DESIGN, ANALYSIS AND FABRICATION OF ZINC CHASSIS/FRAME

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ABSTRACT: The overall objective of the project is to design and fabricate a chassis frame for solar-E-passenger vehicle. FRAME/CHASSIS is an important part of an automobile. The chassis serves as a frame work for supporting the body and different parts of the solar-E-passenger vehicle. Also, it should be rigid enough to withstand the shock, twist, vibration and other stresses. Along with strength, an important consideration in chassis design is to have adequate bending stiffness for better handling characteristics. So, maximum stress, maximum equilateral stress and deflection are important criteria for the design of the chassis. This report is the work performed towards the optimization of the solar-E-passenger vehicle chassis with constraints of maximum shear stress, equivalent stress and deflection of chassis under maximum load. Structural systems like the chassis can be easily analyzed using the finite element techniques. A sensitivity analysis is carried out for weight reduction. So a proper finite element model of the chassis is to be developed. The chassis is modeled in PRO-E. FEA is done on the modeled chassis using the ANSYS Workbench18.0, Solid Works, a computer aided design (CAD),and software was used for design and modeling ,as well as finite element analysis(FEA).

Keywords: AUTOCAD, CREO, ANSYS, SOLD WORKS, ZINCCHASSIS, Design, Engineering, Electric Vehicle, FEA, Solar, Solar Energy,

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1. FUNCTIONS OF FRAME

- To solar passenger vehicle the weight of the vehicle and its passengers
- To withstand the engine and transmission torque
- To withstand the centrifugal force while cornering.
- To withstand the bending stresses and twisting due to the rise and fall of the front and rear axles.
- It also maintains constant distance between all the parts of the vehicle body and components.

1.1 MECHANICAL HEAT TREATMENT PROCESS

Heat treatment involves the use of heating or chilling, normally to extreme temperatures, to achieve the desired result such as hardening or softening of a material. Heat treatment techniques include

1.1.1 Annealing
1.1.2 Case hardening
1.1.3 Tempering
1.1.4 Solar passenger vehicle bruising
1.1.5 Normalizing and
1.1.6 Quenching.

At the time of manufacturing, the body of a vehicle is flexibly molded according to the structure of chassis. It provides strength needed for supporting vehicular components and payload placed upon it. Chassis is usually made of zinc alloy. Because of their low specific gravities, the strength to weight ratio of these alloy materials are markedly superior to those of metallic materials. High damping capacity of composite materials can be beneficial in many automotive applications in which noise, vibration, and hardness is a critical issue for passenger comfort. In the present work, design and analysis with different cross sections for different materials like steel, zinc alloy and aluminum. The model of zinc alloy chassis was created in AUTOCAD and analyzed with ANSYS software.

After analysis a comparison is made between iron chassis and zinc alloy chassis and in terms of deflections and stresses, to select the b Literature Survey Considering C, I and Box type cross sections, is analyzed by employing a polymeric composite heavy vehicle chassis for the same load solar passenger vehiclerying capacity, with a reduction in weight of 70 to80 .The numerical results are validated with analytical calculation considering the stress ribution License, which permits unrestricted use, Many composite materials offer a combination of strength and comparable to or better than any traditional metallic metals. Because of their low specific gravities, the strength to weight-ratio and modulus to weight ratio of these composite materials are markedly superior to The fatigue strength weight ratio as well as fatigue damage tolerances of many composite laminates are excellent.

2. OBJECTIVES

The long-term objective of this project is to design, fabricate and assemble a fully functioning vehicle powered by solar energy.The goal our team is to develop a complete set of plans, design solar-E-passenger vechicle concept, and to purchase critical components within our budgetary constraints. This will consist of the following:

1. Frame
- Frame design,
- Analysis, and
- Fabrication

2.1 CONSTRAINTS

With the goal of designing an efficient FRAME, matters such as safety, connections for equipment, size limits, visibility are all considered. If these constraints are not met, the vehicle will not be permitted to transportation of passengers in the future.

