Investigation and Simulation of Coconut Fibrous Husk Extracting Tool Geometry Using Finite Element Analysis.

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Abstract: - This report includes the thorough analysis of developing tool geometry to extract coconut fibrous husk. The research consists of the purpose of selection of the tool material, determining the force, the stress, strain energy, deformation, and loadings. The report also includes the study of the material science and selection of the material used for developing the tool which proves high in strength, possess good mechanical properties, cost effective, safe in design considering important parameters used in mechanical engineering design. The study of the structure of coconuts and its properties and the strength required to peel its fibrous husk using a tool was considered in the report. The material used to develop the extractor tool was Structural steel with medium carbon content ranging 0.25 to 0.55 %. The method used was Finite Element Method. The analysis software used was Ansys 16.0. The analysis results obtained on considering the de husking properties of coconut gave force required for peeling of coconut fibrous husk as 114 N For the shear stress of the coconut husk extracting tool the maximum value obtained was 1.6539 x 10^6 and the minimum value obtained -1.7689 x 10^6. For the shear elastic strain of the coconut husk extracting tool maximum value obtained was 2.1501 x $10^{-5}$and the minimum value obtained -2.2995 x 10^{-5} . The total deformation of the coconut husk extracting tool, the maximum value obtained was 6.9214 x 10^{-6} and the minimum value obtained was - 7.6904 x $10^{-7.}$

Keywords: - Analysis, Tool geometry, Coconut fibrous husk, Tool material, Strength, Mechanical Properties, Finite Element Method.

INTRODUCTION: - Coconut husk removing is very laborious and tedious process. In most of the countries coconuts are used only for consuming it as a part diet. Apart from using it as diet, it is majorly used as a form of productive source mostly in India and Sri Lanka. The fiber produced by the coconut husk is used as brooms, door mats, brushes, for rope making, crafts etc. Coconuts are mainly cultivated in the states of Kerala, Tamil Nadu, Andhra Pradesh, Karnataka, Goa, Maharashtra, Assam and Orissa in India. Most of the Farmers in India are using the traditional methods of de-husking coconuts by using pointed steel rod where the coconut husk has to be engaged, and husk is removed by spreading the spike rod.

This involves an excellent skills, perfection and concentration. Traditional method of husk removal is shown below.

Figure 1. Traditional method of Coconut Husk Removal

But de husking coconuts manually using a steel rod has its own disadvantages also.

i) It is very time consuming process.
ii) Excellent practice is needed for this task.
iii) There may be chance of an accident as the coconut has to strike against the pointed tip. It may sometimes cause injuries to hands.
iv) Need of huge manpower.
v) Ergonomics is another factor as the human has to stand and require a particular bending position to perform the de husking task.
vi) Atmospheric comfort conditions may also affect de husking throughout the year (summer, monsoon and winter) in India.

Many methods and machines of de husking of the coconuts are developed and are available today. The coconut de husking methods and machines are categorized below.

1) Manually Operated Commonly Used.

a) Husk Remover tool of Coconut (Developed by Cecil P.Waters)
b) Coconut husk removing spanner. (Developed In Malabar Region Kerala, India by Thazhakkara, Muraleedharan)
c) KAU coconut De husking tool (Developed by Jippu J and Joby B) Kerala Agricultural University).

2) Power Operated Machines

a) Hydraulic Coconut De-husking (Hydraulic Coconut De-husking Machine, Coconut Development Board/De husking Machine. 2011).

b) Coconut De-Husking Machine. (B. N. Nwankwojike, O. Onuba, U. Ogbonna, Development of a Coconut De husking Machine for Rural Small Scale Farm Holders International Journal of Innovative Technology & Creative Engineering, Vol.2 No.3, March 2012)

Among the above mentioned coconut de husking methods the hydraulically operated coconut husk extraction method is best suited because of its husk productivity, safety, ergonomics design, low labor requirement, and time efficient. Here in this report the thorough investigation and design of coconut husk extracting tool which is controlled and operated hydraulically is been performed. Analysis of forces, stresses, selection of material on the verge of basics of design of mechanical elements of peeler tool (husk extracting tool geometry) was performed.

NEED FOR THE STUDY:-

a) To acquire testing results of the de husking of the coconuts in terms of the stresses , loading , forces and different parameters of Mechanical Design.
b) To acquire and test the strength and sustainability of the coconut de husking tool geometry on various types of coconuts with different properties.
c) To study the various materials and selection of the material for development of tool that stands perfect meeting the specific design parameters.
d) To simulate and analyze the tool geometry which will prove Safe, Easy and Simple, More Effective and further which can serve the medium and small scale Coconut Farmers.
e) Advanced engineering which can be adopted and used by coconut Farmers across the globe.

LITERATURE REVIEW:-

A. F. Alonge [2011] : In this report the thorough details regarding the Engineering Properties of the coconuts is discussed. It is in terms of its (coconut) size, sphericity, roundness, volume, surface area, density, coefficient of friction.

B. N. Nwankwojike [2012] : The research states that the machine with a pair (two numbers) of rollers were used. These pairs consist of protruded parts (spikes) which de husk the coconut when the handle was provided with rotary motion. The coconut de husking efficiency was about 93.45 % , With average of 79 per hour of coconut husk extraction. Since it is operated manually the machine eliminates power requirement which turned beneficial in power crisis rural areas.

Abi Vargheser [2014] : In this research report the study of Different Coconut de husking machines is been done. The machines are been categorized and classified as Manually Operated De-husking Machine and Power operated De-husking Tool. For small scale of coconut husk extraction manually operated machine tool is suited but when it comes to processing industries the best suited option is using power operated coconut de husking machines.

Vinod P. Sakhare [2014] : Analyzed a hydraulic system coconut husk extractor with a cylinder , guide valve , hydraulic unit , and de husking mechanism .The study also included the derivation of the de –husking force required to extract the coconut husk. The analysis was carried out on the time required to extract one coconut where obtained time of 12.1

seconds. It specified the use of this particular is safer than other power operating and Manually operated De- husking and reduce the labor cost to and is nearly half of conventional method of Coconut De-husking.

Muh. Fajar Nuh Pratama [2015] : This research study specifies the characteristics of the peeler knife for de husking coconuts. The mechanical design parameters includes the stripping force, knife design, stripping force analysis, the value of the stress and the value of deflection through the Finite Element Method (FEM). The contact angle of 30° and 45° vertical and horizontal directions, and stripping angles of 10°, 20°, 30°, 40° and 50° were included . The knife material was selected middle steel (MS) and cast iron (CI). The design analysis and testing using the Finite Element Method concluded that for the paring knife design was chosen as Cast Iron type with a contact angle of 45°.

THEORY OF CONCEPTUAL APPROACH:-

About Coconut:-

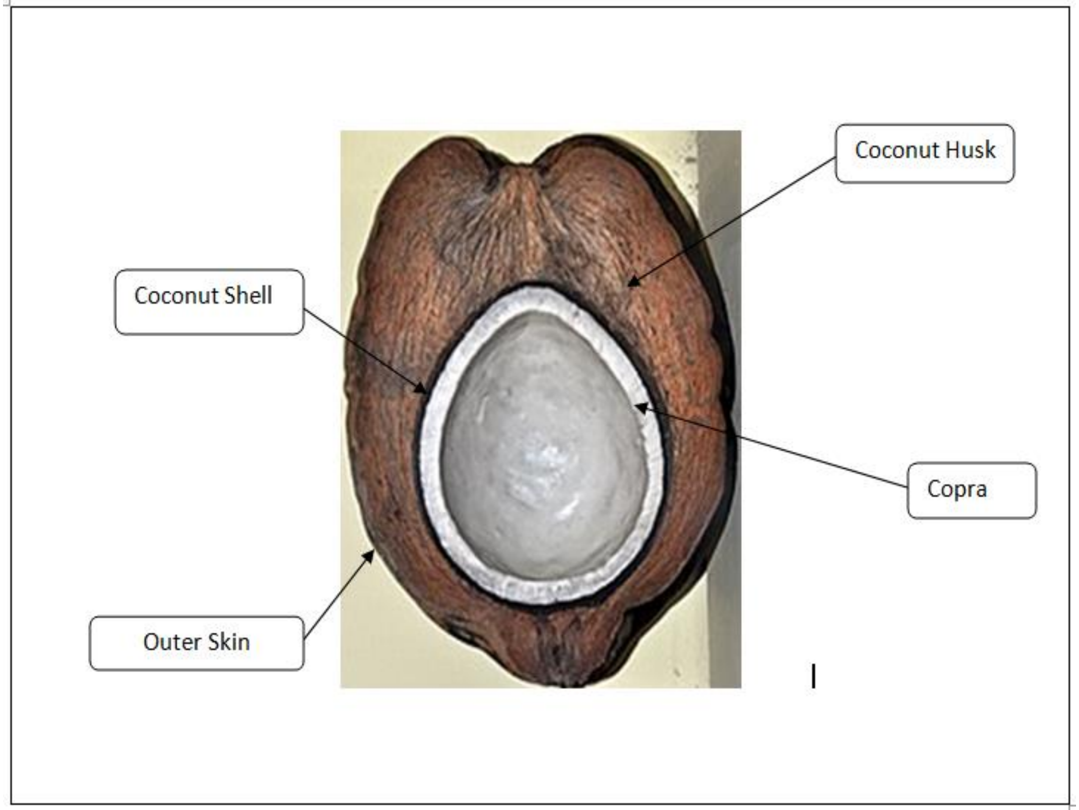

Figure3 :- Structure of Coconut.

