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Design and Analysis of Go-Kart Chassis for Front, Side and Rear Impact

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ABSTRACT

This paper deals with Go-kart chassis building with the help of modelling software CATIA V15 and analysis of the same for front, side and rear impact. The cassis has been designed for light weight profile and engine mounting of capacity 135cc. The go-kart vehicle is meant for participation in various Go-kart event organized all over the India. The preliminary test for these events is checking of 3-D model of the chassis frame and analysis of the same chassis frame under front, side and rear impact. During collision the chassis is under impact loading conditions so it has to be thoroughly analyzed for impact loads. The studies found below shades some light on how the chassis behaves under impact loading conditions. Chassis is made up of a tubular cross section pipe, fabricated assembly of EN8 grade and a few other grades. In this kart, we have used EN8 class tube with 1 inch diameter and 1.5 mm wall thickness. The results obtained for permissible stresses, Factor of safety and deformation are found to be well within range. This makes the chassis suitable for Go-kart events. The main criteria that has been focused here is maximum deformation and stress. The stresses should be well within Von-mises stress range and so as the Factor of safety. After analysis, both are found to be well within range.

KEYWORDS: *3-D Modelling, analysis, stress, factor of safety, GO-kart, chassis*

1. INTRODUCTION

The Go-kart is a small, simple, self-propelled, lightweight vehicle for easy operation. Because of its low ground clearance, this type of vehicles are specifically designed and fabricated for racing events. The main parts involved are the chassis, axle, steering, engine, wheel, bumpers and tyres. Its engine could be either two-stroke or four stroke engine. Chassis bears all the weight of the vehicle therefore utmost attention has to be given to chassis design and fabrication. Thus, chassis should have high strength and stability. This project involves modeling and analysis of the go-kart chassis which is constructed with the tubular AISI4130 beams. Modelling is performed on CATIA V5 software and analysis on ANSYS 19 software. The chassis is designed to withstand optimum loads applied or the loads it is going to experience while moving.

1.1. CHASSIS

The chassis is the main component of go-kart vehicle as it has too bear all the weight of the vehicle. It is also subjected to various external impact loads. The loads can be applied dynamically when vehicle has collision with other bodies. Mostly the impacts occur on front, side and rear part of chassis. For vehicle moving with average 40km/h speed the impact forces are nearly 33000N. If the speed goes above the average the impact loads nears doubles. So, in this work the analysis is carried out for average speed and average Factor of safety to be obtained is set to 2. The material selected for the chassis tubes is AISI 4130. As this material has Cr and Mo its is readily weldable. The self-weight of chassis by providing this material to the CAD model is coming out to be 5.06kg. So, the material is also aiding for the lightness of the chassis. This makes the Go-kart agile.

1.2. Material properties of AISI 4130 (Table-1)

AISI 4130 alloy steel contains chromium and molybdenum as strengthening agents. It has low carbon content, and hence it can be welded easily in any condition hence highly suitable for Go-kart Chassis.

PROPERTIES	AISI 1018	AISI 4130
BRINELL HARDNESS	130 TO 140	200 TO 300
ELONGATION AT BREAK(%)	17 TO 27	18 TO 26
SHEAR STRENGTH (MPA)	280 TO 300	350 TO 640
TENSILE STRENGTH (MPA)	240 TO 400	440 TO 980
RESILIENCE (MJ/M3)	75 TO 100	120 TO 180
FATIGUE STRENGTH (MPA)	180 TO 270	320 TO 660
THERMAL EXPANSION (MICROMETER/MK)	12	13
STRENGTH TO WEIGHT (BENDING POINTS)	16 TO 17	19 TO 29
THERMAL SHOCK RESISTANCE POINTS	14 TO 15	16 TO 31
CARBON (%)	0.15 TO 0.2	0.28 TO 0.33
CHROMIUM (%)	0	0.8 TO 1.1

1.3. Table 2 Carbon Steel AISI4130 Chemical Composition

Standard	ASTM A29
Grade	4130
C	0.28-0.33
Mn	0.40-0.60
P	0.035
S	0.040
Si	0.15-0.35
Cr	0.80-1.10
Mo	0.15-0.25