Spatial constraints were of primary concern during the design phase. Since material was purchased by our teams, frame design and fabrication were started before the complete model was finished; therefore, when designing the various systems of the vehicle, the designer would need to check the frame model to assure that interference with the frame was not occurring. This added one more factor to consider during the design process.

Budgetary constraints were a major problem for the team. Since the team acquired RS16,000 in grants, the team was able to purchase key components such as, frame material The team used the budget below to allocate funds;

1.Frame Material – zinc alloy
Rectangular bar -80x40x1.8mm
Square 25.4x25.4x1.8mm
2.Mounting Materials – Iron Alloy (1500 Rs)

3. METHODOLOGY

Any design project will require the use of many different types of software (AUTO CAD, CREO, and ANSYS) and research to achieve the objectives. Solid Works will be used for the modeling, drafting, and assembling of all the components. Research on electrical components for performance and purchasing will use journals and web sites. Engineering Equation Solver (EES) and Microsoft Excel was used to perform a parametric analysis to determine the appropriate size of the motor and other various safety factor analysis.

Frame/Chassis

The chassis is defined as the basic structure of any vehicle. It is the central piece to which all other components are attached. Apart from structural integrity, this elementary part of the vehicle will protect the driver in case of an accident; it plays a big role in the solar passenger vehicle's safety. As the solar passenger vehicle is aimed to participate in an efficiency competition, it was necessary to design a chassis as light as possible, while maintaining a high standard of safety.

The first step in designing the chassis was to comprehend all the competition rules about the chassis. The rules concerning the chassis are basic, which provide a certain freedom in design. However, more constraints were added along the manufacturing process, which was conducted by a local welding company. For example, the company requested that a small gap be left between each connecting member to have some space for the welding procedures. Therefore, once all the constraints were known, it was necessary to determine the type of our chassis. We decided to have a space frame chassis. This type of chassis is constructed from an arrangement of small simple members which derive a larger frame.

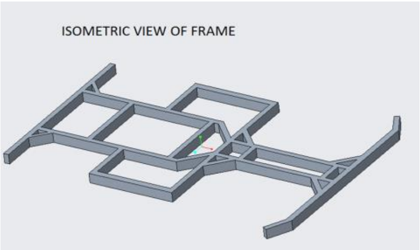

Figure 3.1.1 Isometric view of frame

A Isometric view of frame chassis is very much like a bar structure, which is a combination of small members in a triangular arrangement that is in either tension or compression. This of course is in an ideal situation. This characteristic assures the members have zero minimal bending moments, allowing the frame to be designed with small sized cross-section members. This would result in a lighter frame that would increase the solar passenger vehicle's efficiency. Newton's Second Law states that

Force = Mass x Acceleration

F= m x a

Given an equal force, a lighter solar-E-passenger vechicle will accelerate quicker at all conditions. With a quicker acceleration, the solar-E-passenger vechicle will reach a higher speed faster and help meet the performance demanded by the Shell Eco-marathon.

Also, the chasis is cheaper in comparison to other types of chassis, and easy to build and modify. With this type of frame in mind, it was time to decide on what material to use. Since the previous team made a purchase of Aluminum 6061 as raw material, the decision to utilize this material was made. Aluminum 6061 was a favorable choice, providing a light frame stiff enough to support multiple driving loads.

Designing an automotive chassis depends primarily on the comprehension of different types of loads that act on it. While in use, automotive chassis endure several loads that can be defined globally (overall deformation of the chassis) as listed below

1. Longitudinal Torsion
2. Vertical Bending
3. Lateral Bending

Multiple types of loads acting on a solar passenger vehicle will directly influence the vehicle's behavior; therefore, if the vehicle is not rigid enough, it will have resulting effects on direction control, as well as in the passenger's protection and comfort. Lack of rigidity will make the vehicle less sensitive to the driver's actions. In other words, it will be hard to determine the vehicle comportment with the road. However, the absence of enough rigidity is not always a problem and the frame must act like a suspension system Accordingly, it is essential to know chassis' rigidity, specifically torsional rigidity. When a vehicle has a satisfactory torsional rigidity, which is the resistance to longitudinal torsion loads, it also has a satisfactory resistance to remaining global loads. Therefore, the analysis of torsional rigidity is a determinant for an optimal chassis.

