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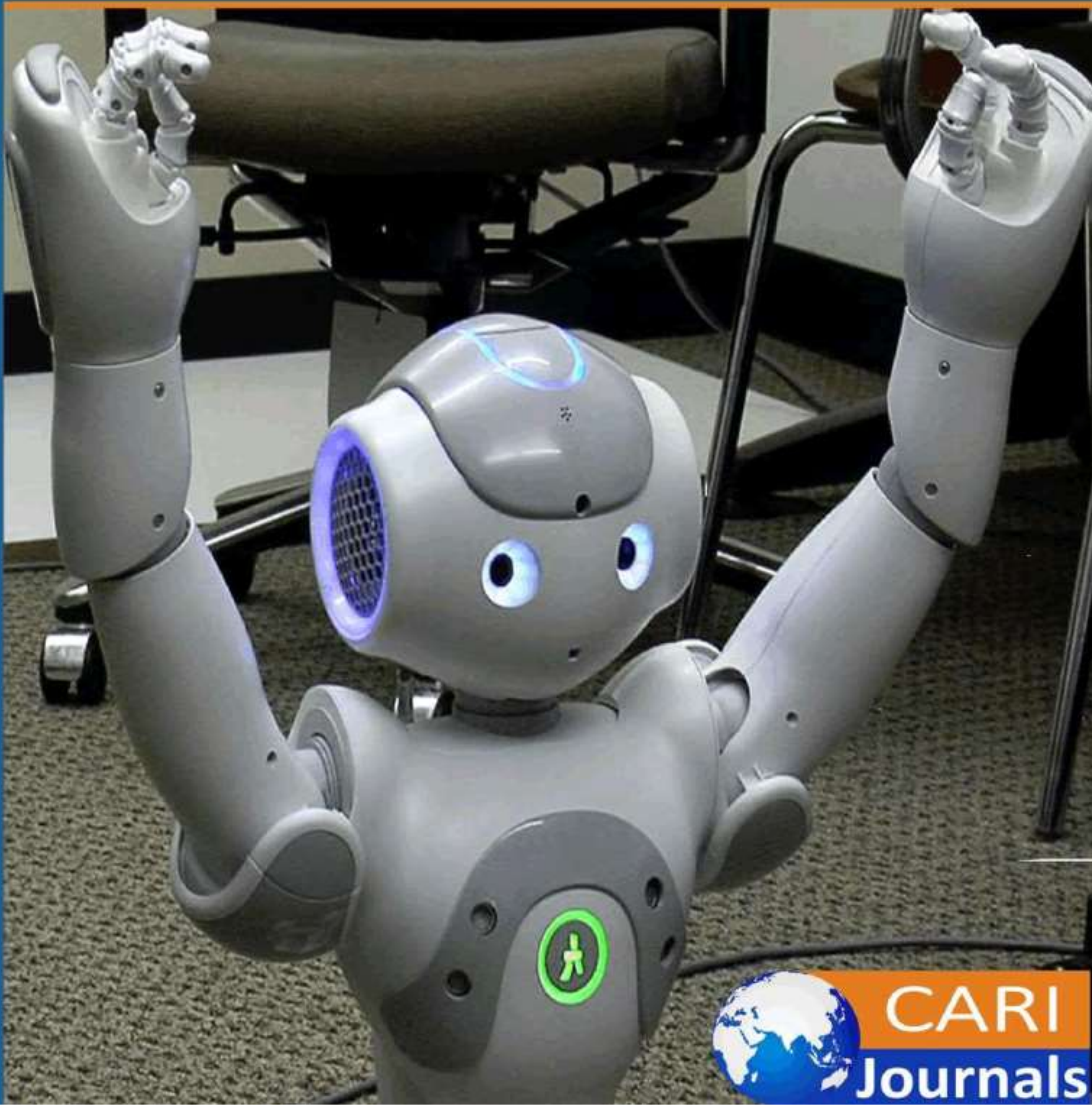

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Driver Safety High Cabin and Chassis Design in Diesel Forklifts

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Abstract

Purpose: In general, most forklift accidents occur due to rollover. After a rollover, the first affected part is the driver's cabin, followed by the chassis and parts. In the study, cabin and chassis designs of diesel forklifts with increased driver safety and performance were made.

