibility of parts. Each tool is made as per its function, which defines the types of loads to be considered. In case of special tools, path or method used to access the part defines the dimensional constraints. If a critical tool like mechanical puller is used for heavy function and if it fails during use, it may cause a heavy damage to parts or injury to the person. As well as an over designed tool will cause high weight and high cost when produced in mass. So optimized special tools are desirable.

In commercial vehicles, maintenance is required to be done after certain interval of time. This is caused by end of life stationary and moving parts which needs replacement. One of such requirements is removal of brake drum from vehicle axle. Over the time, wheel nut, brake drum etc. gets jammed and very difficult to remove. During such processes, there is always a risk of failure of good working part and also raises safety issue. Parts gets stuck due to various reasons which includes corrosion, rust, eccentric hole alignment of parts, unintentional friction between moving parts, misalignment of parts during fitment or due to working condition. This paper focuses on making a standard tool, a mechanical puller to remove brake drum easily and safely and without breaking any parts or assemblies.

Paper is organized as follows. Section II describes automatic text detection using morphological operations, connected component analysis and set of selection or rejection criteria. The flow diagram represents the step of the algorithm. After detection of text, how text region is filled using an Inpainting technique that is given in Section III. Section IV presents experimental results showing results of images tested. Finally, Section V presents conclusion.

II. RELATED WORK

The main objectives of this paper are as mentioned below:

- Concept preparation of a mechanical puller for removal of brake drum from the vehicle
- Creation of 3D models and assemblies

- Identification of forces acting on brake drum to overcome by a mechanical puller
- Study of different materials for mechanical puller.
- Structural analysis of mechanical puller for determination of stress
- Design optimization using CAD software and CAE software to get better option.

A mechanical puller is used to disassemble tightly fitted parts or assemblies for example brake drum, gear or bearing and shaft assembly or an axle hub assembly. A centre screw is used as pulling mechanism by locking it on the centre shaft. The centre screw is rotated by applying torque. It helps in sliding of brake drum towards the puller by converting torque into force and rotary displacement into linear displacement.

After a study of the existing literature, following scope of project have been defined in the investigation of different options for mechanical puller. Scope includes preparation of concept for creating various options considering space available in and around targeted assembly for replacement, functioning of special tool and serviceability points, ease of operation and ease of handling of special tool, repeated usage and storage limitations, selection of different shapes and sizes of parts of the tool. Study of different materials and its properties, identification of material for proposed parts, material selection based on functionality of parts, identification of forces acting on parts, determination of for analysis considering factor of safety, study of analysis results for stresses and possible high stress regions, remaking of earlier 3D parts considering stress analysis and redoing CAE activities till get expected results of stress plot, reduction of material chunk and size optimization of parts using CAD and CAE software

III. METHODOLOGY

The optimization of a special tool is done as per steps below: -

- Step 1: Determination of forces
- Step 2: Material selection
- Step 3: Initial stress analysis
- Step 4: Redesigning
- Step 5: Stress analysis
- Step 6: Validation

IV. EXPERIMENTAL RESULTS

Below image shows drum removal tool. CAD model is prepared based on original concept This CAD model has main parts included as base frame which acts as a main body of the structure. It has vertical frame which consists of pillars and plates which actually take all the reaction forces while mechanical puller is in operation.

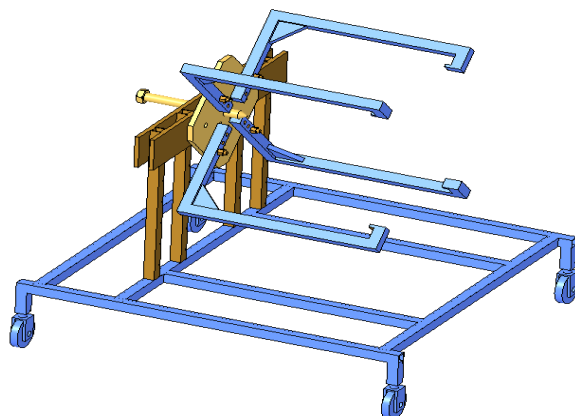


Fig. 1 Mechanical puller for brake drum

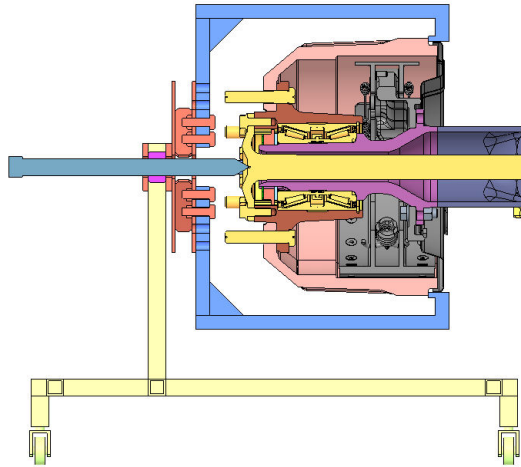


Fig 2 Clamping with maximum contact angle

Tightly fitted parts:

When two parts are assembled the difference between the mating surface dimensions is called fit. There are three major types of fits clearance fit, transition fit and interference fit. To design a tool to pull out brake drum, engagement and disengagement forces are needed to be found out. The forces acting on are calculated as per below equation.

$$F = \pi \mu P D_s L \tag{1}$$

F is force required for engaging, P is pressure on connecting parts, μ is the coefficient of friction between mating surfaces. D_s is nominal diameter of connecting surfaces and L is length of connecting surfaces. The radial stress is considered a pressure P on the connecting surfaces and can be calculated as

$$P = \frac{E \delta_D}{2 D^3} \left[\frac{(OD^2 - D^2)(D^2 - ID^2)}{OD^2 - ID^2} \right] \tag{2}$$

E is modulus of elasticity, δ_D is diametrical interference of connecting parts, OD is outer diameter of outer part, ID is inner diameter of inner part, D is diameter at interference.

$$P = \frac{\delta_D}{\frac{D}{E} \left(\frac{OD^2 + D^2}{OD^2 - D^2} + \vartheta_O \right) + \frac{D}{E} \left(\frac{D^2 + ID^2}{D^2 - ID^2} - \vartheta_I \right)} \tag{3}$$

Based on calculations, $F = 300$ N for brake drum with $ID = 162$ mm.

Material:

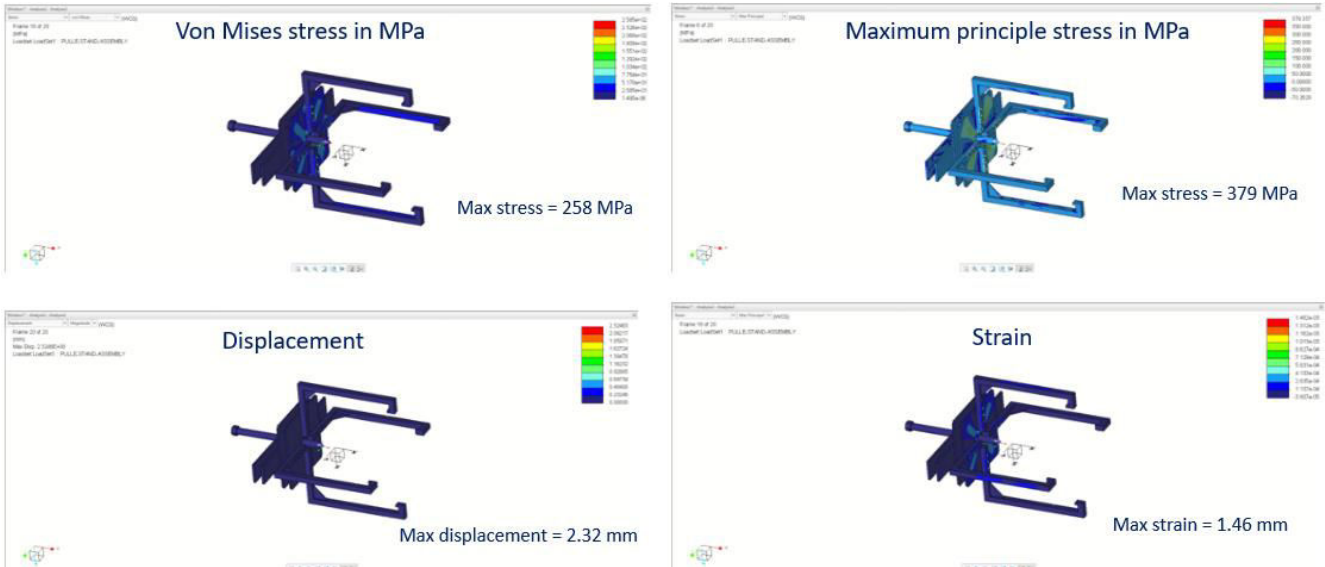
For development of mechanical puller EN9, EN19 and EN47 alloy steels are studied. All these steels have high tensile strength and toughness. These materials are studied and compared for chemical composition and mechanical properties.

