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Design and Carry Out a Finite Element Structural Analyses on Design Model

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***Abstract*— the first step in solving any problem is to identify it. In stress analysis ask whether the problem is static or dynamic, the finite element method was developed more by engineers using abstract methods. This experiment presents the developing of a computer program, using pro/engineer software to Design and carry out a finite element structural analyses on the design model. The main Aim from this experiment is to develop the capability as a mechanical engineering designer and to understand the application of industrial FEM software in a mechanical engineering design also to design a devise (RELEASE MECHANISM) withstands the stresses placed on it when used in real life using finite element method programs, with fully care on Shape, Size, Dimension, Maximum Load also the "Mechanical properties" and the Cost (weight of the material before manufacture).**

***Index Terms*—Area, pressure, force, stress, Displacement Poisson's Ratio, stress von mises, Strain, Young modulus, Yield stress, Factor of safety.**

I. INTRODUCTION

Finite element analysis (FEA) was first developed for use in the aerospace and nuclear industries where the safety of structures is critical. Today, the growth in usage of the method is directly attributable to the rapid advances in computer technology in recent years. As a result, commercial finite element packages exist that are capable of solving the most sophisticated problems, not just in structural analysis, but for a wide range of phenomena such as steady state and dynamic temperature distributions, fluid flow and manufacturing processes such as injection molding and metal forming. It was first applied to problems of stress analysis and has since been applied to other problems of continue .In all applications the analyst seeks to calculate a field quantity: in stress analysis it is the displacement field or the stress field in thermal analysis. A finite analysis dose not produces a formula as solutions, nor does it solve a class of problems.

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II. AIMS

To develop the capability as a mechanical engineering designer and to understand the application of industrial FEM software in a mechanical engineering design.

III. OBJECTIVE

To Design and carry out a finite element structural analyses on my design model.

IV. NOTATION

Symbol	Meaning	Units (SI)
A	Area	mm2
p	pressure	Mpa
F	force	N
σ	stress	N/mm2
α	Angle	Degree
Δ , S	Displacement	mm
v	Poisson's Ratio	--
σ_{VON}	stress von mises	N/mm2
ε	Strain	--
E	Young modulus	N/mm2
σ	Yield stress	Mpa
FoS	Factor of safety	--

V. DESIGN

Each designer has a sense with his ability to imagine the devise and applied it through computer aided design CAD Programmer. Production design deals with conversion of ideas into reality and, as in other forms of human activity, aims at fulfilling human needs.

A- **Drawing of the lever and the hunger of the release mechanism using with fully focusing on:**

-The preliminary dimensions from the given drawing to make the assembly corresponding and well balanced.
-Round all the inner corners to minimize the stress concentration.
The next figure shows the assembly drawing:

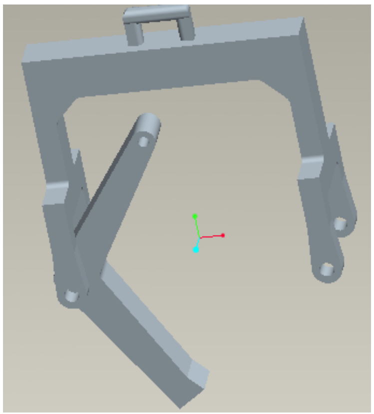


Figure (1) assembly drawing

Two proper engineering drawings for parts:

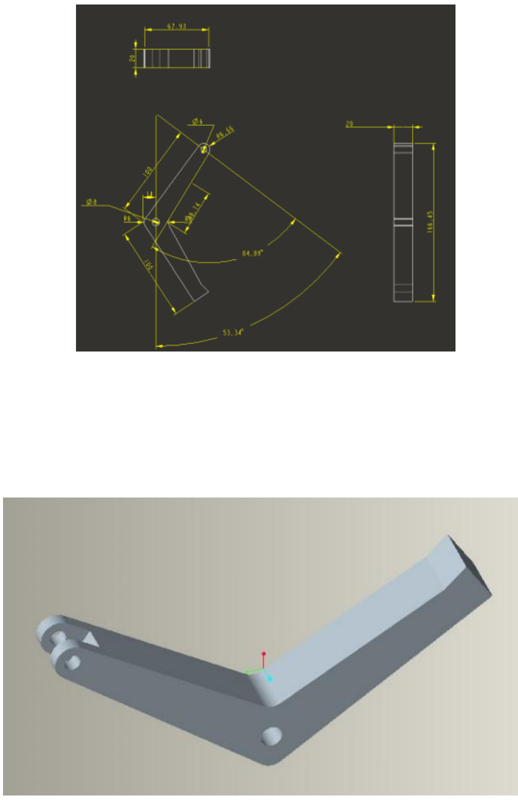


Figure (2) two proper engineering drawings for parts

The next figure shows the hunger drawing:

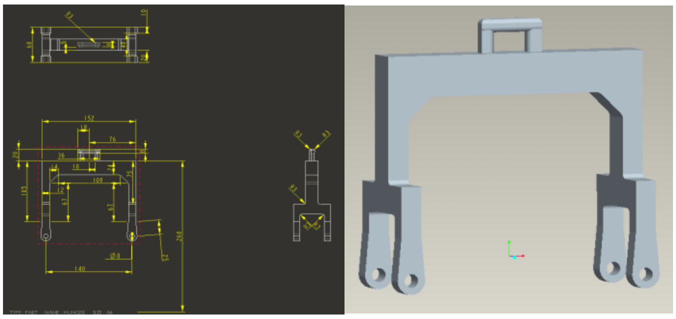


Figure (3) the Hangar

B-Selecting material:

The basic requirements for selecting materials:

- **Commercial factor:**

1. Cost.
2. Availability.
3. Easy to manufacture.

- **Engineering properties such as:**

1. Electrical conductivity.
2. Strength.
3. Toughness.
4. Ductility
5. Ease of forming by extrusion, forging and casting.
6. Machinability.
7. Corrosion resistance.

Diagram (1) Classification of engineering material

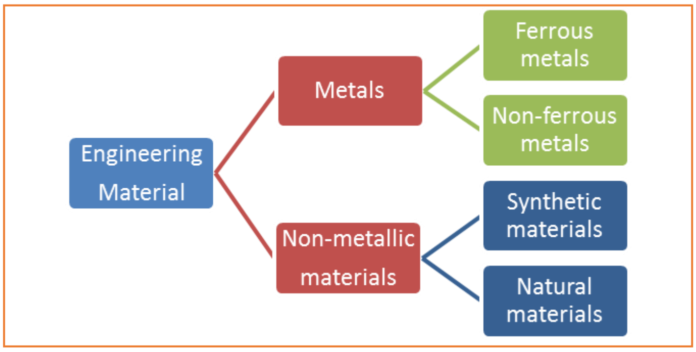
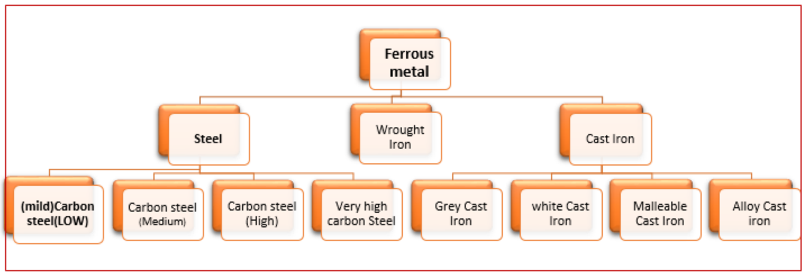


Diagram (2) Classification of ferrous metal material



C- Kinds of carbon steel:

The table below compares the four different main kinds of carbon steel and their properties:

Material	Description	Strength/ brittleness	Machinability	Ductility	Cost
Low/mild carbon steel	*Have less than 0.30% of carbon. *Most Common Used grads.	*good strength that because less of carbon percent.	*Nice machine & weld *Easy to fabrication.	*more ductile than other carbon steel family	*Relatively low cost.
Medium Carbon steel	*Have from 0.30 to 0.45% of carbon steel	*increase carbons mean increase hardness and strength also increase brittleness.	*more difficult in machining	*decrease in ductility	*little more than mild steel cost.
High carbon Steel	*Include 0.45 to 0.75% of carbon.	*high strength and hardness also increase brittleness.	*challenge in machine and welding	*more decrease in Ductility	*higher than mild steel and medium carbon steel
Very high carbon steel	*up to 1.50% of carbon.	*more strength and hardness with high in brittleness.	*need to change the mechanical properties to machine it “difficult in machining”	*poor in ductility	*very high cost that because it is common to use in metal cutting tools.