Methodology: Cabin and chassis tests were carried out with the Solid works program. According to the test results, the chassis and cabin design was made. Welding and assembly processes on the chassis of high-strength materials suitable for this design have been completed.

Findings: As a result of the studies, the cabin design, which is different from other similar forklifts, notches on the edges of the fender, the removal of fuel and oil tanks from the chassis, eliminating the leakage test, and the steps on the sides of the chassis being made monolithic, are important innovations.

Unique contributor to theory, policy and practice: As a result of all these studies, our KFD30 model was developed. This new model stands out with its new design and manufacturing on the forklift.

Keywords: *Cabin, Chassis, Solid works*

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INTRODUCTION

As a result of forklifts tipping over, the driver's cabin on the chassis can be seriously damaged, reducing the driver's safety. Therefore, driver's cabin material selection and geometry are very important for safety. In this study, cabin and chassis design and manufacturing were carried out by taking these reasons into consideration. Studies in the literature on cabin and chassis were examined [1,2,3], [4,5]. In general, it is seen that the steps and mudguards of forklifts are manufactured in two parts. In our work, as an innovation, the steps and fenders were manufactured as a single piece in order to increase the strength of the chassis and components and to improve maneuverability by shortening the length of the forklift. Cabin and chassis designs were also made accordingly. In order to better see the differences, advantages and disadvantages in chassis and cabin design, the cabins and chassis of equivalent diesel forklift models [6,7,8], [9,10] were examined. First of all, material selection was made according to the bending strength values obtained with Solidworks. Chemical analyzes [11] of these materials to be used in the manufacture of chassis, cabin and lift were carried out. In table 1 below, the chemical analyzes of the materials to be used in the manufacture of chassis, cabin and lift are given. Unlike equivalent forklifts, the holes opened in the cabin have been rearranged to increase the operator's field of vision. Unlike other equivalent forklifts, notches have been cut on the edges of the upper and lower fender for easy assembly and welding of the opened chassis openings. With the work done in this way, unique and technological gains were achieved during the production of our prototype model.

Table 1. Spectral analysis tests of materials used in forklift chassis, cabin and lift manufacturing.

Sample	% Fe	% C	% Mn	% Si	% P	% S	% Ni
Forklift Cabin Manufacturing Sheet	99,30	0,076	0,428	0,008	0,009	0,019	0,048
	% Cr	% Cu	% Mo	% V	% Ti	% Al	% Nb
	0,024	0,030	0,003	0,0009	0,00008	0,038	0,0002
	%W	% Sn	% Co	% Pb	%B	%Zn	%N
	0,0001	0,002	0,002	0,0001	0,000	0,002	0,0001
Sample	% Fe	% C	% Mn	% Si	% P	% S	% Ni
Forklift Cabin Manufacturing Profile	99,254	0,064	0,423	0,040	0,012	0,003	0,047
	% Cr	% Cu	% Mo	% V	% Ti	% Al	% Nb
	0,021	0,040	0,004	0,0009	0,0004	0,043	0,003
	%W	% Sn	% Co	% Pb	%B	%Zn	%N
	0,0001	0,002	0,006	0,0001	0,0001	0,0009	0,0001
Sample	% Fe	% C	% Mn	% Si	% P	% S	% Ni
Forklift Chassis Material	98,174	0,173	1,262	0,215	0,033	0,002	0,005
	% Cr	% Cu	% Mo	% V	% Ti	% Al	% Nb
	0,034	0,007	0,0009	0,004	0,015	0,022	0,032
	%W	% Sn	% Co	% Pb	%B	%Zn	%N
	0,0001	0,000	0,002	0,0001	0,0001	0,002	0,0001
Sample	% Fe	% C	% Mn	% Si	% P	% S	% Ni
Forklift Lift Material	98,172	0,294	0,762	0,315	0,020	0,005	0,063
	% Cr	% Cu	% Mo	% V	% Ti	% Al	% Nb
	0,076	0,142	0,018	0,062	0,001	0,021	0,0001
	%W	% Sn	% Co	% Pb	%B	%Zn	%N
	0,0001	0,010	0,006	0,0001	0,0005	0,012	0,0008

CHASSIS AND CABIN DESIGN AND STRENGTH TESTS

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Mounted on the chassis; significant changes were made to the design and manufacturing of the steps, fenders and driver's cabin.