- EN9 - It is a medium carbon steel used for engineering applications.
- EN19 - It is an alloy steel used in machining tools and auto industry.
- EN47 - EN47 is a steel alloy also known as spring steel.

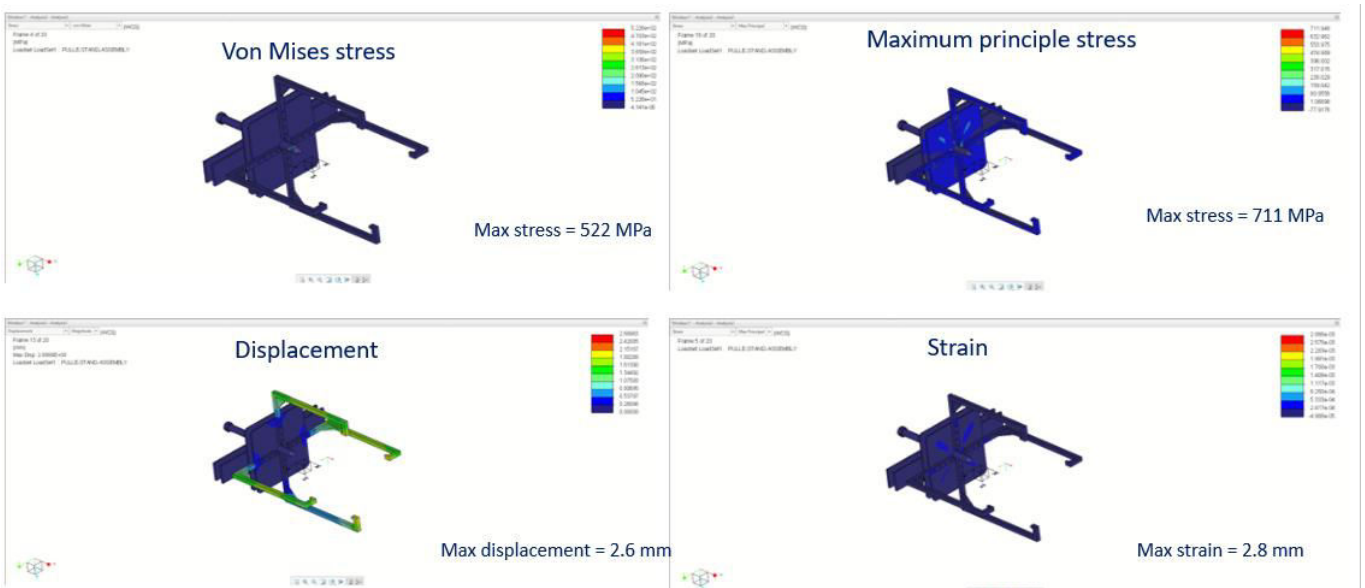
CAE results: -

Ansys software is used for CAE analysis. Load cases are applied as per actual load on vehicle axle and material is assigned. Different iterations are carried out and result are showcased as below.

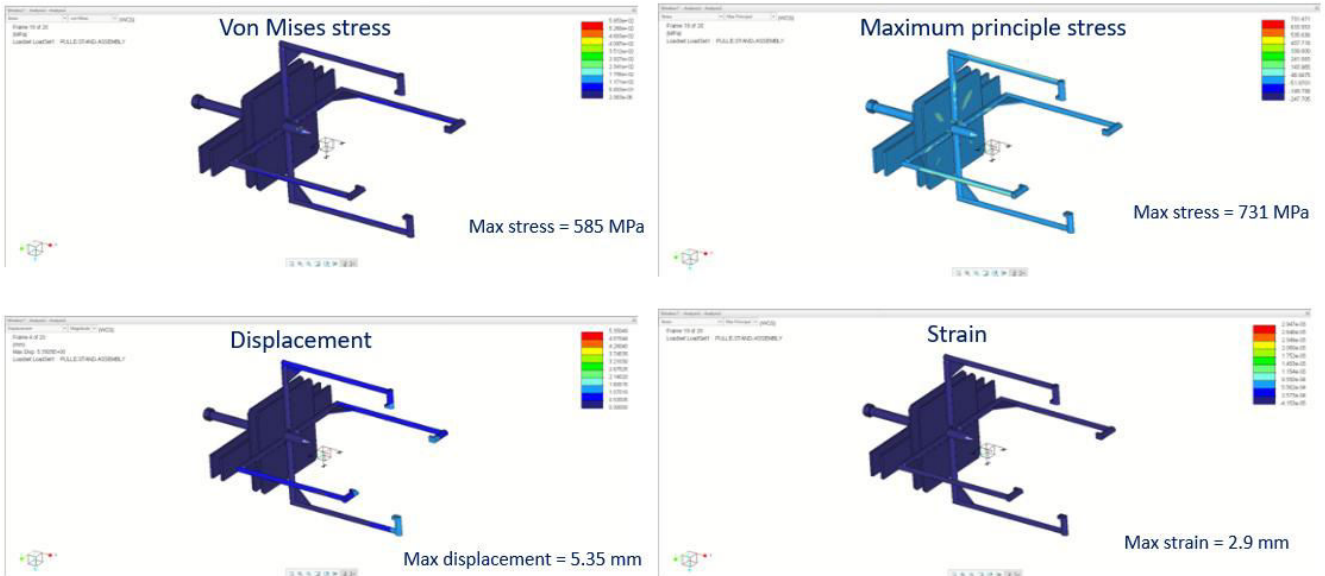
A. Puller jaw square tube size used as 20 mm.