With the intention of advancing quickly in through the design and using the material already purchased by the previous senior design team, the modeling process of the spaceframe wascompleted mainly through trial and error. Team members decided based on several designs, whichwere examined considering a variety of factors. To ensure the final design was optimal, finite element analysis (FEA) was performed to study the torsional rigidity of the solar passenger vehicle. The software used for this analysis was the Solid Works finite element package.

The theoretical model to study longitudinal torsion consists of a square tube in which one extremity is fixed and the other is applied a torque with relation to the longitudinal axis.

In this model, the tube represents the chassis and its extremities, the rear and front suspension. This model can be applied to the solar passenger vehicle chassis using CREO (Fig. 3.1.3).

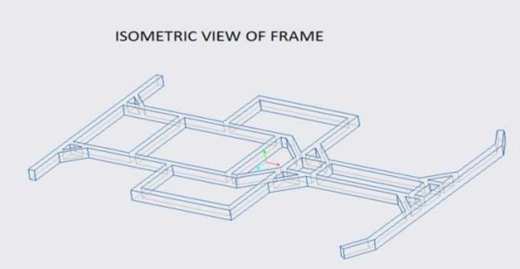

Figure 3.1.3wire frame of chassis

Torsional rigidity can be evaluated by dividing the torque applied on the chassis by the angular deflection. The mathematical representation is as follows:

Where,

1. Kt - Torsional rigidity
2. T - Applied torque
3. θ - Angular deflection

$$Kt = \frac{T}{\theta}$$

The finite element method simulation was performed in accordance to the following guidelines:

4.The model was constrained by applying a geometry fixture on the rear suspension

5.A 1000N force was applied in the opposite direction along the vertical plane in each node of the front suspension. This creates a twist about the frame.

Torsional rigidity of the frame was just one of the factors to be considered in designing the frame. One of the rules of the Shell Eco-marathon is that the solar passenger vehicle must withstand a force of 700N applied in all three directions at the roll bar. This can be illustrated with the roll bar considered as a beam with both ends fixed and a vertical force being applied (Fig. 3.4).

The roll bar analysis was performed using the same software used for torsional rigidity. The FEA static simulation was performed in accordance with the following guidelines:

1.both the rear and front suspension were fully fixed

2.A 1000N force was applied to the roll bar in all three directions (one in each simulation)

4. DESIGN OF ZINC CHASSIS

4.1Design of Chassis In Autocad

Today, developing new cars mostly takes place in a virtual environment. Many of today's and tomorrow's vehicles are being designed with Siemens NX CAD, which helps to turn automotive dreams into successful products. Automotive designers still start with a clay model to capture the emotions, but then automotive engineers use NX to turn these emotions into real products. The Digital Enterprise solution portfolio also helps to create the digital twin of the product which then enables realistic simulations to optimize the car before it's being built.

Computer-aided design and computer-aided manufacturing software (CAD/CAM) is used in mechanical, electrical, and electronic design; simulation, drafting, and engineering; and design analysis and manufacturing.

AutoCAD can be applied in automobile engineering to design upholstery, engine, and wheels of an automobile. AutoCAD is used to designing and developing automobiles including bikes and scooters.

Drafting materials were created using Solid Works. To create the needed models, planar sections were removed from the overall frame model. This would effectively decrease the amount of time for frame fabrication. Creating the entire frame in this manner allowed for the frame construction to match as similar as possible to the modeled frame. Since this process may lead to slight variations in the final welding when the sections are oriented in 3D space, once the frame is completely built, the frame model may need to be modified slightly.

Using the assembly files,). Since the weld shop does not have 3D modeling software, there was great importance on making the drawings concise and clear. The table setup drawings include information such as dimensions, part numbers, and notes. There was a total of four table setups. The first three setups were all planar sections created against the table, and the fourth setup was combining all the created sections with the addition of the cross members.