The steps were made monolithic (Fig. 1),

The front and rear fenders were made monolithic (Fig. 2),

Easy assembly and welding, notches to the fender edges (Fig. 3),

By increasing the holes in the top sheet of the cab, operator visibility is increased (Fig.4),

Fuel (Fig. 5) and oil reservoir (Fig. 6) were excluded.

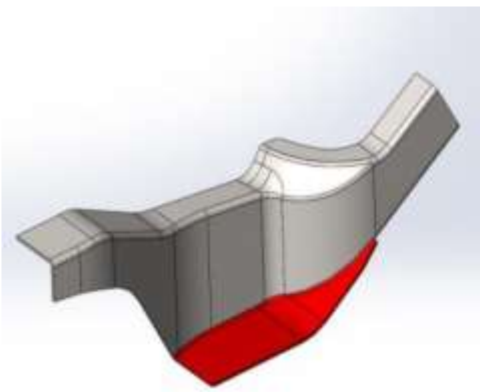

Figure 1. View of the steps as a whole

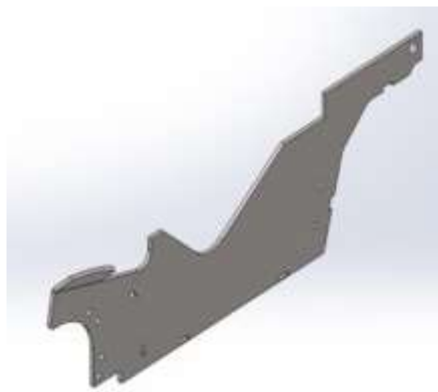

Figure2. Monolithic view of the front and rear fenders

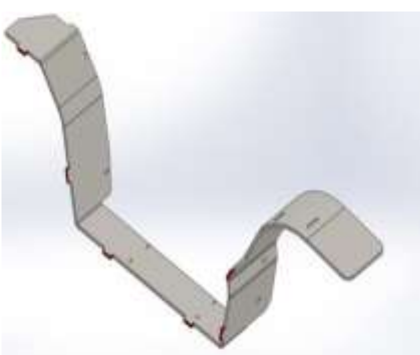

Figure. 3. View of the notches in the upper and

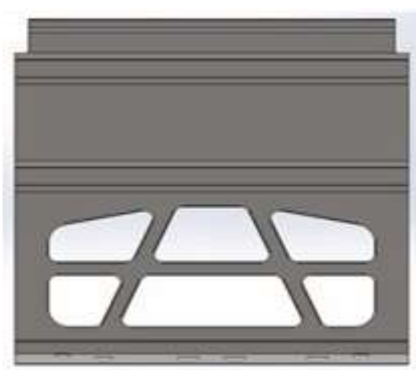

Figure 4. Cab top sheet

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Lower fenders.

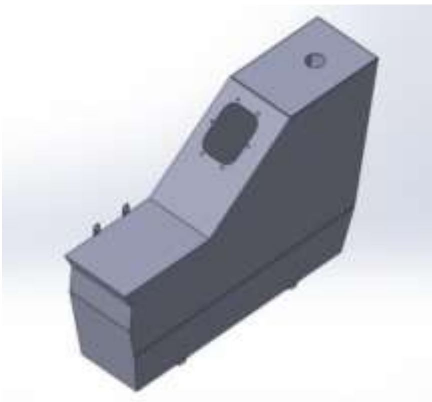

Figure 5. Fuel tank view

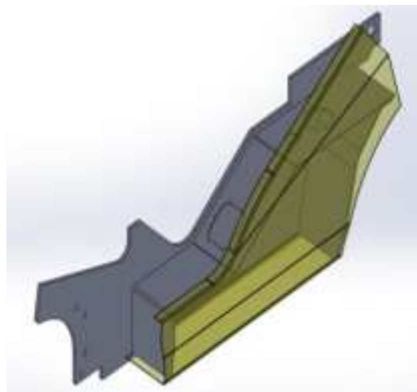

Figure 6. Oil Tank view

Cabin and Chassis Design and Manufacturing:

After the cabin and chassis assembly was completed, virtual strength tests such as tensile and bending were performed with Solidworks in accordance with the standards. In order to increase driver safety, cabin strength testing was carried out in accordance with standards [12]. According to this, Bending tests were performed on the forklift cabin from a height of 1.63 m, with a fall energy of 1360 kg.