The structure of the coconut is shown above .The coconut fruit consists of thin hard skin , thicker layer of fibrous husk , the shell which is hard, and the white portion is known as copra and centre of the fruit consist the coconut water . The shell surrounded outer husk is very hard, laborious, less safer and tedious task to be removed manually. The brown coconut indicates the seed is ripe which consists of the brown fibrous husk.

On random selection of one hundred coconut seeds for its physical property testing using a vernier caliper with least count of 0.02 mm the values obtained and the range were discussed .The major diameter (outer skin) of coconut range between 17.36 – 19.7 cm , The minor diameter (coconut shell) range between 13.22 – 15.40 cm. Surface area ranges from 4724 mm^2 to 5797 mm^2, the volume ranges from 600 cm to 800 cm. The average density observed was 1.065 g/cm^3. Average modulus of elasticity was observed was 153.6 N/mm with an average load at yield was 5390.6 N and deformation at yield was 35.22 mm respectively on the major axis.

Coconut De - husking Machine:-

The fig below describes the de husking in more easy and self explanatory way.

Figure 3 :- Coconut De-husking Machine Setup

Figure 4:- Husk Extraction Technique using stripping Tool

Some Important Mechanical Properties of Materials:-

The figure below shows the representation of iron – iron – Carbide equilibrium diagram.

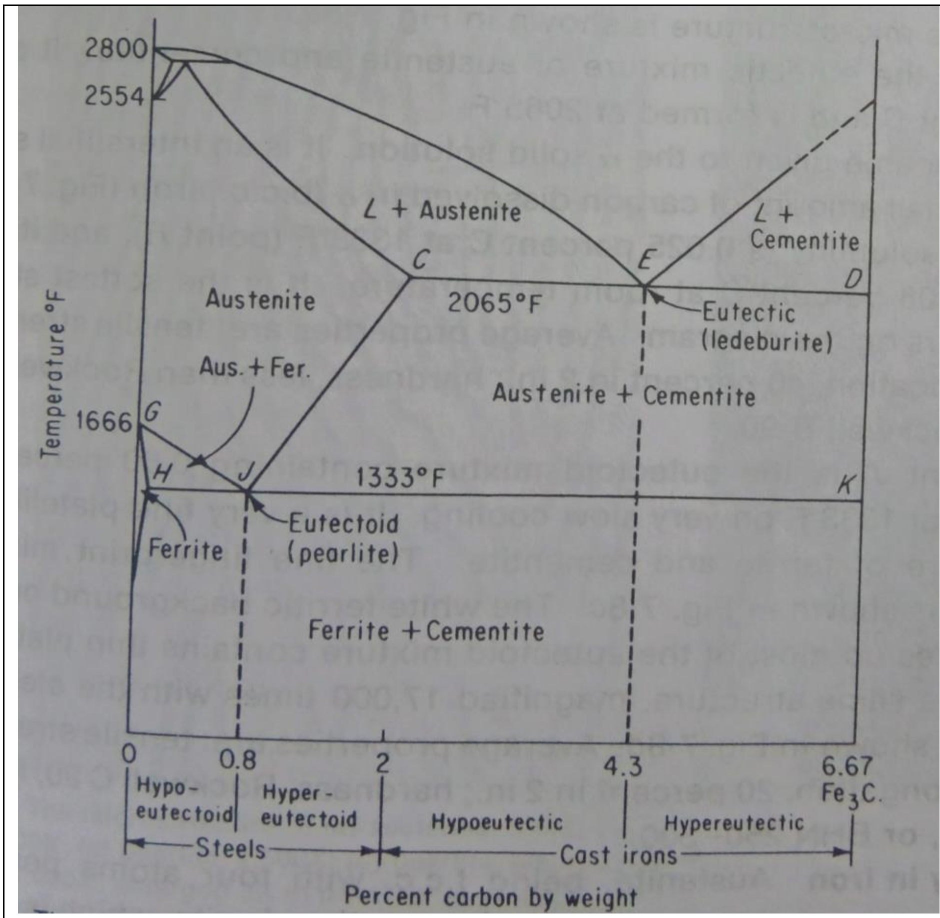

Figure 5 :- The iron – iron – carbide Equilibrium Diagram

The Diagram above represents the division of the iron- iron- carbide diagram into two parts. The alloys which consists less than 2 % carbon are called steels and those containing more than 2 % of carbon are called cast irons. Further it is detailed that 0.8 % carbon alloy is called as eutectoid (pearlite) , alloys consisting 0 – 0.8 % of carbon are called hypoeutectoid steels and alloys consisting 0.8 – 2 % of carbon are called hypereutectoid steels. Cast iron is also further divided of which the carbon content 2 – 4.3 % are called as hypoeutectoid cast iron and carbon content between 4.3 – 6.67 % are called hypereutectoid steels.

Steels:-

Steel is an alloy which is made up of iron . It consists of carbon which helps to improve the strength of the steel. The percentage of carbon also maximizes to improve fracture resisting properties of steels. Structural steel is less expensive when compared with other metals. The steel also has low maintenance cost and also has long life. Hence structural steel proves more economic and best option.