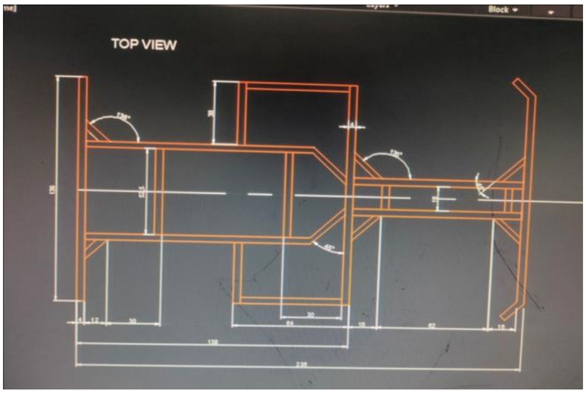

Figure :4.2 Top View of Frame In Auto-cad

5. FABRICATION OF FRAME

Not only was the team responsible for the design of the frame, but also for the manufacturing of the frame. The team worked in conjunction with Arrow Pin and Product Inc. in Chicago Heights, Illinois. Through this process, the team gained experiential learning through manual labor and drafting opportunities.

Raw material, 80x40x1.8mm zinc rectangular hollow bar, was cut to specifications using the individual member drawings and BOM. Members were then located on the table and TIG welded together. Before welding, the surface of the locations to be welded was scrubbed to clean and

remove oxidation. This process involved welding the joints, allowing the joints to cool, and inspecting the section to verify straightness. The welding process followed the four table setup drawings. Once sections were finished, they were stored until needed in the fourth table setup drawings. Sections were welded together

The first step in the table preparation was the removal of rust and top level to create a flat surface. After creating the reference and center lines, the team used the table setup drawings to etch the member locations into the welding platform. Once the member locations are etched into the table, stops were tacked on the table to properly seat the members in their respective locations.

From the generation of the BOM, it was determined that no additional raw material was needed. This was determined by summing the lengths of all the members and assuming that 20% of the material will be scrapped. Errors were expected due to student participation on the layout and preparation processes. Additionally, the welders are not cutting all material at once.

Unfortunately, this will not result in the most efficient use of material, but due to spatial constraints on cite, this is required process.

Figure:5.2 Top View Of Zinc Chassis

A mounting plate is the part of a hinge, handle or latch that mounts the hardware to a cabinet. Mounting plates make it easier to attach doors to frames. A mounting plate is the portion of a hinge that attaches to the wood. Mounting plates can be used in doors, cabinetry and furniture.

It is simply used to mount equipment inside an enclosure.

6. RESULTS

Results were derived using a conservative manner. This section includes FEA, purchasing information, and parametric analysis. To determine the following analysis by using Ansys work bench software.

1.Load or force analysis

2.Mesh analysis

3.Maximum principle stress analysis

4.Directional deformation analysis
5.Elastic strain analysis

MECHANICAL PROPERTIES OF ZINC CHASSIS MATERIAL:

Frame

As a starting point, it was important that the chassis had low center gravity and weight, fits general suspension system, and meets the competition requirements. Several designs of the frame were made, until a final design was selected. Analyzing the results for tension the maximum stress can be determined. Tension of 5MPa obtained does not exceed the yield strength of 56MPa for zinc alloy

Mechanical Properties	Parameters value	Unit
Density	6600	Kg/m3
Yield Strength	56	MPa
Ultimate tensile strength	330	MPa
Poisson Ratio	0.29	
Elastic Modulus	$107x10^6$	psi
Shear Modulus	$90x10^6$	psi
Thermal Conductivity	113	w/mk

