Design and Analysis of Manually Operated Sisal Fibre Extraction Machine

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Abstract - *The focus of the project is to design and analyze sisal fibre extracting machine which can be operated manually to extract fibres from sisal leaf. Thus, the aim of the project is to develop a machine which consumes absolutely no electricity and yields good quality of fibre to increase the productivity and also to encourage small scale industries to use this machine instead of old-time consuming methods. The demand of natural fibres is increasing in the world for industrial uses to make high value products. An enormous potential of sisal fibre is present for making ropes, twines, paper, carpets, cloth and handicrafts, which has not been exploited so far. The aim of this study was to design and develop a small-scale portable sisal decorticator for extracting fibre from sisal leaves. Sisal fibre needs to be washed, dried and brushed after decortication process for getting good quality fibre to make domestic products. This technology has a great potential and needs to be commercialized in sisal growing areas of the country.*

***Key Words*: Sisal leaves, Sisal fibres, manually operated, Natural fibres, Blunt blades etc**

1.INTRODUCTION

Many plants produce fibre from their fruits, seeds, stems and leaves, such as coir, cotton, kapok, hemp, ramie, flax, kenaf, jute, nettle, manila, abaca, bamboo and sisal. Sisal (Agave sisalana) is a fibrous plant, which is originated from Mexico (Chand and Rohatgi, 1994), but widely cultivated and naturalised in many other countries, such as Brazil, China, Kenya, Tanzania, Madagascar and Mozambique. The Sisal plant has a shallow root system that goes about 0.6 m deep and has 7-10 years life. Sisal is cut first time after 2-3 years and is subsequently cut after every 6-12 months. Sisal can be grown in wasteland, dryland and in saline soils and it can withstand severe drought conditions. Sisal fibre is mostly used in cordage industry due to its great strength, better spinning characteristics resistance to the action of saline water. Sisal fibre is considered a renewable resource with several environmental advantages over glass fibres, which is mostly used to make baler twines in agriculture. Other important traditional uses include making carpets, rugs, sacks, yarns, general and marine ropes and other domestic products. Sisal leaves are harvested manually using a sickle. A mature leaf attains a length of about 0.6 to 2.0 m.

Fig-1: Sisal plants

As we know plastic is choking the world right now, natural fibres can be good alternative for plastic. In this paper we will be designing a sisal fibre extraction machine which can be operated manually using Catia V5 R21 modelling software. And then in later part we will analysing the different parts of the machine to obtain stresses and total deformation using ANSYS software.

2. METHODS OF FIBRE EXTRACTION

2.1 Traditional method

In the past, the fibre was extracted manually by scraping away the pulpy matter with a blunt knife. Sometimes, leaves were cut longitudinally into thin ribbons and immersed in water till the pith matter was separated from the fibre. After retting, the fibre was washed and dried in the sun. Sometimes sisal leaves were boiled in water and beaten to remove the pithy matter from fibre, which was then washed and dried. Then those fibres are used as ropes and other items. However, hand processing of sisal leaves is a tedious, laborious and slow exercise resulting in low productivity and low quality of the fibre. Moreover, the acidic sap released during manual decortication causes skin irritation and discomfort.

2.2 Using machinery

In southern part of America and Africa these fibres were extracted for commercial purposes, so large amount of fibres was extracted. And tradition method was not an efficient method for this requirement hence fibre extraction machine is used. This machine consists of blade which squeezes out the pulp out of the leaf and fibre will be left out. These machines usually use diesel engine or electric motor to rotate the blade. In this project we are going to design a manually operated machine which uses neither of them.

3. DESIGN

In this project our main idea was to design a simple machine which can be used by farmers or in small-scale industries. And to make sure the machine completely runs on manual power that is which does not use electricity or any form of fuel, which will be helpful for farmers to extract fibre with minimum investment. And to make sure to design a portable machine which can be carried to the any place and fibres can be extracted. So, this machine has several parts out of which the main part is blade. This blade has blunt edges and rotates at a certain rpm, when the sisal leaf is fed the blunt edges scrapes out the pulp from the leaves exposing the fibres. The fibres are then processed for the particular use.