1.4. Chassis Dimensions (Table-2)

Parameters	Values
Mass of vehicle (with driver)	130kg
Radius of tyre	5.5 inches
Vehicle Length	78 Inch
Vehicle wheel base	48 inch
Vehicle width	40 inch
Tube dimension	1 inch
Pipe thickness	1.5 mm

1.5. Engine and transmission (Table-3)

Go-kart has usually small engine. So, to increase power to weight ratio the vehicle weight has to be as minimum as possible. The engine specifications for various Go-kart events is always specified. In this kart, we use a Bajaj Discover 134.6cc, 4-valve, 4-stroke single cylinder petrol engine, air cooled, which produces about 12.8 BHP of power at 9000rpm, maximum torque is 11 N-m @7000rpm. The power from the engine is transmitted to the rear two wheels using chain drive. Between these two, transmission system is incorporated. This plus weight of driver is the total weight on the chassis.

Engine specification:

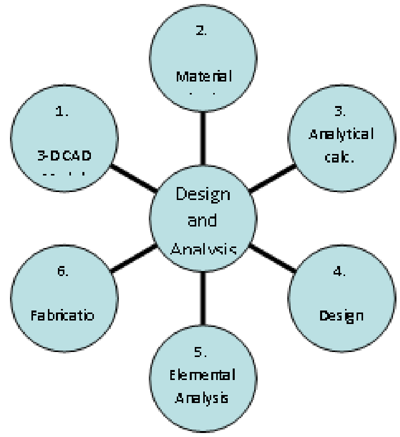
Displacement	134.6cc
No. of cylinders	1
No. of Gears	5
Max Power	12.8Bhp at 9000rpm
Max Torque	11Nm at 7000rpm
Cooling	Air cooling
Bore	54mm
Stroke	58.8mm
Engine valves	4 VALVES, 4 STROKE

2. DESIGN METHODOLOGY

Design methodology involves various steps to be taken in right sequence to generate a fully functional design. Here, for prototype building CAD softwares are used. Material selection is done and applied to the CAD model. Analytical calculation are done are checked weith analysis results of ANSYS. Changes were made to make a final design. This design is then fabricated.

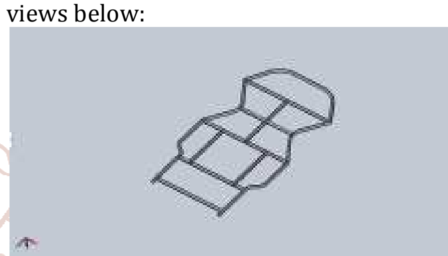
2.1. Methodology

The following design and analysis methodology has been followed to reach to the conclusion that the Go-kart is safe to develop and drive. The detailed work flow is depicted in pictorial representation below:

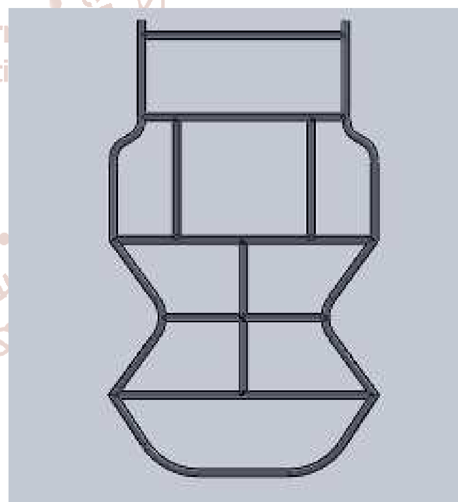


2.2. CHASSIS DESIGN

The chassis has been modelled using CATIA V5 by using tubular cross section beams. The models are as shown in various views below:



Isometric View



Top View

Right Side View

2.3. Finite Element Analysis

The CAD Model of the chassis is then Analyzed in ANSYS software for front, side and rear impact. Vehicle speed is taken as 40km/h. So, corresponding impact force on static body of chassis is calculated with the help of impulse-momentum principle of collision of bodies. The chassis is considered to be in dynamic equilibrium condition. Meshing and refinement is reiterated to get best optimum results.