6.1 FORCE ANALYSIS IN ANSYS :

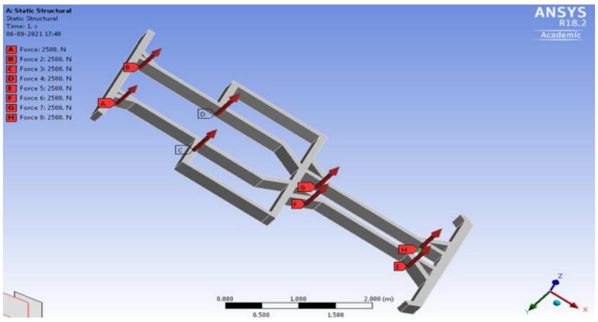

Figure6.1 Force Analysis In Ansys

Fig.6.1.1 shows the force reaction plots for existing double type chassis and modified single type chassis respectively under 2G vertical loading. The simulated values of force reaction at the CG for existing chassis are -1.824x10-2 N, 6.635x10-3 N, 5.224x10-3 N along X-axis, Y-axis, Z-axis respectively. The computed values of reaction forces at the CG for modified chassis are 4.618x10-5 N, 2.407x10-3 N, 1.778 x10-5 N along X-axis, Y-axis, Z-axis respectively. Table 3 shows computed. From that, it is concluded that the frame only suffers elastic deformation.

6.2MESH ANALYSIS

The meshing of double and single type chassis is done in ANSYS workbench tool using global mesh control strategy. The domain of all bodies is divided into small discrete cells for solving the mathematical equations at nodal/cells position. Fig. 3 shows the meshed 3D models of existing and modified chassis of the solar-E-passenger vehicle. Existing double type chassis is discretised into 121,145 nodes, 63,446 elements while modified single type chassis has 110,442 nodes and 53,577 elements respectively.

6.2.1 ANALYSIS OF THE UNCONSTRAINED STRUCTURE

The existing and modified 3D solid models of solar-E-passenger vehicle chassis prepared in Weldment's module of SolidWorks tool is imported into the ANSYS Workbench module.

The existing double type chassis consists of 1 part, 61 bodies and modified single type chassis consist of 1 part, 53 bodies respectively. Meshing and loading conditions for the structure are described in the following sub-sections.

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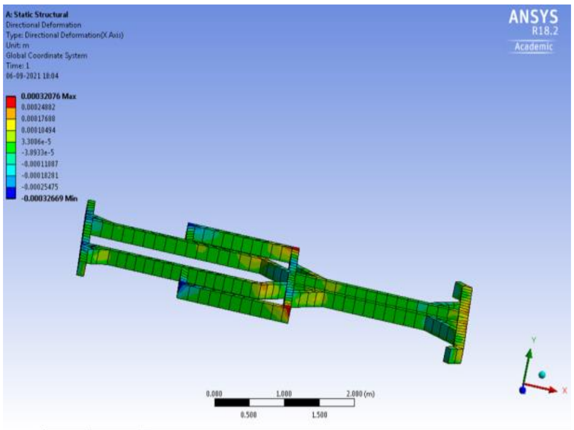


Figure 6.2 Mesh Analaysis of Frame/Chassis on Ansys

6.3 MAXIMUM PRINCIPLE STRESS ANALYSIS

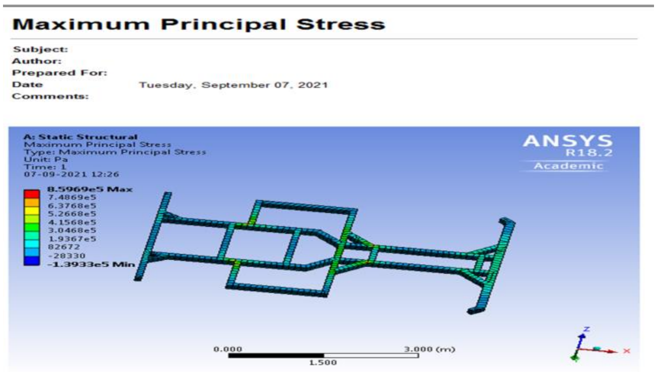
Fig. 4 shows the Maximum Principle Stress result in plots for existing double type chassis and modified single type chassis respectively under 2G vertical loading. The maximum equivalent stresses are 147.25 and 133.4 MPa, with a safety factor of 1.6978 and 1.8741 for existing and modified chassis respectively.