$$E_{düş.} = m\ x\ g\ x\ h \qquad (1)$$

$$E_{düş}. = 1360x9.81x1.63 = 21747\ jül \approx 21750\ Nm \qquad (2)$$

$m\ (kg)\ldots$ *Load force applied to the cabinet*

$g\left(m/s^2\right)\ldots$ *Gravity acceleration*

$h\ (m)\ \ldots$ *Fall height on the cabin*

It was observed that the cabin sheet stretched by 1.5 mm with the load applied to the cabin. Since, according to the standard, a maximum stretch of 20 mm is accepted, it can be seen that the bending strength values inside the cabin are well above the standard limits. This shows that the safety of the driver's cabin is quite high. Below are the cabinet strength tests performed with Solidworks. In cabin and chassis manufacturing, it is necessary to know the tensile and bending forces acting on the cabin and chassis. These forces were calculated with the help of finite elements using solid work. In our model, cabin and chassis manufacturing; Chemical analyzes of the materials to be used were made taking into account virtual and real test results. Cabin test results made with

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Solidworks; Figure 7, Figure 8, Figure 9, Figure 10, Figure 11 and Table 2, Table 3, Table 4, Table 5, Table 6 are also given

Table 2.Study Properties

Study Properties

Study name	Static 1
Analysis type	Static
Mesh type	Solid Mesh
Thermal Effect:	On
Thermal option	Include temperature loads
Zero strain temperature	298 Kelvin
Include fluid pressure effects from SOLIDWORKS Flow Simulation	Off
Solver type	FFEPlus
Inplane Effect:	Off
Soft Spring:	Off
Inertial Relief:	Off
Incompatible bonding options	Automatic
Large displacement	Off
Compute free body forces	On
Friction	Off
Use Adaptive Method:	Off
Result folder	SOLIDWORKS document (C:\Users\tekno\Desktop\kabin)

……………….. Figure7 . model information

Table 3. Units

Units

Unit system:	SI (MKS)
Length/Displacement	mm
Temperature	Kelvin
Angular velocity	Rad/sec
Pressure/Stress	N/mm^2 (MPa)

Table 4.Material Properties

Material Properties

Model Reference	Properties	Components
[illegible]	[illegible]	[illegible]

Table 5. Mesh İnformation

Mesh information

Mesh type	Solid Mesh
Mesher Used:	Blended curvature-based mesh
Jacobian points	4 Points
Maximum element size	45.6564 mm
Minimum element size	0.563769 mm
Mesh Quality Plot	High
Remesh failed parts with incompatible mesh	Off

Mesh information - Details

Total Nodes	1372733
Total Elements	715371
Maximum Aspect Ratio	271.63
% of elements with Aspect Ratio < 3	78.3
% of elements with Aspect Ratio > 10	0.108
% of distorted elements(Jacobian)	0
Time to complete mesh(hh;mm;ss)	00:02:02
Computer name	

Figure 8. Mesh Quality Plots

Table 6. Resultant Forces

Resultant Forces

Reaction forces

Selection set	Units	Sum X	Sum Y	Sum Z	Resultant
Entire Model	N	-130.118	21349.2	0.0943326	21349.9