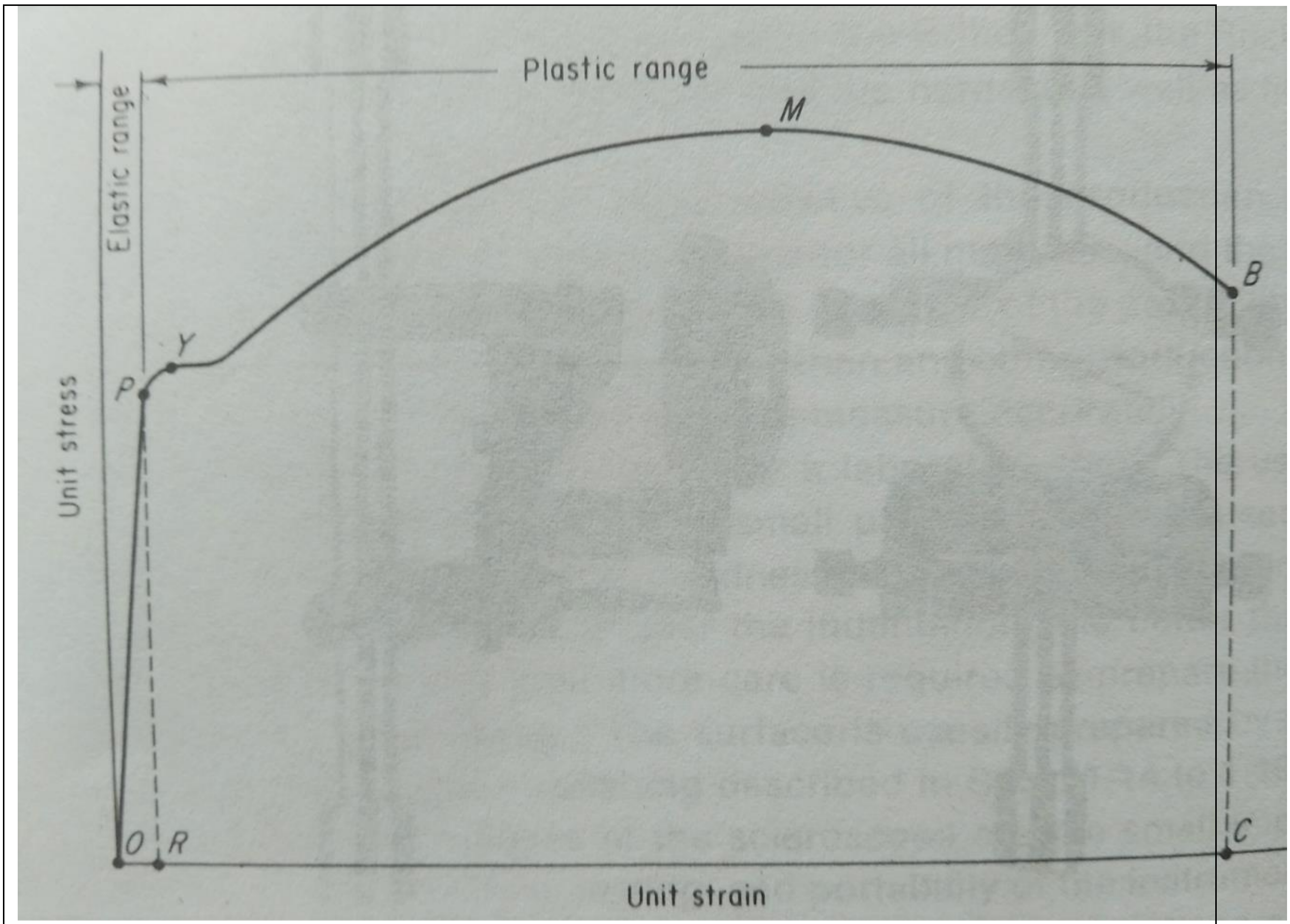

Fig 6 : Stress v/s Strain diagram for a ductile steel.

Where,

Line OP = Limit of Proportionality

Point Y = Yield Point

Point M = Ultimate Strength

Point B = Breaking Strength

Types of Structural Steel :-

a) Carbon Steel :- It consists upto 2.1 % of carbon.

i) Ultimate tensile strength ranges from 410 to 440 N/mm^2 .

ii) Yield strength ranges from 350 to 400 N/mm^2 .

b) High Strength carbon Steel :- These are the steels used in structures such as transmission lines.

i) Ultimate tensile strength ranges from 480 to 550 N/mm^2 .

ii) Yield strength ranges from 350 to 400 N/mm^2 .

c) Medium and high strength micro alloyed steel :- Alloy such as chromium , nickel and molybdenum are used in this steels which helps to increase the strength while retains the desired ductility.

i) Ultimate tensile strength ranges from 490 to 590 N/mm^2 .

ii) Yield strength ranges from 300 to 450 N/mm^2 .

d) High strength quenched and tempered steel: - In this type of steel , heat treatment is done to develop high strength.

i) Ultimate tensile strength ranges from 700 to 950 N/mm^2 .

ii) Yield strength ranges from 550 to 700 N/mm^2 .

e) Weathering steel :- These are corrosion resistant steel and are often not painted.

i) Ultimate tensile strength ranges from 700 to 950 N/mm^2 .

ii) Yield strength ranges from 550 to 700 N/mm^2 .

f) Fire resistant steel :- These steels are also known as thermo mechanically treated steels and are used in place where structure are more prone to fire.

Carbon Range of steels

a) Up to 0.25 % carbon defines Low carbon steel.

b) 0.25 to 0.55 % carbon defines Medium carbon steel.

c) Above 0.55 % carbon defines High carbon steel.

\Microstructures of Steels:-

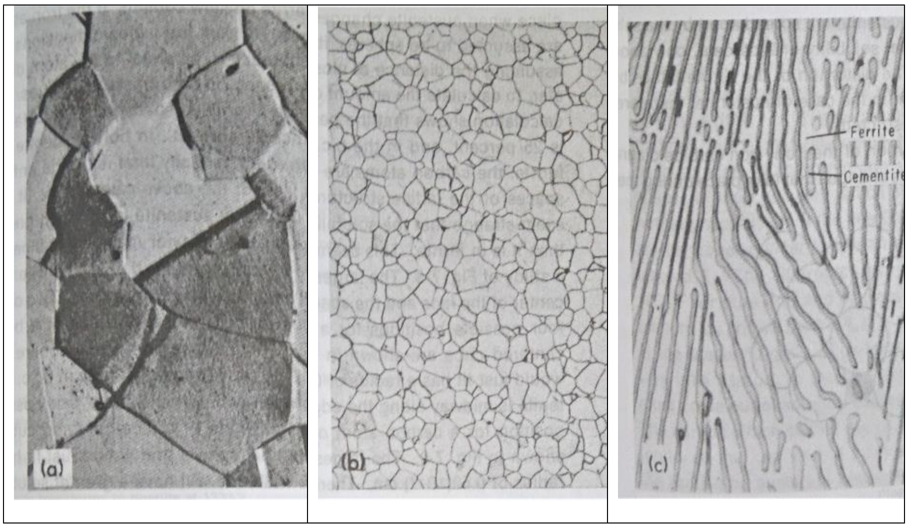

Figure 7 :- The Microstructure of (a) austenite, 500X (b) ferrite, 100X (c) pearlite 2,500X
(a, b, c Research Laboratory , U.S Steel Corporation)

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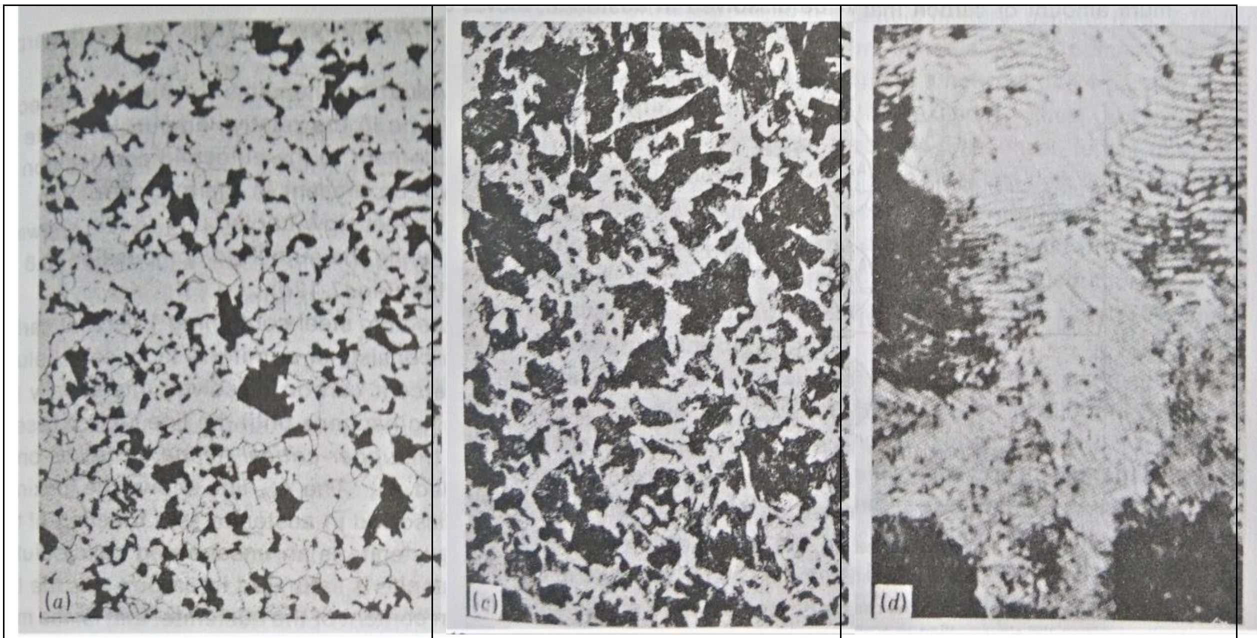


Figure 8 :- Photomicrographs of (a) 0.2 % Carbon Steel slow cooled , 100X (c) 0.4 % Carbon Steel , Slow Cooled , 100X (d) 0.8 % Carbon Steel , Slow Cooled , 500X .