Chassis specification in ANSYS 19 is as follows:

Model (B4) > Geometry > Parts

Object Name	chassis
State	Meshed
Graphics Properties	
Visible	Yes
Transparency	1
Definition	
Suppressed	No
Stiffness Behavior	Flexible
Coordinate System	Default Coordinate System
Reference Temperature	By Environment
Behavior	None
Material	
Assignment	Structural Steel
Nonlinear Effects	Yes
Thermal Strain Effects	Yes
Bounding Box	
Length X	843.7 mm
Length Y	1417.6 mm
Length Z	25.4 mm
Properties	
Volume	6.4461e+005 mm³
Mass	5.0602 kg

The analysis meshing and results obtained are as follows:

2.3.1. Front Impact

For front impact meshing is done by taking mesh quality into consideration. Details of meshing is as follows:

Model (A4) > Mesh

Object Name	Mesh
State	Solved
Display	
Display Style	Body Color
Defaults	
Physics Preference	Mechanical
Relevance	0
Element Order	Program Controlled
Sizing	
Size Function	Adaptive
Relevance Center	Coarse
Element Size	Default
Mesh Defeaturing	Yes
Defeature Size	Default
Transition	Fast
Initial Size Seed	Assembly
Span Angle Center	Coarse
Bounding Box Diagonal	1649.90 mm
Average Surface Area	4609.0 mm²
Minimum Edge Length	0.11560 mm
Quality	
Check Mesh Quality	Yes, Errors
Error Limits	Standard Mechanical
Target Quality	Default (0.050000)
Smoothing	Medium
Mesh Metric	None
Inflation	
Use Automatic Inflation	None
Inflation Option	Smooth Transition
Transition Ratio	0.272
Maximum Layers	5
Growth Rate	1.2
Inflation Algorithm	Pre
View Advanced Options	No
Advanced	
Number of CPUs for Parallel Part Meshing	Program Controlled
Straight Sided Elements	No
Number of Retries	Default (4)
Rigid Body Behavior	Dimensionally Reduced
Triangle Surface Mesher	Program Controlled
Topology Checking	Yes
Pinch Tolerance	Please Define
Generate Pinch on Refresh	No
Statistics	
Nodes	235886
Elements	117460

Impact loading is taken as follows:

Model (A4) > Static Structural (A5) > Loads

Object Name	Force	Fixed Support
State	Fully Defined	
Scope		
Scoping Method	Geometry Selection	
Geometry	2 Faces	
Definition		
Type	Force	Fixed Support
Define By	Vector	
Magnitude	33000 N (ramped)	
Direction	Defined	
Suppressed	No	

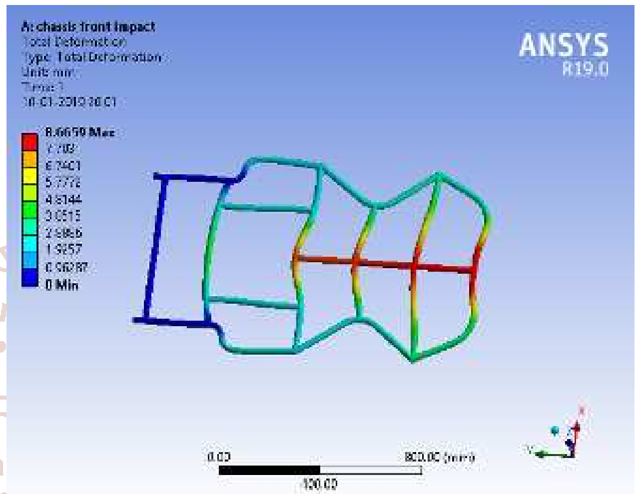


Figure Front Impact (Total Deformation)

The average deformation values are well within the acceptable range.

Time(s)	Min.(mm)	Avg (mm)
1.	0	3.5877

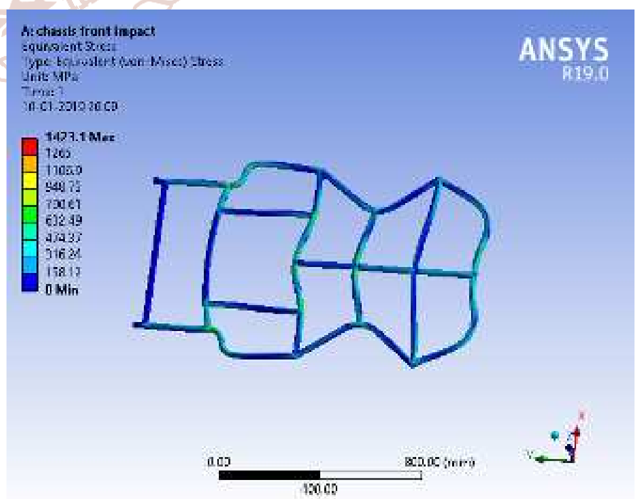


Figure Front Impact (Von-Mises Stress)

The average stress values are well within the acceptable range.