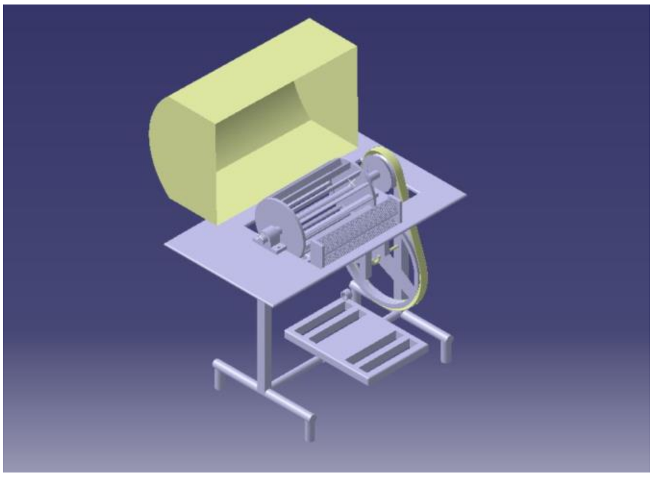

Fig-2: Iso-metric view of the machine

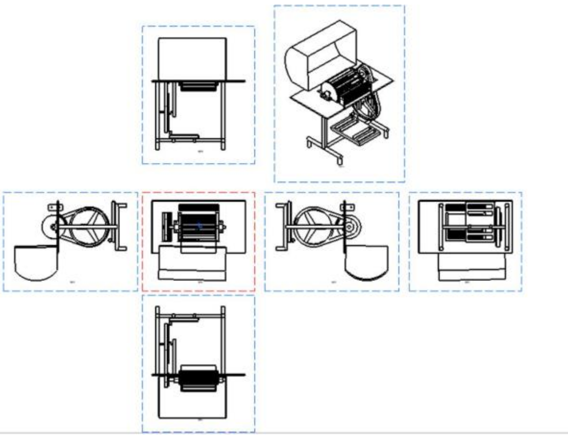

Fig-3: Draft of design

Table -1: Parts list

SL no	Part name	Quantity
1	Frame	1
2	Blade	1
3	Shaft	1
4	Bearing	2
5	Bearing housing	2
6	Driven wheel	1
7	Driver wheel	1
8	Belt	1
9	Pedal	1
10	Connecting rod	1
11	Covering shed	1

The pedal is operated by human by stepping on it. The to and fro motion of the pedal in converted to rotary motion by the connecting rod, which rotates the driver wheel. The driver wheel is attached to the driven wheel with a belt, so the driver wheel rotates the driven wheel, which is attached the shaft and the shaft is attached to the blade. This is how the blade is rotated manually.

4. CALCULATIONS

- Design dimensions-
  Diameter of driver = 330 mm (d1)
  Diameter of driven = 100 mm (d2)
- Minimum speed required to run the machine= 300 rpm (n2) (assumed)
- Center distance = 305 mm (a)