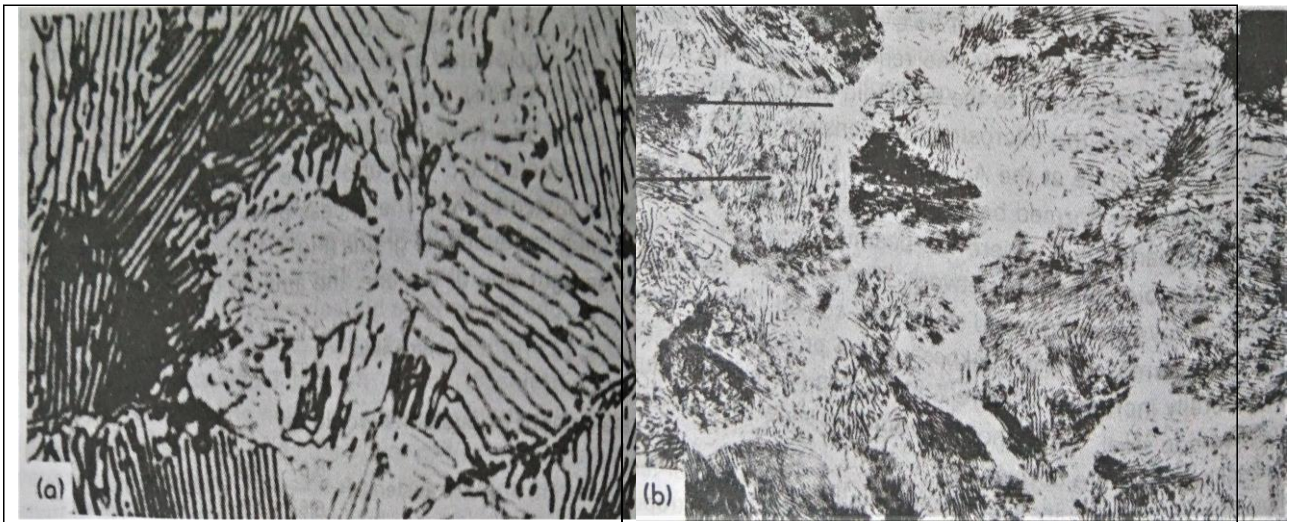


Figure 9 :- Photomicrographs of (a) 1% Carbon Steel , Slow Cooled 500X (b) 1.2 % Carbon Steel , Slow Cooled 300X.

Some Representative Specification of Standard Steels :

Table 1 :- Standard Steel Specifications

AISI NO	%C	% Mn	% P max	% S max	SAE NO
PLAIN- CARBON STEELS					
C1010	0.08-0.13	0.30-0.60	0.04	0.05	1010
C1015	0.13-0.18	0.30-0.60	0.04	0.05	1015
C1020	0.18-0.23	0.30-0.60	0.04	0.05	1020
C1025	0.22-0.28	0.30-0.60	0.04	0.05	1025
C1030	0.28-0.34	0.60-0.90	0.04	0.05	1030
C1035	0.32-0.38	0.60-0.90	0.04	0.05	1035
C1040	0.37-0.44	0.60-0.90	0.04	0.05	1040
C1045	0.43-0.50	0.60-0.90	0.04	0.05	1045
C1050	0.48-0.55	0.60-0.90	0.04	0.05	1050
C1055	0.50-0.60	0.60-0.90	0.04	0.05	1055
C1060	0.55-0.65	0.60-0.90	0.04	0.05	1060
C1065	0.60-0.70	0.60-0.90	0.04	0.05	1065
C1070	0.65-0.75	0.60-0.90	0.04	0.05	1070
C1074	0.70-0.80	0.50-0.80	0.04	0.05	1074
C1080	0.75-0.88	0.60-0.90	0.04	0.05	1080
C1085	0.80-0.93	0.70-1.00	0.04	0.05	1085
C1090	0.85-0.98	0.60-0.90	0.04	0.05	1090
C1095	0.90-1.03	0.30-0.50	0.04	0.05	1095

The SAE number 1030 to 1055 falls under the category of medium carbon steel having carbon content (0.25 – 0.55 %) .

Cast Iron: - Cast Iron is alloys of iron and carbon. Cast iron contains 2 to 6.67 percent of carbon. High carbon contents make the cast iron very brittle, most commercial manufacturing types use the range of 2.4 to 4 percent of carbon. Ductile property of cast iron is very low. Cast iron has the tendency to melt readily and can cast into complicated shape. Casting is the only suitable process for the alloys known as cast irons. Due to its brittleness cast iron are low in strength as compared to steels. The types of cast irons are as follows.

1) White cast iron: - In this type of cast iron all the carbon is in combined form of cementide.It consist of 2.8 to 3.6 % of carbon.

2) Malleable cast iron: - In This type of cast iron all of the carbon is uncombined in the form of irregular round particles known as temper carbon. Malleable cast iron is obtained by heat treatment of white cast iron.

3) Gray Cast Iron: - In this type of carbon most or all of the carbon is uncombined in the form of graphite flakes. It is one of the most widely used alloys of iron. Most of the gray cast irons are hypoeutectic alloys containing 2.5 to 4 percent of carbon.

4) Chilled Cast Iron :- in this type of cast iron , white cast iron layer at the surface is combined with a gray iron interior. Chilled cast iron is used for manufacturing of heavy duty machinery parts such as railway-car wheels , crushing rolls, sprockets , stamp shoes and dies.

5) Nodular Cast Iron :- In this cast iron the carbon is largely uncombined in the form of compact spheroids by addition of special alloys. Nodular cast iron are also known as ductile iron.some applications of nodular cast iron crankshafts, pistons, cylinder heads, switch boxes, motor frames, circuit breaker parts, flywheels, bearings, tool and die, wrenches etc.

6) Alloy cast iron :- These cast iron are the types in which properties or the structure of any of the above types are modified by addition of alloying elements.

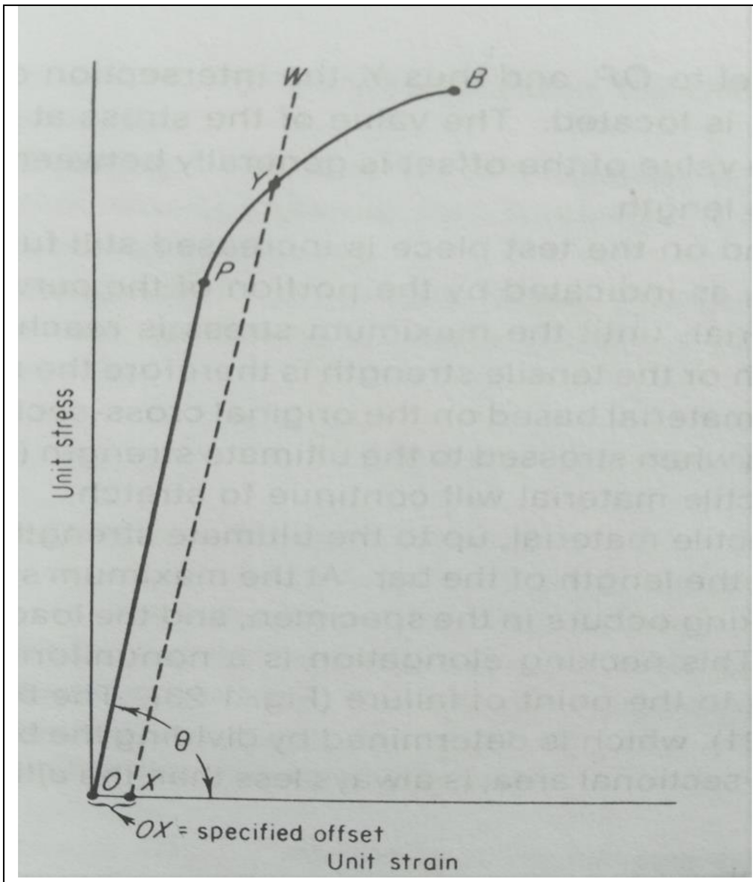
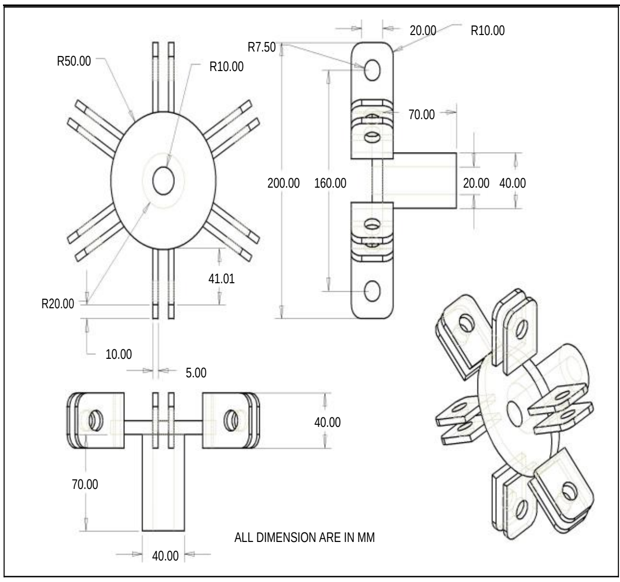