Time(s)	Min.(MPa)	Avg (MPa)
1.	0	223.93

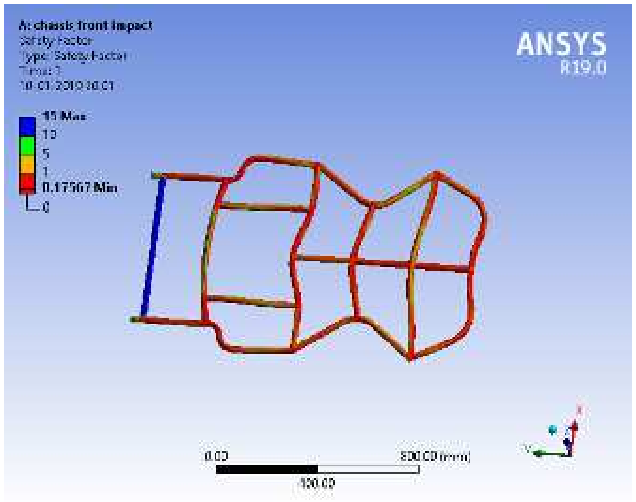


Figure Front Impact (factor of safety)

The average FOS values are well within the acceptable range.

Time(s)	Min.	Avg
1.	0.17567	2.5828

2.3.2. Side Impact

For side impact meshing is done by taking mesh quality into consideration. Details of meshing is as follows:

Model (C4) > Mesh

Object Name	*Mesh*
State	Solved
Display	
Display Style	Body Color
Defaults	
Physics Preference	Mechanical
Relevance	100
Element Order	Program Controlled
Sizing	
Size Function	Adaptive
Relevance Center	Coarse
Element Size	Default
Mesh Defeaturing	Yes
Defeature Size	Default
Transition	Fast
Initial Size Seed	Assembly
Span Angle Center	Coarse
Bounding Box Diagonal	1649.90 mm
Average Surface Area	4609.0 mm²
Minimum Edge Length	0.11560 mm
Quality	
Check Mesh Quality	Yes, Errors
Error Limits	Standard Mechanical
Target Quality	Default (0.050000)
Smoothing	Medium
Mesh Metric	None
Inflation	
Use Automatic Inflation	None
Inflation Option	Smooth Transition
Transition Ratio	0.272
Maximum Layers	5
Growth Rate	1.2
Inflation Algorithm	Pre
View Advanced Options	No
Advanced	
Number of CPUs for Parallel Part Meshing	Program Controlled
Straight Sided Elements	No
Number of Retries	Default (4)
Rigid Body Behavior	Dimensionally Reduced
Triangle Surface Mesher	Program Controlled
Topology Checking	Yes
Pinch Tolerance	Please Define
Generate Pinch on Refresh	No
Statistics	
Nodes	192044
Elements	96037

Impact loading is taken as follows:

Model (C4) > Static Structural (C5) > Loads

Object Name	*Fixed Support*	*Force*
State	Fully Defined	
Scope		
Scoping Method	Geometry Selection	
Geometry	15 Faces	14 Faces
Definition		
Type	Fixed Support	Force
Suppressed	No	
Define By		Vector
Magnitude		33000 N (ramped)
Direction		Defined

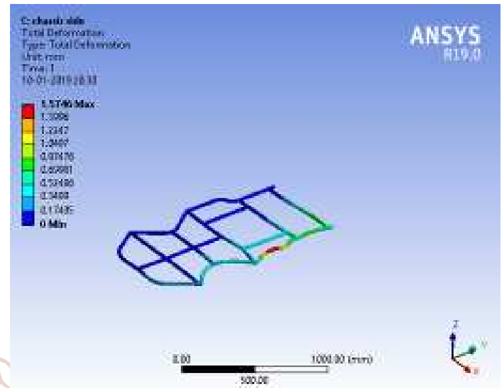


Figure Side Impact (Total Deformation)

The average deformation values are well within the acceptable range.