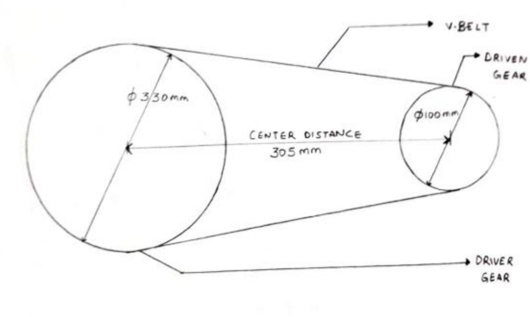

Fig-4: Center distance

- Velocity ratio is given by
  r = d1/d2 = 330/100 = 3.3
- Speed at which driver should rotate (n1)
  n2/n1 = d1/d2
  3.3 = 300/n1
  n1 = 90 rpm
- Belt length
  $L = \pi(r2 + r1) + 2x + (r1 - r2)^2/x$
  $L = \pi(165 + 50) + (2*305) + (165 - 50)^2/305$
  L = 1330 mm
- Young's modulus of sisal fibre (approx.) = 10 GPa
- Force/torque required to squeeze the pulp from the leaf
  Leaf specifications
  L = 400 mm
  B = 100 mm
  Thickness (h) = 8 mm
  E = 10 GPa
  y = 4 mm (approx.)
  $\text{Force(f)} = \frac{48yEI}{L^3}$, $I = Bh^3/12$
  f = 128 N
  Note: - This is not the force required at the leg pedal. It should be more than 128 N
  (To overcome friction and other losses)
- Torque = f * r
  T = 128 * 50
  T = 6400 N-mm
  T = 6.4 N-m
- Power required at the driven (drum)
  $P = 2\pi NT/60$ (N = n1)
  P = 60.31 watt

5. ANALYSIS

Structural analysis for the parts frame, pedal and belt is done to obtain the maximum and minimum values of total deformation, stress and strain. SFD and BMD for shaft is done. The software used for analysis was ANSYS 16.