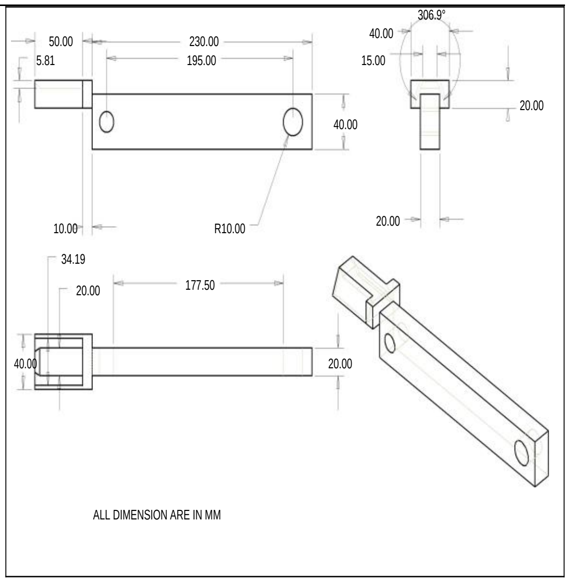
Fig 10 :- Stress v/s Strain diagram for a Cast Iron

ANALYSIS OF HUSK EXTRACTING TOOL:-

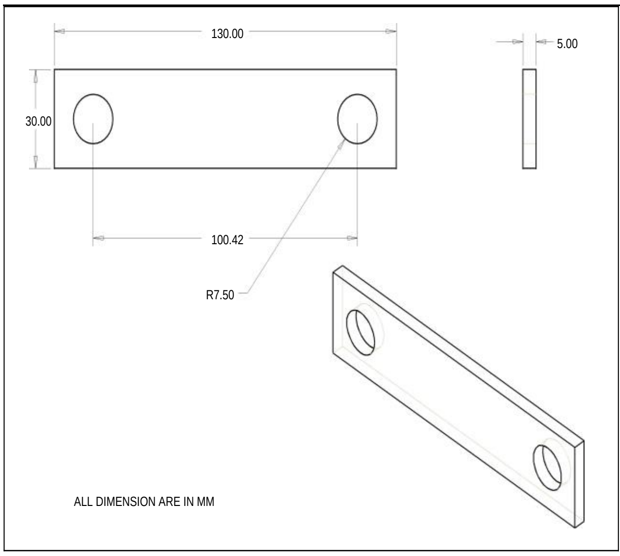
Detailed Drawing of Tool Geometry and its Relevant Parts:-



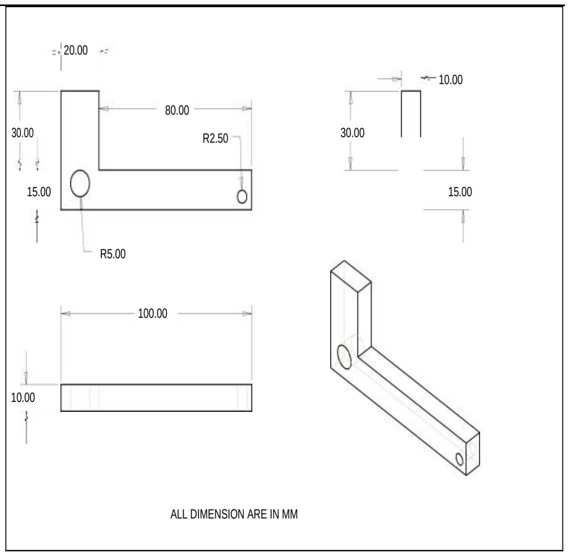
(a)



(b)



(c)



(d)

Fig11: Details of Tool Geometry and its relevant parts. (b) – Peeling Knife (De husking Tool)

Finite Element Analysis (FEA) and Testing of coconut husk extracting tool (Ansys 16.0) :-

a) Modeling :-

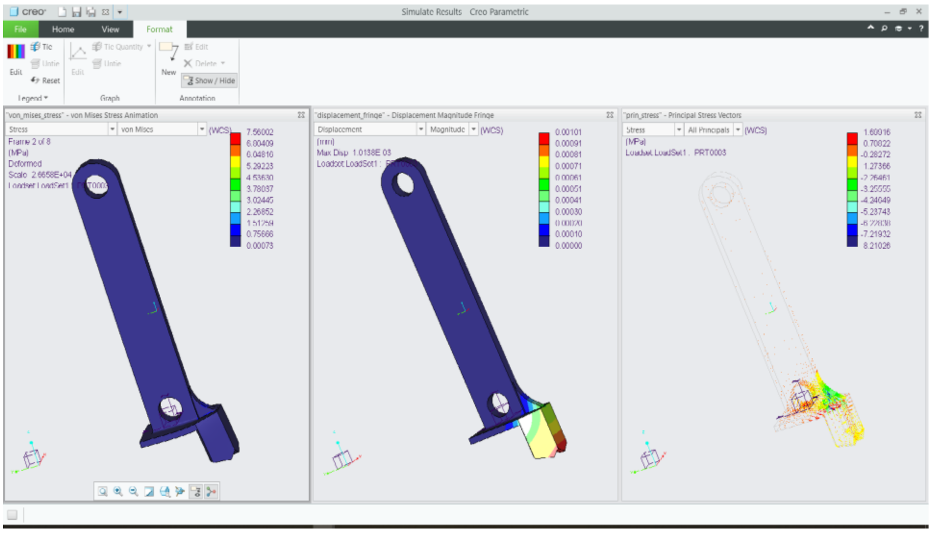


Fig 12 :- Model of Coconut Husk Extracting Tool.

b) Meshing

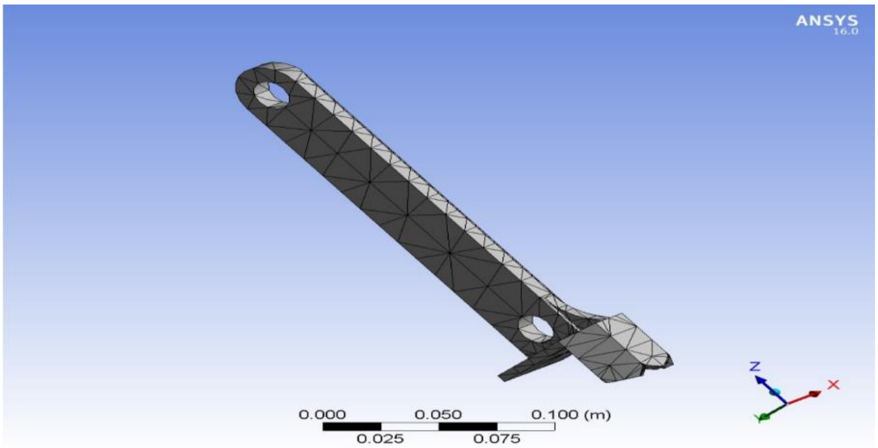


Fig 13 :- Meshing of Coconut Husk Extracting Tool.

c) Fixed loading support

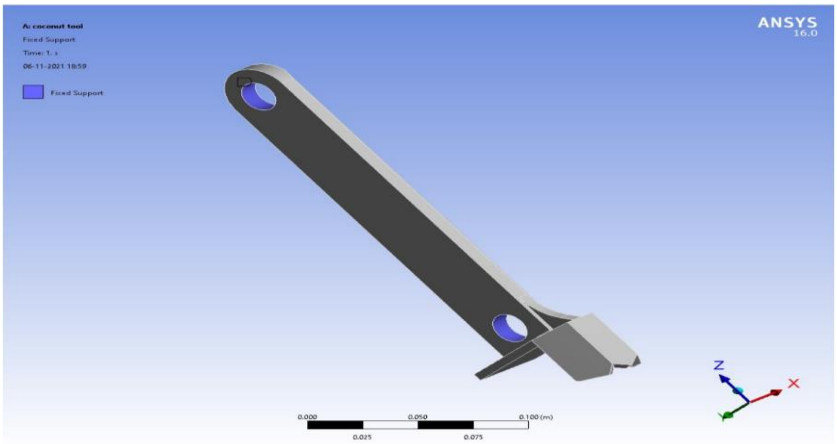


Fig 14 :- Fixed support of Coconut Husk Extracting Tool.