Reaction Moments

Selection set	Units	Sum X	Sum Y	Sum Z	Resultant
Entire Model	N.m	0	0	0	0

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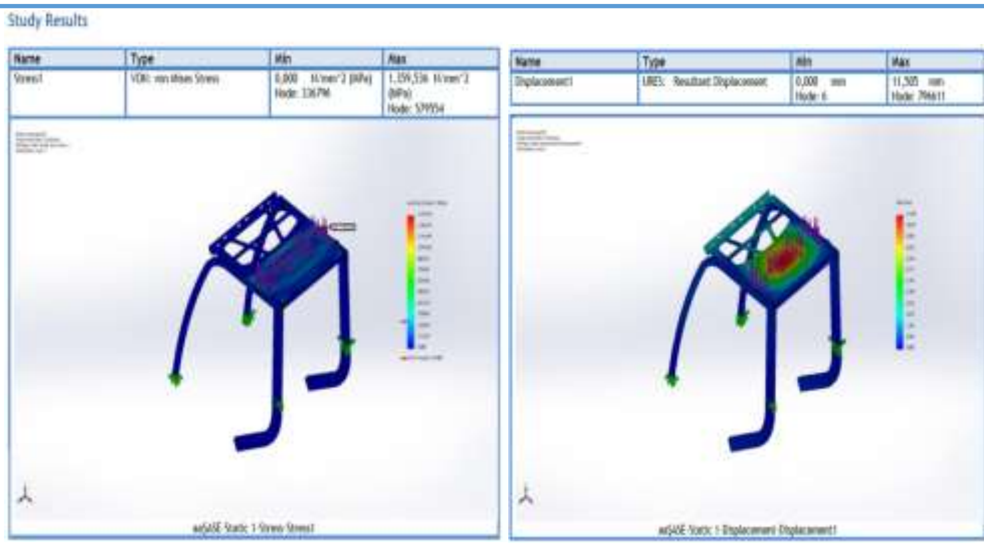

Figure 9. a) Cabin tensile force b) Cabin bending force

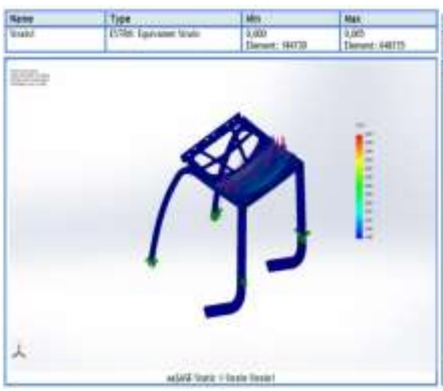

Figure 10. Equivalent Stress.

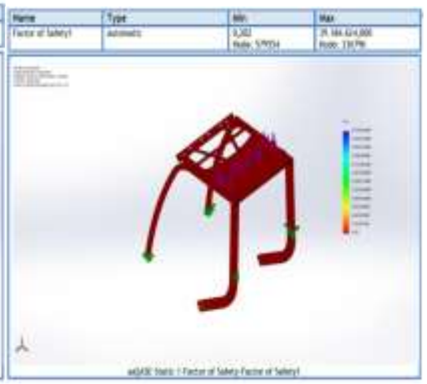

Figure 11. Safety Factors

Chassis Tests:

Now let's do the same tests for the chassis. Accordingly, the test results made with Solidwork;

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Figure 12, Figure 13, Figure 14.a, b, Figure 15, Figure 16 and Table 7, Table 8, Table 9, Table 10 is also given.

Figure 12. Model Information on Chassis

Figure 13. Load types and fixtures

Table 7. Chassis Study Properties

Study Properties

Study name	Static 1
Analysis type	Static
Mesh type	Solid Mesh
Thermal Effect:	On
Thermal option	Include temperature loads
Zero strain temperature	298 Kelvin
Include fluid pressure effects from SOLIDWORKS Flow Simulation	Off
Solver type	FFEPlus
Inplane Effect:	Off
Soft Spring:	Off
Inertial Relief:	Off
Incompatible bonding options	Automatic
Large displacement	Off
Compute free body forces	On
Friction	Off
Use Adaptive Method:	Off
Result folder	SOLIDWORKS document (C:\Users\tekno\Desktop\dtsel)

Table 8. Units

Units

Unit system:	SI (MKS)
Length/Displacement	mm
Temperature	Kelvin
Angular velocity	Rad/sec
Pressure/Stress	N/mm^2 (MPa)

Table 9. Chassis material properties.

Table 10. Reaction forces and moments

Loads and Fixtures

Fixture name	Fixture Image	Fixture Details
Fixed-1		Entities: 10 face(s) Type: Fixed Geometry

Resultant Forces

Components	X	Y	Z	Resultant
Reaction force(N)	-11803	12878.4	0.0565548	17469
Reaction Moment(N.m)	0	0	0	0

Load name	Load Image	Load Details
Force-1		Entities: 4 face(s) Type: Apply normal force Value: 2000 kgf