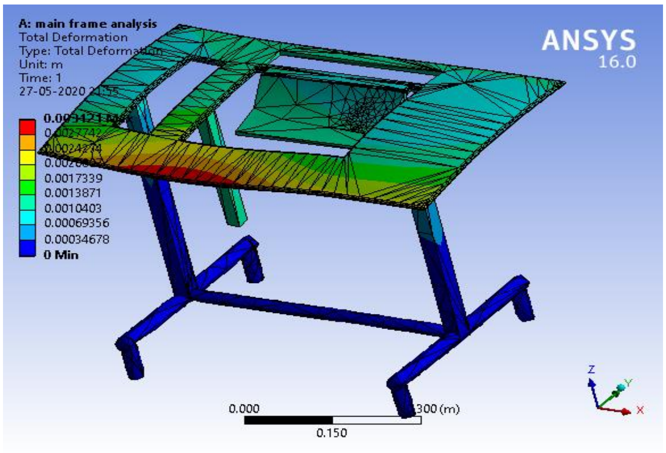

Fig-5: Total deformation of frame

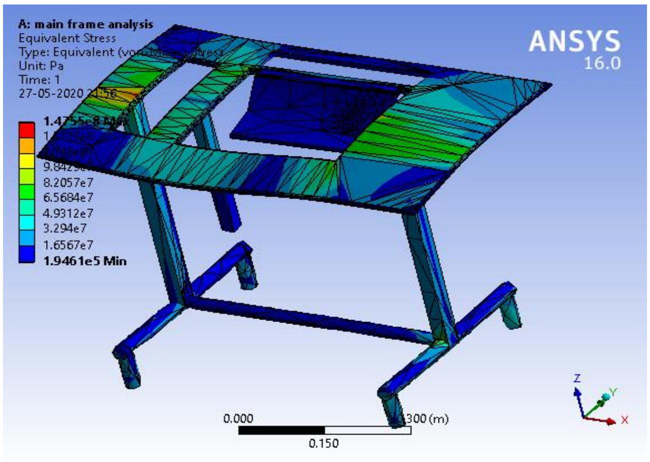

Fig-6: Equivalent stress of frame

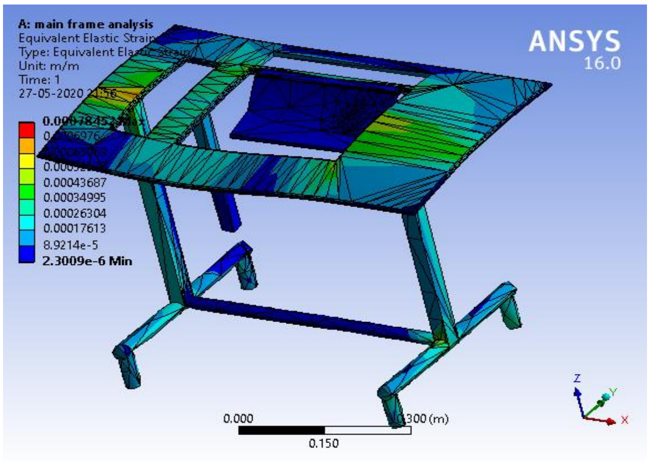

Fig-7: Equivalent strain of frame

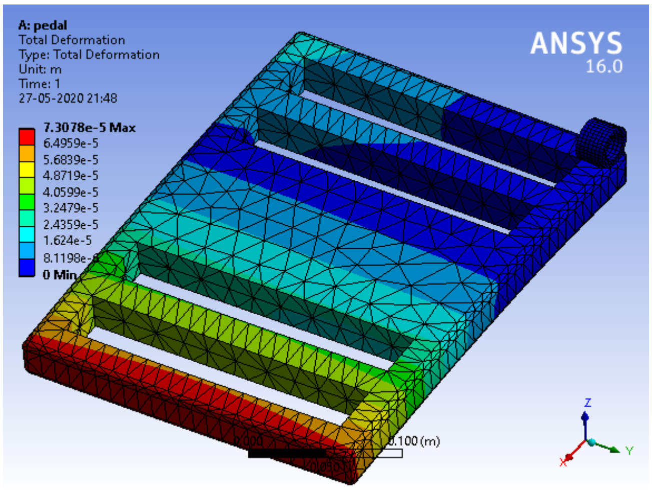

Fig-8: Total deformation of pedal

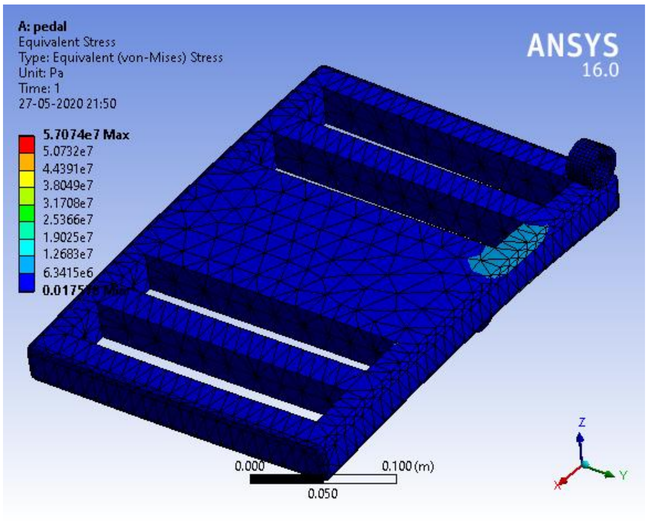

Fig-9: Equivalent stress in pedal

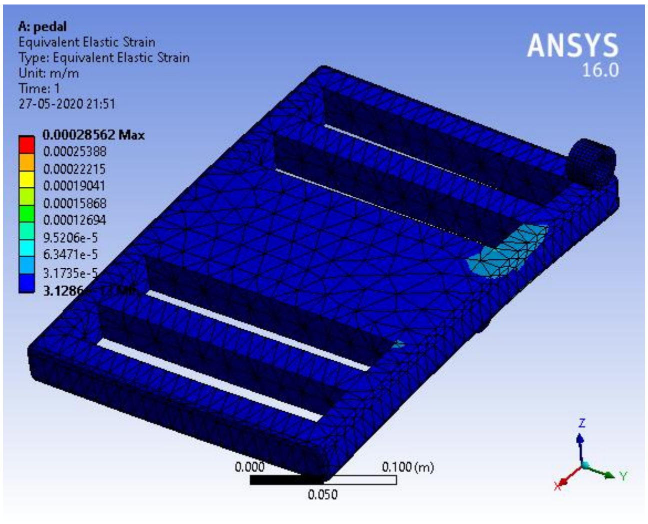

Fig-10: Equivalent strain in pedal

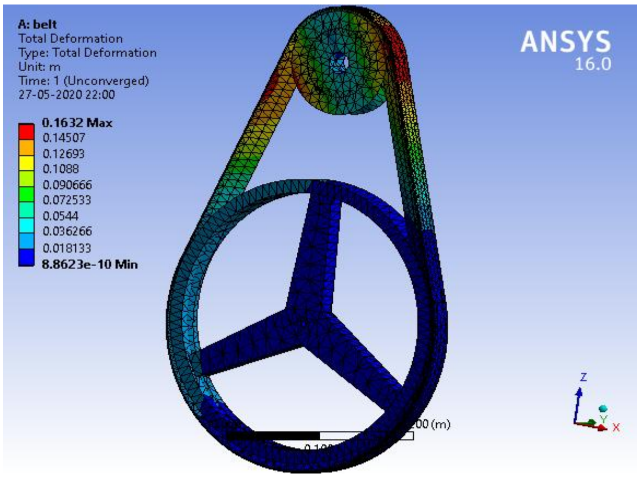

Fig-11: Total deformation of belt

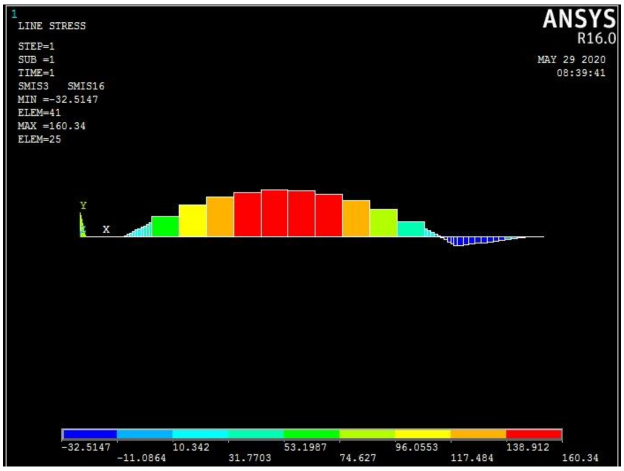

Fig-12: SFD of shaft

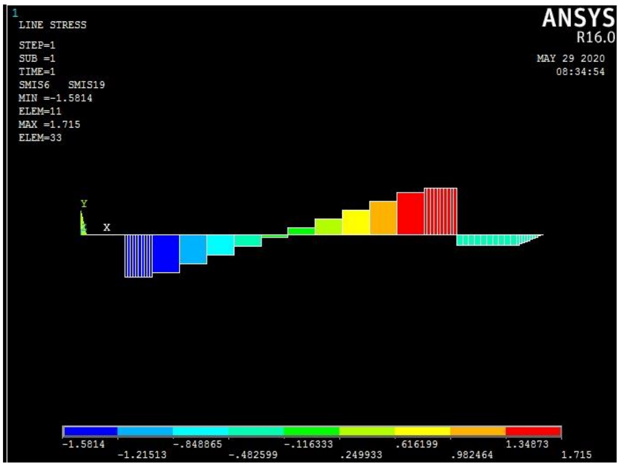

Fig-13: BMD of shaft

Table -2: Analysis values

SL no	Part name	Max Deformation (m)	Max Stress (Pa)	Max Strain (m/m)
1	Frame	0.003121	1.475e8	0.007845
2	Pedal	7.3078e-5	5.707e7	0.0002856
3	Belt	0.1632	-	-

Table -3: Shear force and bending moment values

Sl no	Part name	Max Shear force (N)	Max Bending moment (N-mm)
1	Shaft	160.34	1.715

6. CONCLUSIONS

A manually operated Sisal fibre extraction machine was designed and analysed in this paper. The demand for natural fibre will increase in the coming future. So, this machine can be used by the farmers or small-scale industries to produce fibres. The quality of fibres extracted from this machine may not be similar to the once extracted using diesel engine or electric motor-powered machine and the productivity will also be less, but the main advantage of this machine is, it can be completely operated manually without using any form of fuel or electricity. So, this technology will be cost efficient for farmers and small-scale industries.

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