Time(s)	Min.(mm)	Avg (mm)
1.	0	0.24106

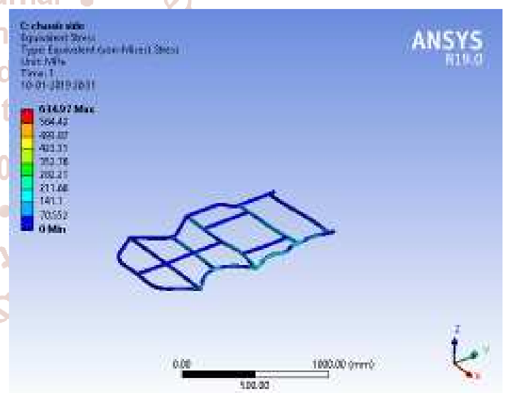


Figure Side Impact (Von-Mises Stress)

The average stress values are well within the acceptable range.

Time(s)	Min.(MPa)	Avg (MPa)
1.	0	50.108

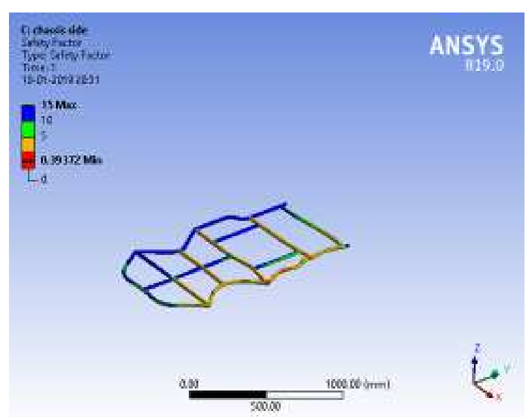


Figure Side Impact (Factor of Safety)

The average FOS values are well within the acceptable range.

Time(s)	Min.	Avg
1.	0.39372	8.4879

2.3.3. Rear Impact

For rear impact meshing is done by taking mesh quality into consideration. Details of meshing is as follows:

Model (B4) > Mesh

Object Name	*Mesh*
State	Solved
Display	
Display Style	Body Color
Defaults	
Physics Preference	Mechanical
Relevance	0
Element Order	Program Controlled
Sizing	
Size Function	Adaptive
Relevance Center	Coarse
Element Size	Default
Mesh Defeaturing	Yes
Defeature Size	Default
Transition	Fast
Initial Size Seed	Assembly
Span Angle Center	Coarse
Bounding Box Diagonal	1649.90 mm
Average Surface Area	4609.0 mm²
Minimum Edge Length	0.11560 mm
Quality	
Check Mesh Quality	Yes, Errors
Error Limits	Standard Mechanical
Target Quality	Default (0.050000)
Smoothing	Medium
Mesh Metric	None
Inflation	
Use Automatic Inflation	None
Inflation Option	Smooth Transition
Transition Ratio	0.272
Maximum Layers	5
Growth Rate	1.2
Inflation Algorithm	Pre
View Advanced Options	No
Advanced	
Number of CPUs for Parallel Part Meshing	Program Controlled
Straight Sided Elements	No
Number of Retries	Default (4)
Rigid Body Behavior	Dimensionally Reduced
Triangle Surface Mesher	Program Controlled
Topology Checking	Yes
Pinch Tolerance	Please Define
Generate Pinch on Refresh	No
Statistics	
Nodes	235886
Elements	117460

Impact loading is taken as follows:

Model (B4) > Static Structural (B5) > Loads

Object Name	*Force*	*Fixed Support*
State	Fully Defined	
Scope		
Scoping Method	Geometry Selection	
Geometry	2 Faces	6 Faces
Definition		
Type	Force	Fixed Support
Define By	Vector	
Magnitude	33000 N (ramped)	
Direction	Defined	
Suppressed	No	