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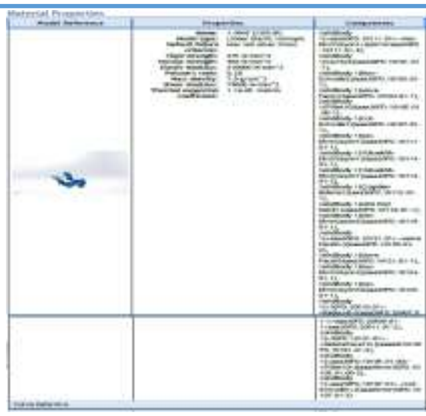


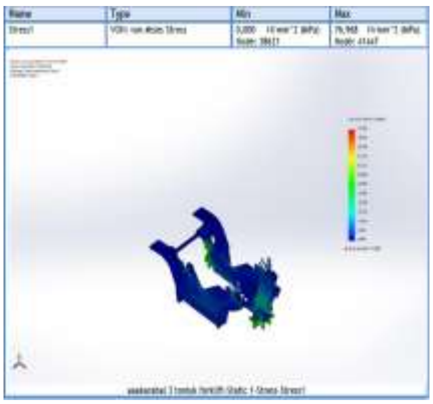
Resultant Forces

Reaction forces

Selection set	Units	Sum X	Sum Y	Sum Z	Resultant
Entire Model	N	-11803	12878.4	0.0565548	17469

Reaction Moments

Selection set	Units	Sum X	Sum Y	Sum Z	Resultant
Entire Model	N.m	0	0	0	0



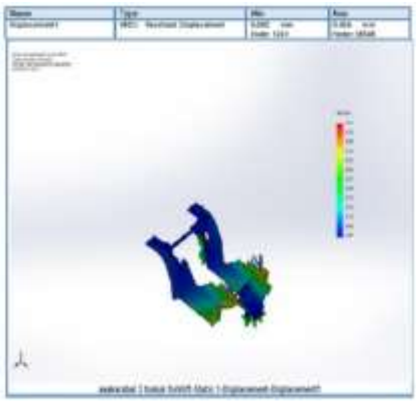
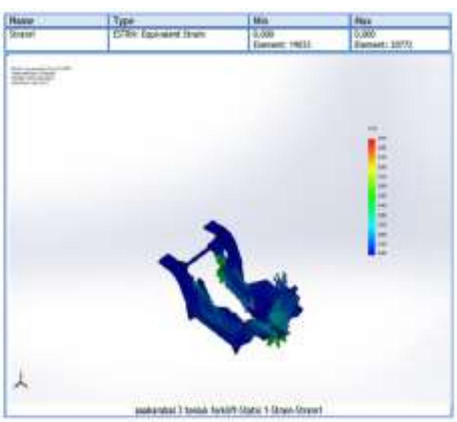


Figure 14.a) Tensile force b)Bending force



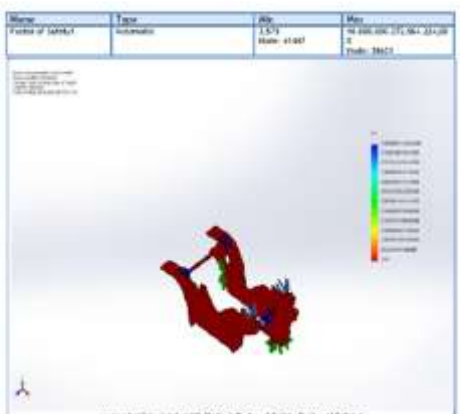


Figure 15. Chassis tensile test. Figure 16. Chassis safety factors

RESULTS

In this study, which focused on cabin and chassis design and manufacturing, many changes were made, unlike other forklift models. These changes are innovations in the design and manufacturing of chassis and components, and such a production technique has not been found in similar forklift models examined in the literature. In general, in equivalent diesel forklifts; Unlike our model, the steps and fenders are made in two parts. Fuel and oil tanks are placed inside the chassis. This requires frequent sealing tests on the chassis. By excluding fuel and oil tanks in our model, this disadvantageous situation has been eliminated. In addition, unlike similar models, the method of welding after combining the openings on the edges of the chassis with the notches opened on the upper and lower fenders can be considered as unique achievements. Since the chassis and its components gain additional strength values, it will be seen that our model has become more advantageous compared to similar forklift models in terms of chassis strength values. In addition, the work done on the cabin to increase driver visibility and safety is different from similar models. With all these changes and innovations made on the chassis components and cabin, our model has become more useful and compact..

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