Table (1) - four different kinds of carbon steel and their properties

Mild carbon steel have been selected to design the release mechanism to the above reasons in the table and for the numbers of points in advantages:

- **ADVANTAGES:**

1. Cheap.
2. Wide variety available with different properties.
3. High stiffness.
4. Magnetic.
5. Most carbon steels are easy machine and weld.

- **DISADVANTAGES:**

Poor corrosion resistance. (Not big issue it can be coated)

D- **Machining the two parts of the release mechanism on the same material for the flowing reason:**

1. No more increasing in cost.
2. Less of chemical reactions including because they are of the same composition.
3. Easily control to the operating machines.

VI. YIELD STRESS AND TENSILE STRENGTH OF MILD STEEL

Basically the strengths of mild steels depend on its material composition. All steels are made with varying alloys and are made from different processes e.g. casting, hot or cold rolling and they all have a different effect on its strength. If you know the specifications of the mild steel you are using there are tables for which you can obtain these values. Typically I have seen the yield stress vary from (250 MPa) to as much as (550MPa), so you can have an idea of just how much they vary based on their composition.

The table below shows the mechanical properties of mild steel also some of famous materials:

Materials	Young's Modulus (GPa)	Proof or yield stress (MPa)	Ultimate strength (MPa)	Poisson ratio
Aluminum	70	15-20	40-50	0.35
Copper	130	33	210	0.34
Mild Steel	200	250	400	0.30
Gold	79	-	100	0.44
Iron	211	80-100	350	0.29
Medium Carbon steel	80	345	525	0.29
high carbon steel	80	495	640	0.29
Silicon	107	5000-9000	-	-
Silver	83	-	170	0.37
Tantalum	186	180	200	0.34
very high carbon steel	-	417.1	655	0.27-0.30
Titanium	120	100-225	240-370	0.32
Tungsten	411	550	550-620	0.28
Zinc (wrought)	105	-	110-200	0.25

Table (2) - mechanical properties of mild steel

A- Determines the safety factor:

Design/ safety factors:

Take into account variability of properties, designer’s use, instead of an average value of, say, the tensile strength, the probability that the yield strength is above the minimum value tolerable.

Working out of the allowable stress on lever of the release mechanism:

1-put the value of the safety factor which it (2.5).

2-work out the allowable stress $[\sigma] = \sigma_{\gamma}/s$

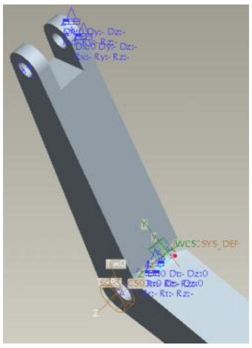
3- $[\sigma]$ = 250/2.5 = 100Mpa

B- Calculation for analyses:

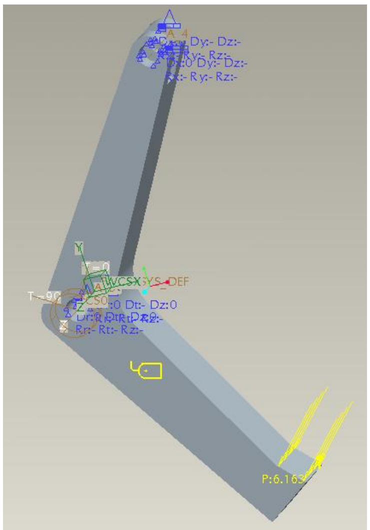
- -Young modulus, (E) = 2E5 N/mm^2.
- -Poisson’s Ratio = 0.3
- -Yield stress = 250 Mpa.
- -Max load = 200 Kg
- -Factor of safety = 2.5 Mpa
- -Material = mild steel

VII. DETAIL DESIGN FOR THE LEVER

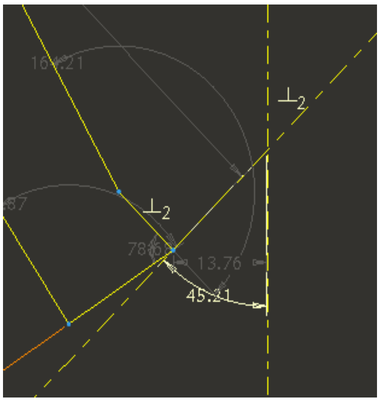
A- Applying the constraints:



B- Applying load:

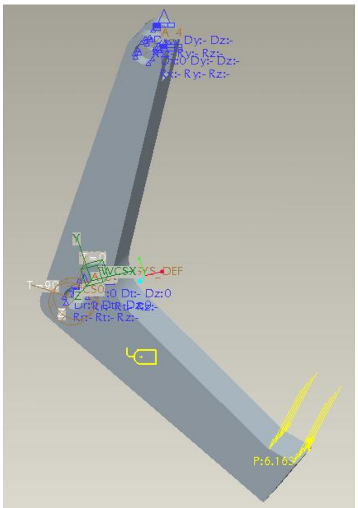


C- Apply cylindrical coordinating system:



$(\alpha)=45.21^{0}$, (A) =225.92m2
F = N = P/2cos α = 200x9.81/2cos45.21= 1392N
P= F/A = 1392/225.92 = 6.163 Mpa

D- Run the analyses with maximum von mises stress:



VIII. SYSTEMATIC APPLICATION OF THE FINITE ELEMENT MODEL

The finite element method was developed more by using abstract methods .it was first applied to problems of stress analysis and has since been applied to other problems of continue .In all applications the analyst seeks to calculate a field quantity: in stress analysis it is the displacement field or the stress field in thermal analysis. A finite analysis does not produce a formula as solutions, nor does it solve a class of problems.

A- Reviewing the result:

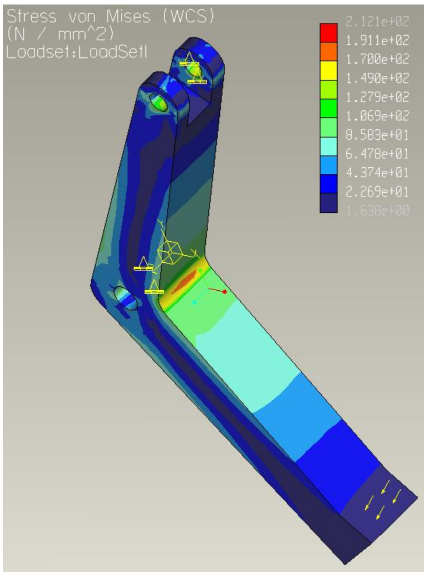
A further analysis will be demonstrated to show the improvement of the model by varying the values of radiuses also check will be done to see how the thickness variation would have an effect on the maximum stress of the model.

NOTE :(The model can be observed that the highest stress value shown in red).

1- ANALYSIS No(1):

The first analysis was (212.1 Mpa) to stress von mises.(BAD)

The allowable stress [σ] =100 Mpa, It need more change with the dimension to achieve ($\sigma_{VON} \leq [\sigma]$)



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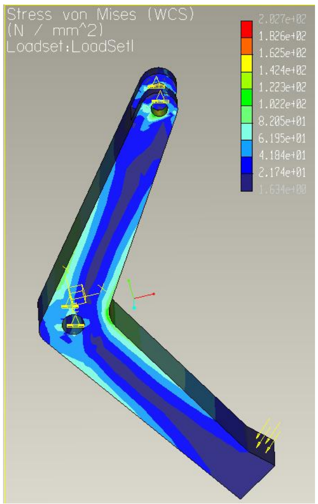
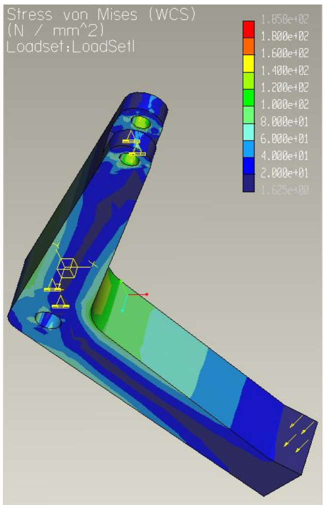
2- ANALYSIS No(2):

Changing the curve to 9 mm >>>>> (Going better).