d) Force

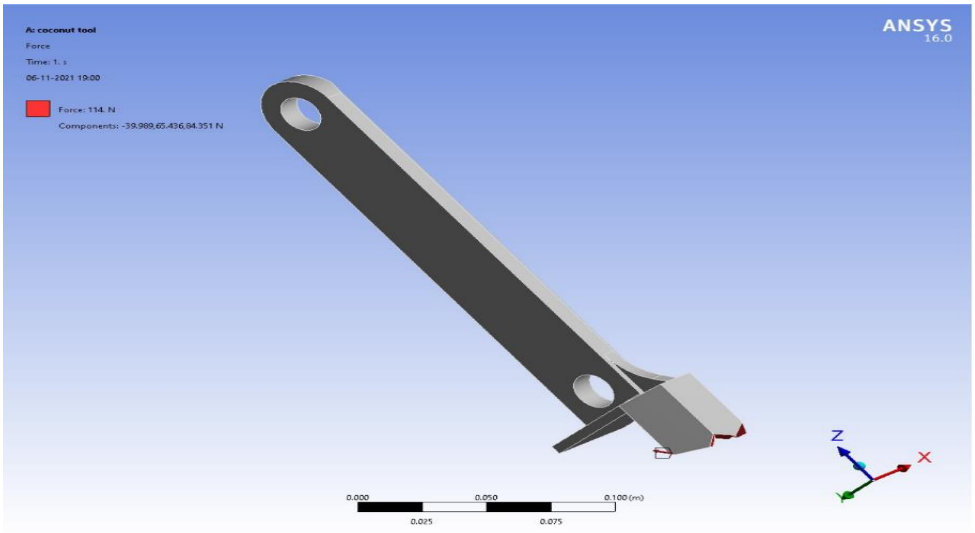


Fig 15 :- Force Analysis of Coconut Husk Extracting Tool.

The force analysis on conditions for peeling of coconut fibrous husk gave the value of 114 N.

e) Shear Stress

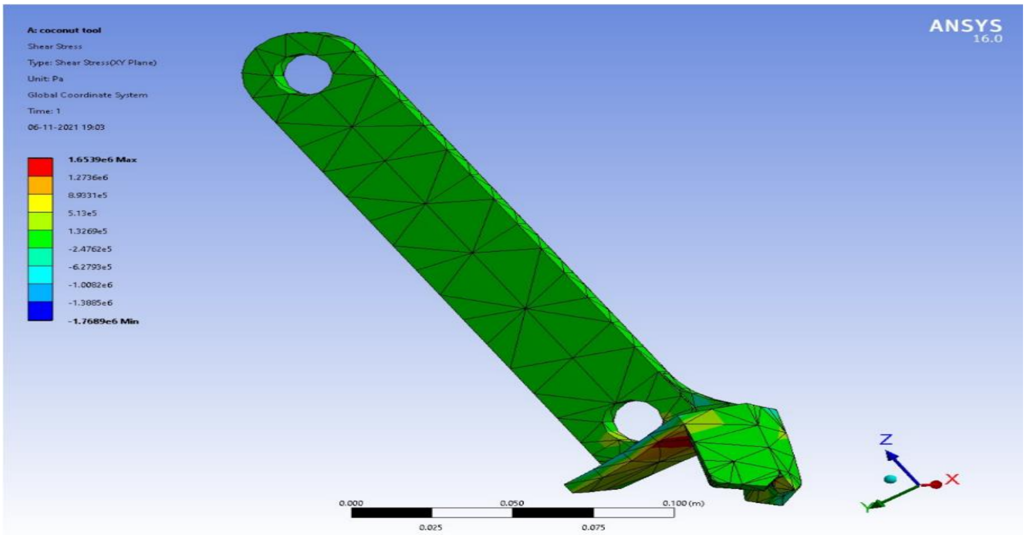


Fig16 :- Shear Stress of Coconut Husk Extracting Tool

The fig above shows the shear stress of the coconut husk extracting tool .The maximum value obtained was 1.6539 x 10^6, the Intermediate value was 1.3269 x 10^5 and the minimum value obtained -1.7689 x 10^6 .

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f) Equivalent Stress (von Mises) :-

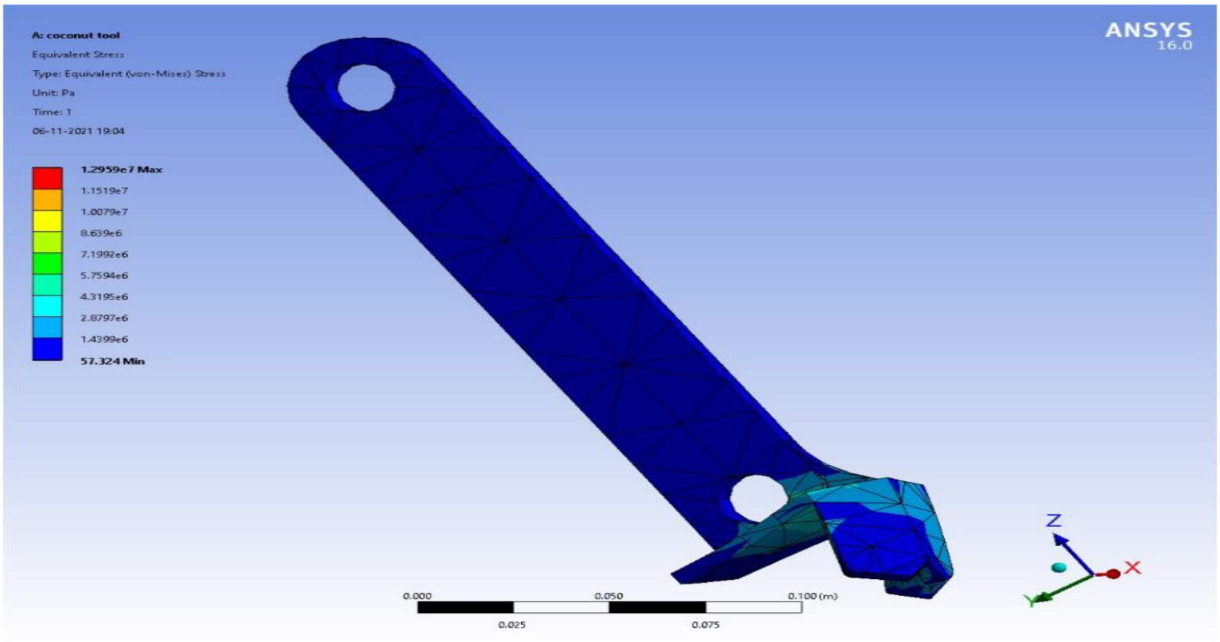


Fig 17 :- Equivalent (von Mises) Stress of Coconut Husk Extracting Tool.

The fig above shows the equivalent (von Mises) stress of the coconut husk extracting tool .The maximum value obtained was 1.2959 x 10^7, the Intermediate value was 7.1992 x 10^6 and the minimum value obtained 57.324.