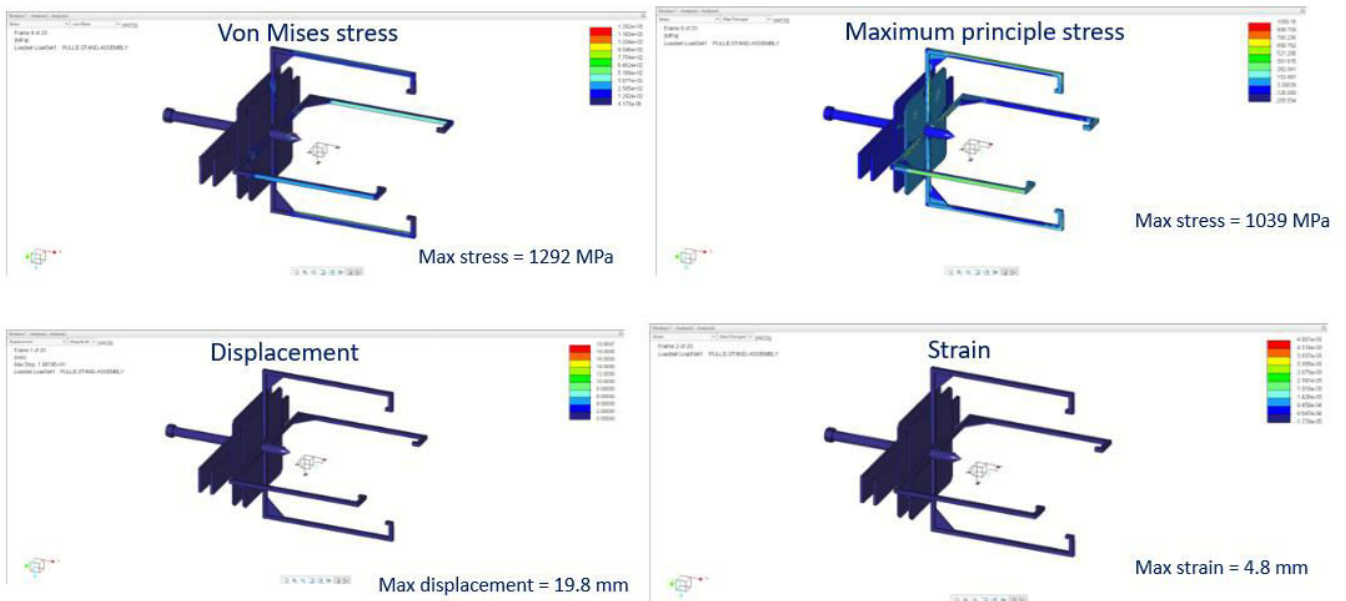
B. Puller jaw square tube size used as 15 mm.



C. Puller jaw round tube size used as 15 mm.



D. Puller jaw square tube size used as 10 mm.



V. CONCLUSION

Square tube and round tube of size 20 mm, 15 mm are used for analysis. Square tube of 20 mm size is showing best results out of selected iterations. However square tube of size 15 mm is adequate for jaw meeting stress and strain levels of selected material. Stress, displacement, and strain are in range of EN9 material properties. Same tool is validated on vehicle axle, and it has met force and functional requirements.



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