Maximum Principal stress theory just one of the failure theory from all, used for brittle materials.

However, if u change the material from brittle to ductile, than it need to look toward vonmises stresses criteria instead of Maximum Principal stress criteria (or we can say Maximum Principal stress theory), in your CAE software (Ansys, Abaqus, HyperWorks etc.). Because Maximum Principal stress criteria will not hold a good agreement between Experiment & Analytical results for Ductile materials.

In this case for brittle material, failure will occurs when Maximum Principal stress for complex loading in the object at any point will reaches equal or more than the Maximum Principal stress of simple tension test.

The Maximum Principal Stress results provided by ANSYS corresponds with the principal stress, σ1, you calculate when determining a stress transformation of a state of stress at a specific point. ... This will provide more accurate results, although it will take a little longer to obtain the results.



Maximum Principal Stress

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Maximum Principal Stress
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Figure6.3Maximum Principle Stress Analysis

6.4 TOTAL DEFORMATION ANALYSIS

Total deformation is the deformation option that you can see all the deformation results related to your model, in three coordinates(X, Y, and Z). Directional: In directional deformation, you can select a coordinate (X, Y, or Z) to see the deformation result of your physical model in this direction.

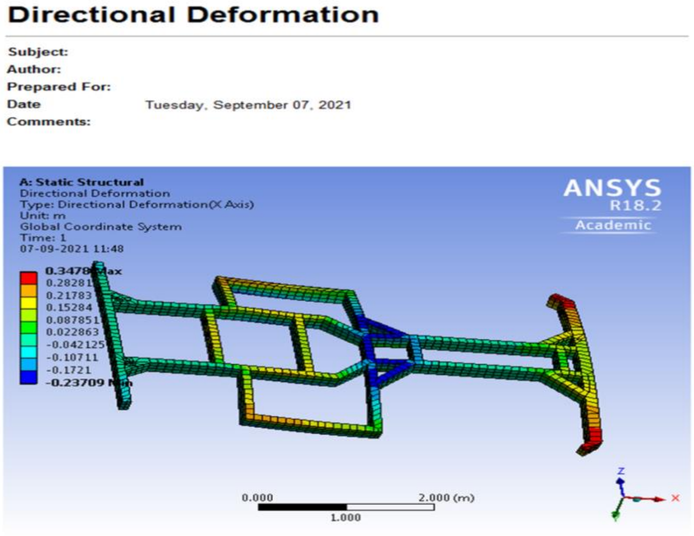
Whenever you solve a problem in ansys, you'll get displacements and stress as output. In displacement, every software allows you to check deformation(displacement) in 3 directions viz., X, Y and Z. These are directional deformations.

You can get the deflection by using general post processor (you can see the contour with colour bar) and time-history post processor (you can get the deflection data at nodes:

Select TimeHistPostpro> Variable Viewer -----then----

Nodal Solution > DOF Solution > Y-Component of displacement. Click OK.

Fig.5.4 shows the directional deformation result plots for existing double type chassis and modified single type chassis respectively under 2G vertical loading. The maximum deformations are 0.4916 mm and 0.5665 mm for existing and modified chassis respectively. The maximum deformation occurs on the front steering hub body for vertical loading



Directional Deformation

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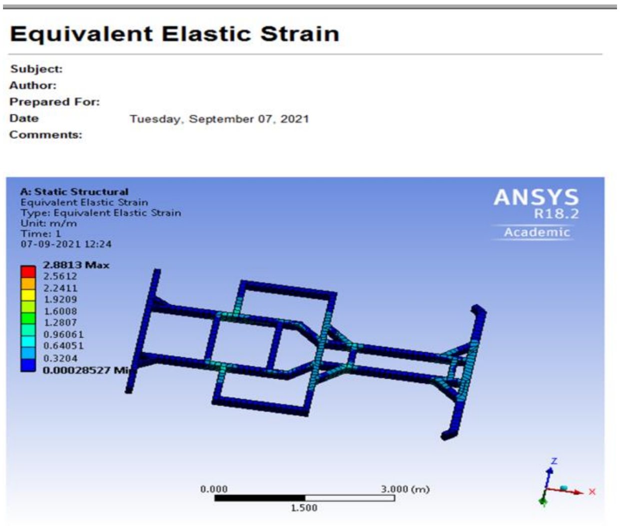
Figure 6.4 Total Deformation Analysis