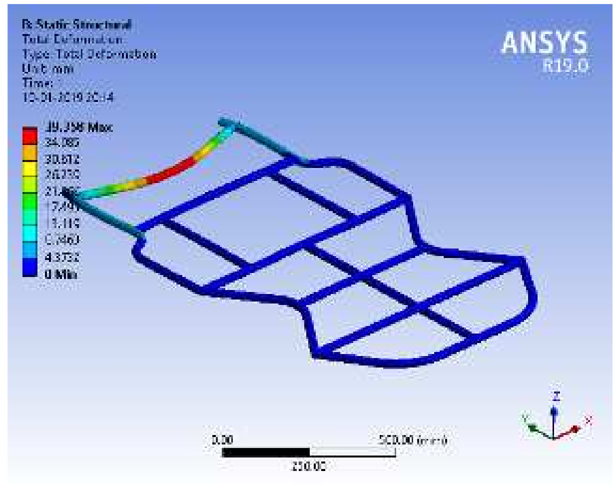


Figure Rear Impact (Total Deformation)

The average deformation values are well within the acceptable range.

Time(s)	Min.(mm)	Avg (mm)
1.	0	3.3643

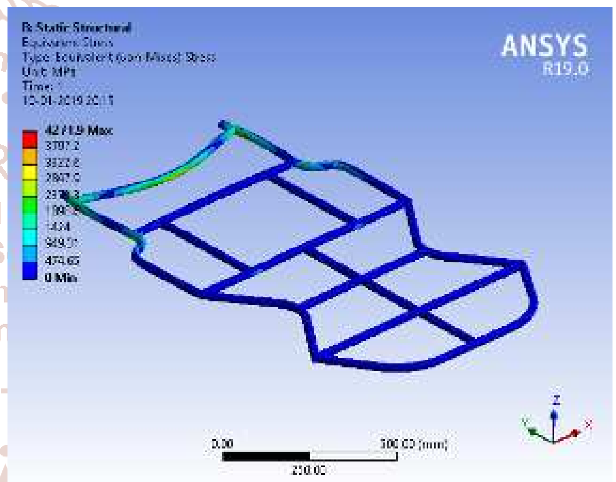


Figure Rear Impact (Von-Mises Stress)

The average stress values are well within the acceptable range.

Time(s)	Min.(MPa)	Avg (MPa)
1.	0	281.97

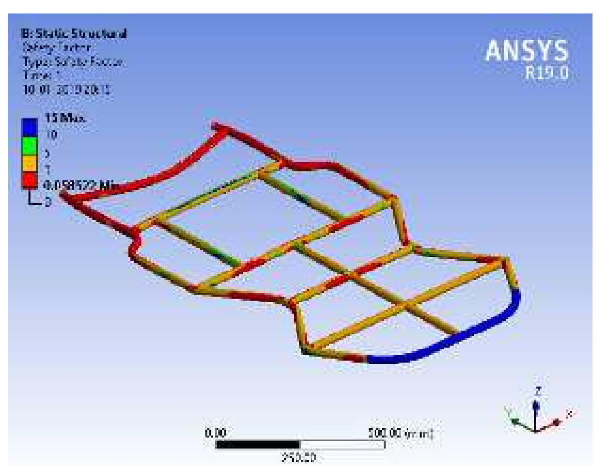


Figure Rear Impact (Factor of Safety)

The average FOS values are well within the acceptable range.

Time(s)	Min.	Avg
1.	5.85e.002	2.8886

Fabrication

The results are optimized stress reduction is done by avoiding stress concentration at sharp edges. The chassis is fabricated and then the Go-kart vehicle is tested on track.

Figure Go-kart Chassis and final vehicle

Conclusions

The basic need of Go-kart vehicle is high power to weight ratio and less clearance. Keeping fabrication in the mind, we tried to make the design optimum and simple with high strength and stability. Thus analysis is done for strength against collisions from the front, rear as well as side. From the above observations we can conclude that AISI 4130 is one of the material that could be very well used for fabrication of go-kart chassis as it gives better performance and good weldablity in any condition. Static analysis is performed in ANSYS software using FEA tools on the chassis CAD model. Maximum equivalent stress(Von Mises), total deformation or displacement and factor of safety are found out from it. The factor of safety obtained in each analysis is found to be greater than 1. Factor of safety is regarded the safe limit and can be used as a criteria to make a Go- kart. Hence we can conclude that the chassis design is safe and stable. The design and analysis of the chassis for Go-Kart helps to find the strength and weakness of the design and corresponding corrections to be made for fabrication. Virtual Analysis serves a good tool for finding out the weak points in the design and any modifications or rectifications that can be done to the design before fabricating it.

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