g) Shear Elastic Strain

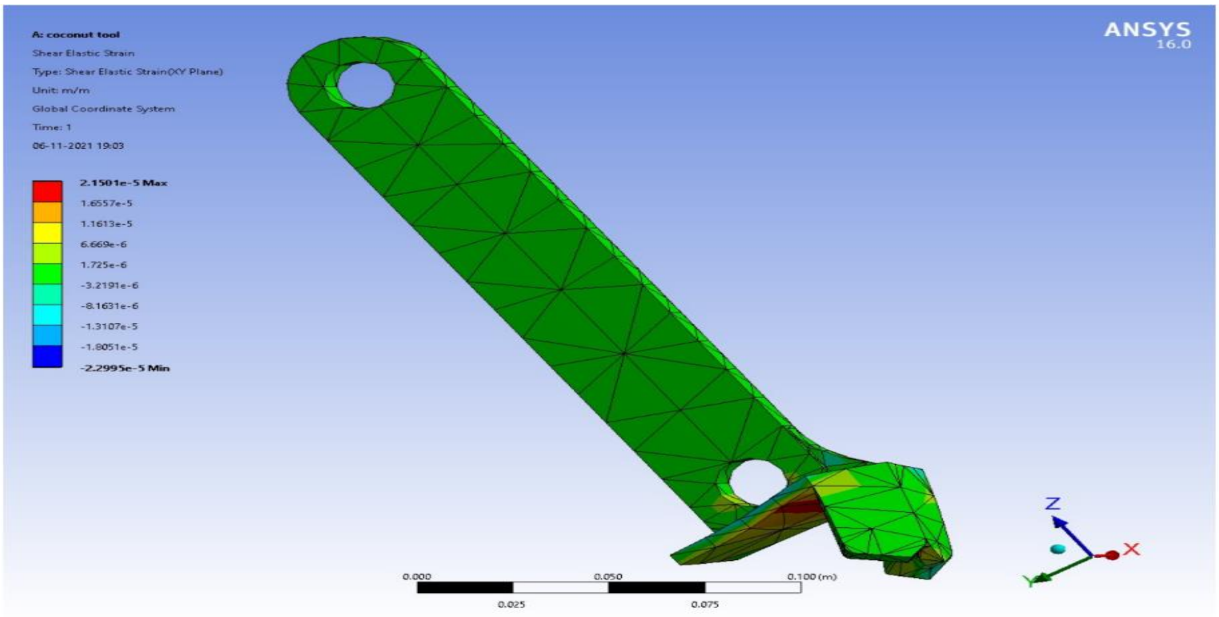


Fig 18 :- Shear Elastic Strain of Coconut Husk Extracting Tool

The fig above shows the shear elastic strain of the coconut husk extracting tool .The maximum value obtained was 2.1501 x 10^{-5}, the Intermediate value was 1.725x 10^{-6} and the minimum value obtained -2.2995 x 10^{-5} .

h) Equivalent Elastic Strain

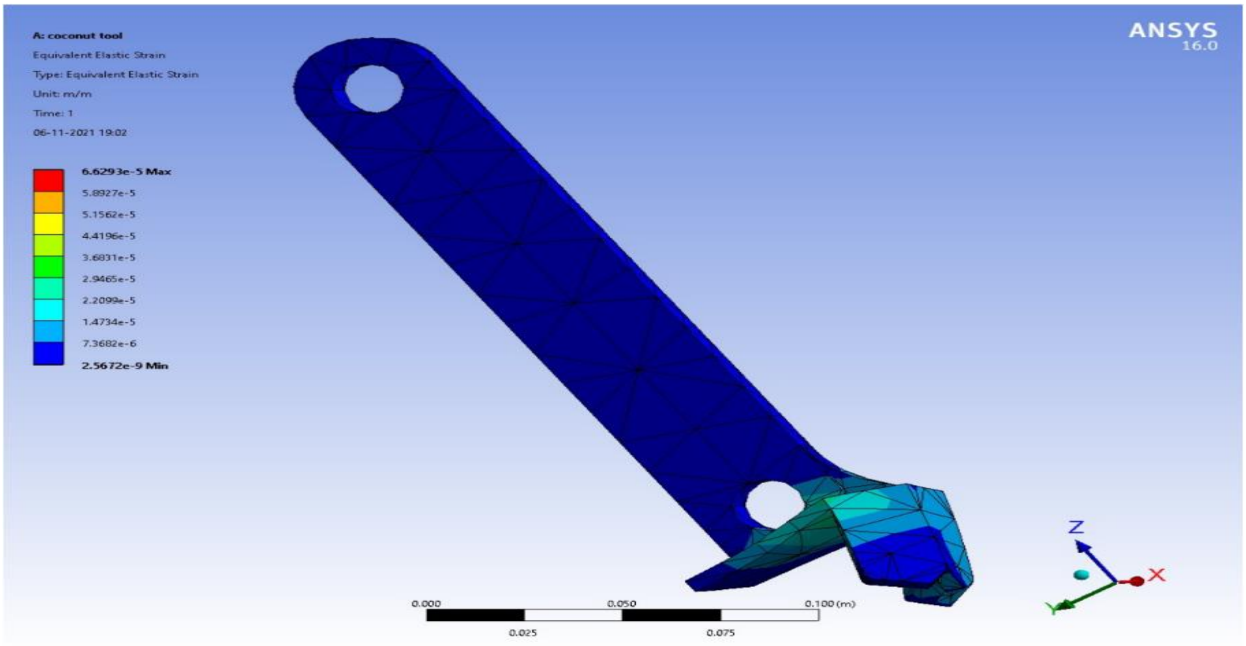


Fig 19 :- Equivalent Elastic Strain of Coconut Husk Extracting Tool.

The fig above shows the equivalent elastic strain of the coconut husk extracting tool .The maximum value obtained was 6.6293 x 10^{-5}, the Intermediate value was 3.6831 x 10^{-5} and the minimum value obtained was 2.5672 x 10^{-9} .

i) Directional Deformation

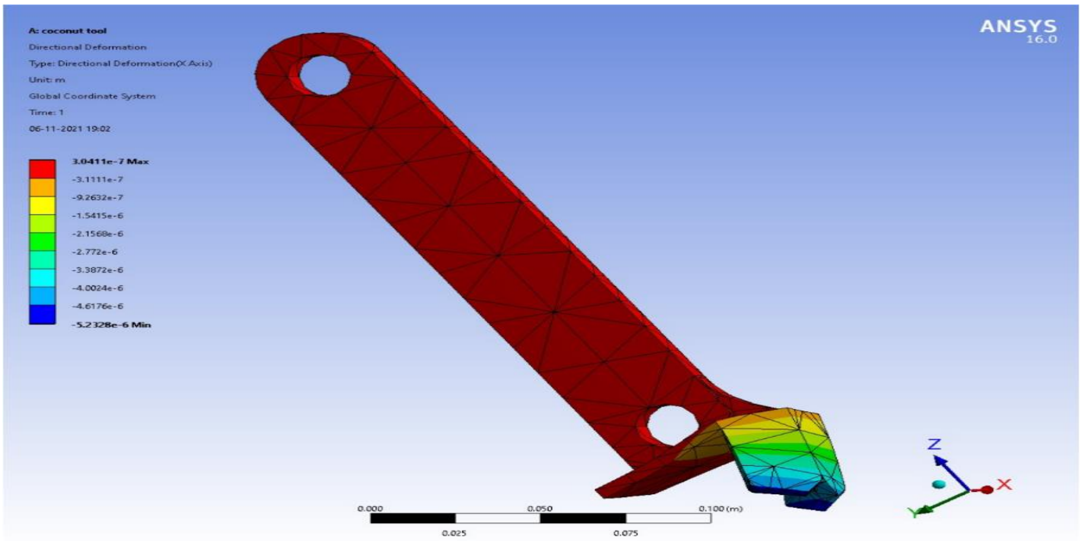


Fig 20 :- Directional Deformation of Coconut Husk Extracting Tool.

The fig above shows the directional deformation of the coconut husk extracting tool along X-Axis. The maximum value obtained was 3.0411 x 10^{-7} , the Intermediate value was -2.1568 x 10^{-6} and the value obtained was -5.2328 x 10^{-6} .