6.5 EQUIVALENT ELASTIC STRAIN:



Equivalent Elastic Strain

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Figure :6.5 Equivalent Elastic Strain Analysis

The equivalent elastic strain is related to the equivalent stress when ν' = ν (input as PRXY or NUXY on MP command) by: (17–145) where: σeq = equivalent stress (output using SEQV) = equivalent elastic strain (output using EPEL, EQV)

7. GRAPHICAL ANALAYSIS

7.0 MEAN STRESS CORRECTION THEORY

The alternating stress amplitude for a stress cycle is computed as half the stress range in the cycle. The amount of damage caused by a stress cycle depends not only on the alternating stress but also on the mean stress. For example, the two cycles below have the same alternating stress but because they have different mean stresses, they cause different amounts of damage.The effect of mean stresses on the cycles to failure is illustrated by the following diagram, called the Haigh diagram.

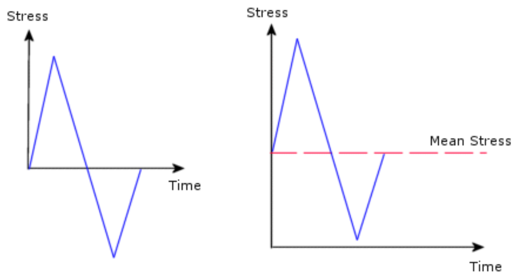
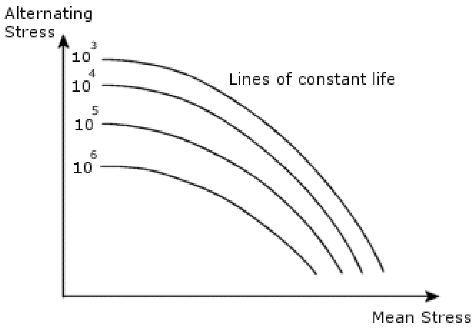


Figure: 7.0 Haigh diagram



The mean stress is zero only when the load is fully reversible. The most straightforward case is when an S-N curve with the same R-ratio as the loading is provided. In this case, the S-N curve is directly used since no correction is needed. If you define S-N curves with different R-ratios, the software accounts for the mean stress by linear interpolation between the curves. If only one S-N curve with an R-ratio that is different from the R-ratio of the loading is provided, a correction is needed

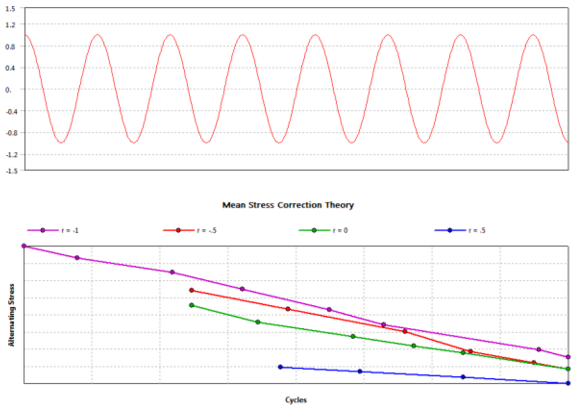


figure:7.1 mean stress correction theory

To discuss correction methods, let us define the following variables for a stress cycle:

Smax = maximum stress
Smin = minimum stress
ΔS = stress range = Smax - Smin
Sa = alternating stress = (Smax - Smin)/2
Smean = mean stress = (Smax + Smin)/2
R = Stress ratio = Smin/Smean
A = amplitude ratio = Sa/Smean

The stress and amplitude ratios for some common loadings are listed:

Loading Type	Stress and Amplitude Ratios
Fully reversed	R = -1, A = infinity
Zero to maximum	R = 0, A = 1
Zero to Minimum	R = infinity, A = -1