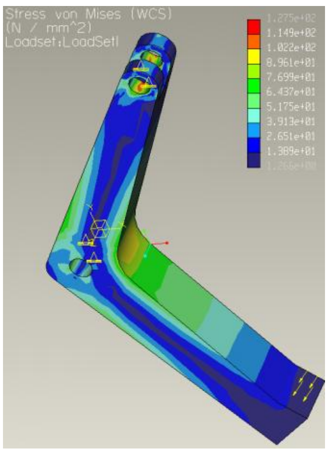
3- ANALYSIS No(3):

Changing the curve to 12mm and thickness of the pin holder going better, but still red color come into view on the hole:



4- ANALYSIS No(4):

After several attempts I have reached a good number which is 1.275 Mpa. Stress Von mises still higher than the allowable stress.

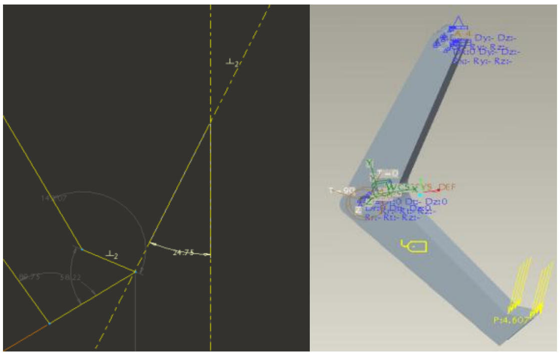


5- ANALYSIS No(5): Modification

Changing the load area:

Note: Alpha (α) angle have been changed to (24.75^0).

- (α)=24.75^0 , (A) =225.92m2
- F = N = P/2cos α = 200x9.81/2cos24.75= 1040.8N
- P= F/A = 1040.8/225.92 = 4.607 Mpa

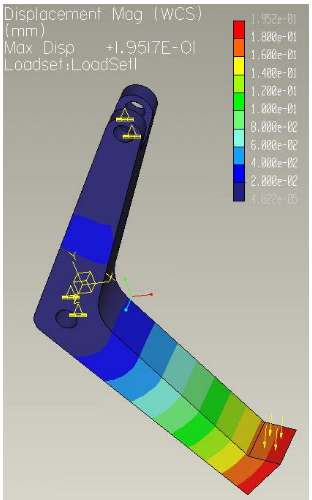


6- ANALYSIS No(6):

Numbers of analysis has been designed with the following actions:

1. Changing the curves radius several times.
2. Changing the thickness of the pin holder several time.
3. Changing the diameter of the pin hole several time.
4. Changing the load area many times.

A- **Displacement distribution diagram:**

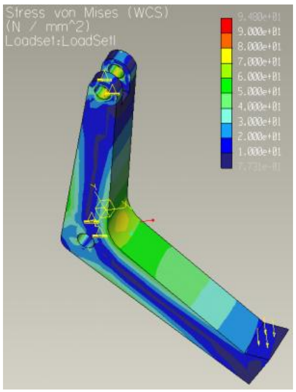


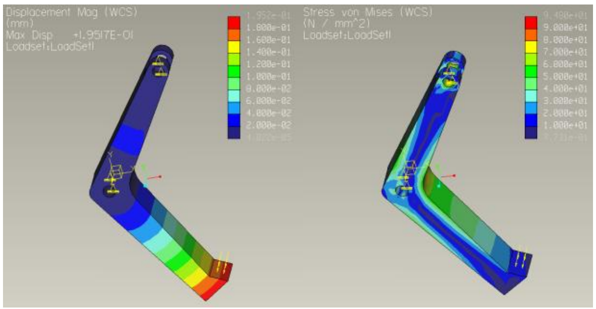
B- **Final analysis:**

1. After changing the angel of hook grip, (α) has been changed to (24.75^0).
2. After calculation with the new (α), the load became 4.607 N.
3. After several attempts a good number have reached which is 94. 8Mpa.
4. Stress Von mises less than the allowable stress $\sigma_{von} \leq [\sigma]$ **(APROVED).**

5. After result analysis I found that this situation is the best case to manufacture the lever.

C- **Values of the maximum von mises stress and the maximum displacement location:**