j) Total Deformation

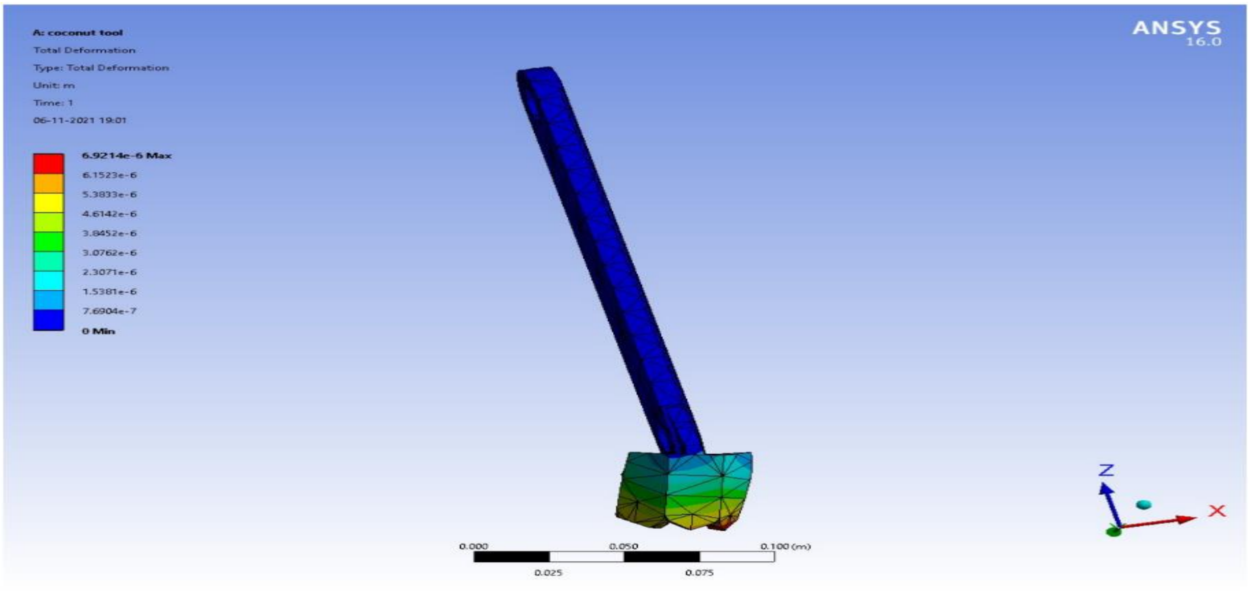


Fig 21 :- Total Deformation of Coconut Husk Extracting Tool

The fig above shows the total deformation of the coconut husk extracting tool .The maximum value obtained was 6.9214 x 10^{-6}, the Intermediate value was 3.8452 x 10^{-6} and the minimum value obtained -7.6904 x 10^{-7} .

k) Safety Factor

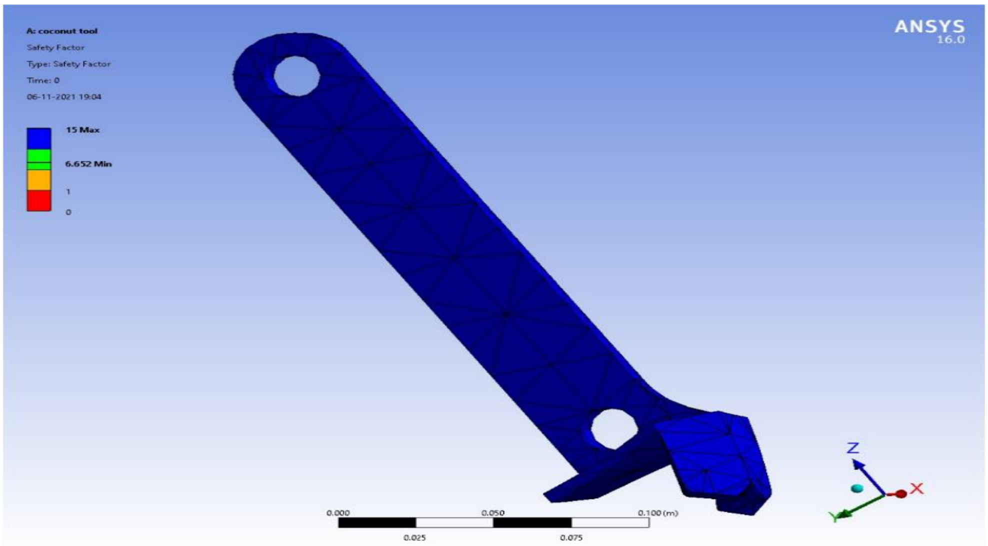


Fig 22 :- Safety factor of Coconut Husk Extracting Tool.

The maximum safety factor was considered as 15 and the minimum safety was considered to be 6.652 .

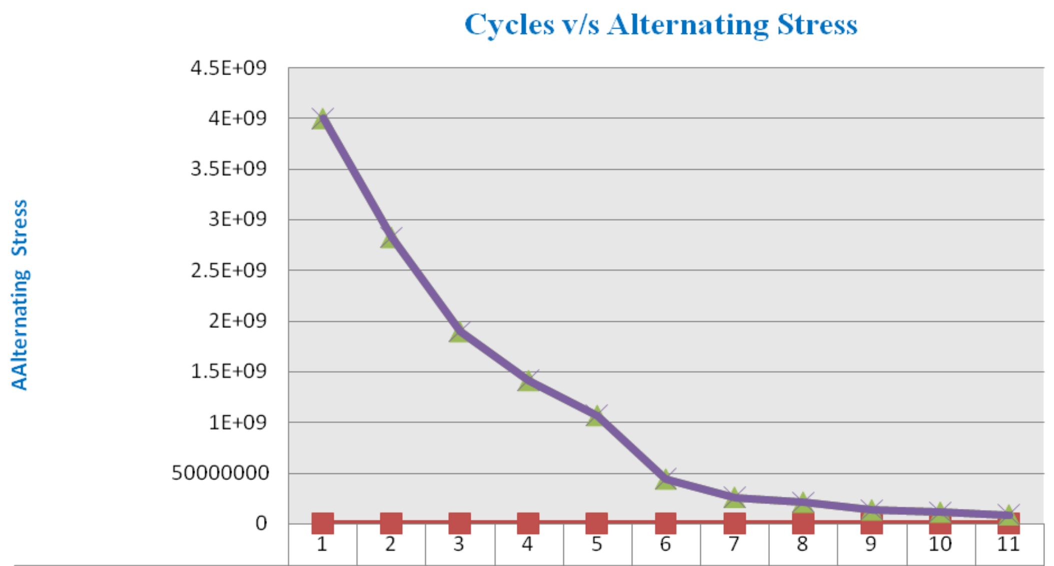
Table 2 : Material data for medium carbon (0.25 to 0.55%) structural Steel.

Sr No	Mechanical Properties of Material	Value obtained
1	Density	7850 Kg/m^3
2	Tensile Yield Strength	2.5 x 10^8 Pascal
3	Tensile Ultimate Strength	4.6 x 10^8 Pascal
4	Compressive Yield Strength	2.5 x 10^8 Pascal
6	Young's Modulus	2.0 x 10^{11}
7	Poisson's Ratio	0.3
8	Bulk Modulus	1.6667 x 10^{11}
9	Shear Modulus	7.6923 x 10^{10}
10	Isotropic coefficient of Thermal Expansion	22^0 C

Table 3 : Alternating Stress and cycles of Structural Steel.

Sr No	Cycles	Alternating Stress Pa	Mean Stress Pa
1	10	3.999e+009	0
2	20	2.827e+009	0
3	50	1.896e+009	0
4	100	1.413e+009	0
5	200	1.069e+009	0
6	2000	4.41e+008	0
7	10000	2.62e+008	0
8	20000	2.14e+008	0
9	1.e+005	1.38e+008	0
10	2.e+005	1.14e+008	0
11	1.e+006	8.62e+007	0

Graphical behavior of Structural Steels in terms of stress developed at number of cycles



	1	2	3	4	5	6	7	8	9	10	11
Mean Stress (Pa)	0	0	0	0	0	0	0	0	0	0	0
Alternating Stress (Pa)	4.00E	2.83E	1.90E	1.41E	1.07E	4.41E	2.62E	2.14E	1.38E	1.14E	8.62E
Cycles	10	20	50	100	200	2000	10000	20000	1.00E	2.00E	1.00E
Sr no	1	2	3	4	5	6	7	8	9	10	11

Fig 23 :- Graphical representation of Alternating stress v/s Cycles.

CONCLUSION:-

1. For the shear stress of the coconut husk extracting tool the maximum value obtained was 1.6539 x 10^6, the Intermediate value was 1.3269 x 10^5 and the minimum value obtained -1.7689 x 10^6 .

2. For the shear elastic strain of the coconut husk extracting tool, the maximum value obtained was 2.1501 x 10^{-5}, the Intermediate value was 1.725x 10^{-6} and the minimum value obtained -2.2995 x 10^{-5} .

3. For the total deformation of the coconut husk extracting tool .The maximum value obtained was 6.9214 x 10^{-6}, the Intermediate value was 3.8452 x 10^{-6} and the minimum value obtained -7.6904 x 10^{-7}

4. The force analysis on conditions which are similar for peeling of coconut fibrous husk gave the value of 114 N.

5. Relevant to the de husking properties of coconut and the thorough study of Engineering properties of material the structural steel with medium carbon content ranging (0.25 – 0.55 % carbon) was used to develop the coconut husk extracting tool which met the standard design requirement for extracting or peeling of coconut fibrous husk.

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