Table7.0: stress and amplitude ratio

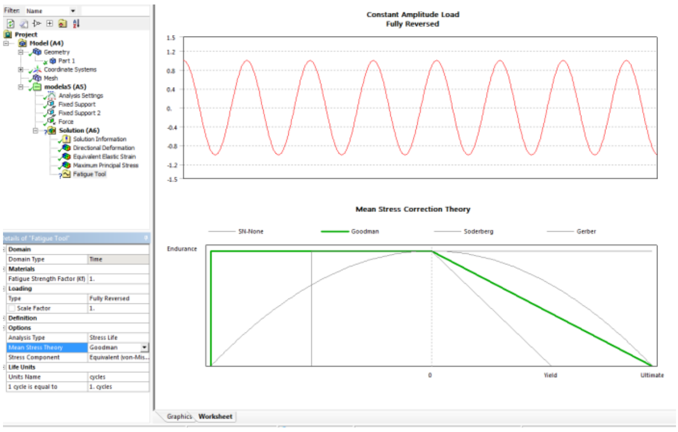
7.1CORRECTION METHODS

In the following let:

Sca = the corrected alternating stress (based on zero mean.),
Sy = yield stress, and
Su = ultimate strength

The software offers the following methods to calculate Sca:

For both variable and constant amplitude events, the software calculates the mean stress in addition to the alternating stress for each cycle and then it evaluates the corrected stress using the specified criteria.



etails of "Fatigue Tool"

Domain	
Domain Type	Time
Materials	
Fatigue Strength Factor (Kf)	1.
Loading	
Type	Fully Reversed
☐ Scale Factor	1.
Definition	
Options	
Analysis Type	Stress Life
Mean Stress Theory	Goodman
Stress Component	Equivalent (von-Mis...
Life Units	
Units Name	cycles
1 cycle is equal to	1. cycles

Figure 7.2:goodman method graph

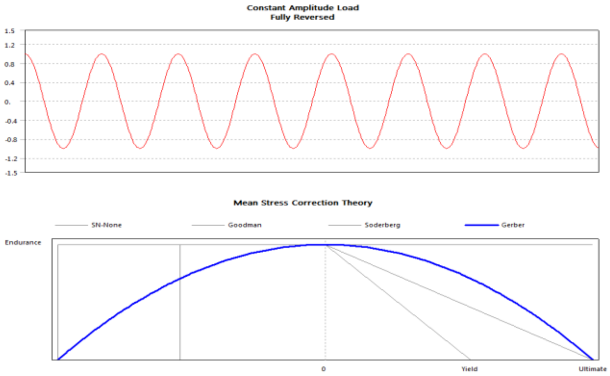


Figure 7.3:gerber graph

8. CONCLUSIONS

The solar vehicle 1st iteration design of chassis is completed. This was accomplished by designing all of the subsystems individually and integrating them into a final design. These subsystems consist of the following:

- Frame – Design and Fabrication of the vehicle frame.
- Frame – Fabrication was completed and transported to campus.

Used in conjunction with plating scheme to mount components.

Supplemental materials were purchased to accommodate the project and its future endeavors. A full inventory was produced by creating interactive Microsoft Excel worksheets. Inventory may be sorted in many different combinations. In addition to components that were already acquired, components that were used for design, but were not purchased, were included in the list as well. This list has been labeled “Master Component List.” Screenshots from the Master Component.

In the future years, emphasis should be on the optimization and fabrication of the entire vehicle. The current model should be used as a starting point. The first iteration design was meant to be flexible to allow variations in design and component configurations. Before beginning any new designs, New component configurations should be explored and evaluated. If current design configurations are used, efforts should be focused on FEA analysis to verify the safety and validity of the design. Upon completion of FEA, fabrication processes should be considered and progressed. Also, new components such as seat belts, headlights, foot pedal, wind shield, wind shield wipers, reverse break lights, and doors.

Project objectives were accomplished with considerations with next year’s team ease to pick up progress.

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