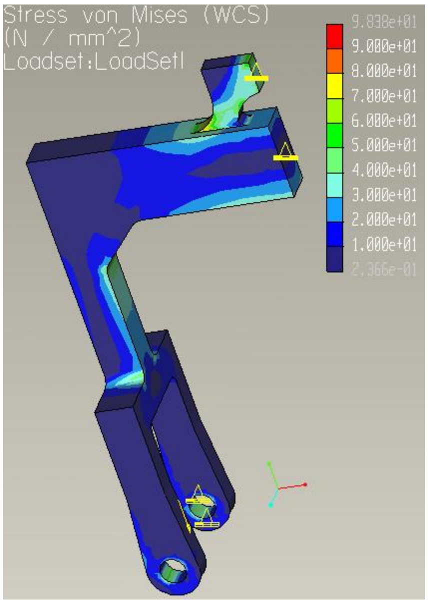




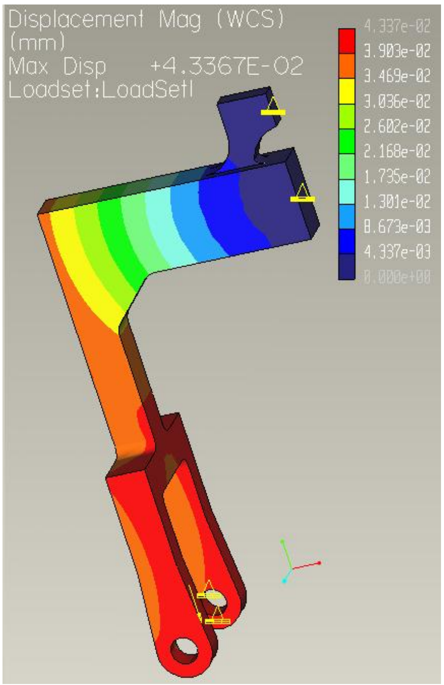
IX. ANALYZING THE HANGER

With following the same procedure to analyze the lever getting the next results:

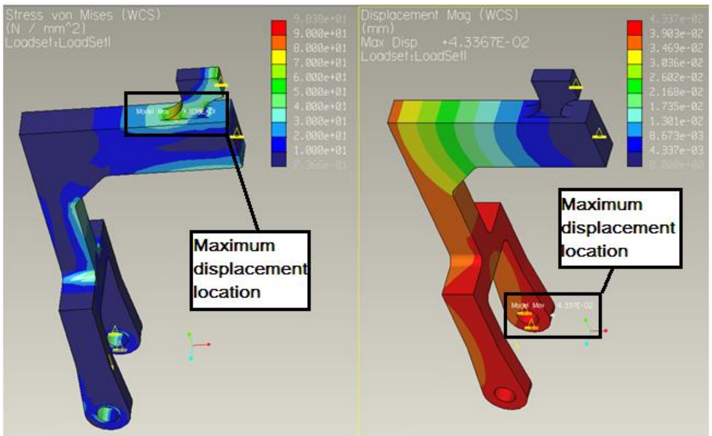
- Stress von mises Equal (98.3 Mpa).
- Stress Von mises less than the allowable stress [σ]von ≤ [σ] **(APROVED).**



A- Displacement distribution diagram:



B- Values of the maximum Von mises Stress and the Maximum displacement location:



X. MODIFICATION OF THE DESIGN ON RELEASE MECHANISM

The modification has been carried out where the changes have been made to the radius and the thickness also the load area of the model respectively. Number of attempt has been done in order to get minimum stress and then adjustment of the thickness is done.

Dimension of all radiuses of the model has been continuously increased and the values of maximum stress have been evaluated to reduce the stress at the positioning of the load. Number of attempts has been tabulated for the illustration.

XI. COMMENTS

Through the analysis number of modification which has been made to the design, by reducing the geometry at the point of the stress concentration. This method of alteration can improve the surface without wastage of more materials.
This work shows that the shape of material can be control important reduction of stress concentration, most of product which are exposed to high stress and requiring high level of safety has to be analyzed to reduce stress concentration.
Evidence show that round shape is mostly used to trap stress concentration. This can be seen on the designing of any devise similar to our design.

XII. CONCLUSION

It can be concluded that the Finite Element Analysis is one of the reliable tool to internally analyze the stress distribution on models. It is time serving tool compared to analogue ways. In designing models which will have sustain high stresses, heavy loads and high pressures, sharp corner has to be avoided to balance materials.

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