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Design and Analysis of Solar Food Cutter with Shaft Mounted Speed Reducer for Agricultural Field Application

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ABSTRACT

Indian agriculture has a lot of dependency on farm labour for many kinds of operation. The main products of the farm are needed to be harvested. Now-a-days the cutting of fruits; flowers and vegetables are done by snips. Hence the main purpose now-a-days is to reduce the labour hours. Thus taking into account the fact that the development of a portable, light weight multi-purpose agricultural cutter using solar powered 12volts D.C motor is required. For this purpose the development of the cutter and then the shaft mounted speed reducer gear box is to be done. After development of cutter, the stress developed at the cutting edge and force acting on entire linkage will be measured. Then these stresses will be evaluated in ansys by applying proper boundary condition. Again different material will be tested and examined for manufacturing.

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I. INTRODUCTION

Agriculture is an important part of the Indian economy and culture, and it can play an important role in distributed generation of energy. This project concept identifies the opportunities for solar energy use in agriculture. Farmers have the tradition of being stewards of the land, and their investment in renewable energy supports their role of protecting the land, air, and water. Solar energy, like other renewable, offers an opportunity to stabilize energy costs, decrease pollution and greenhouse gases (GHGs), and delay the need for electric grid infrastructure improvements. Solar energy systems have low maintenance costs, and the fuel is free once the higher initial cost of the system is recovered through subsidies and energy savings (from reduced or avoided energy costs).

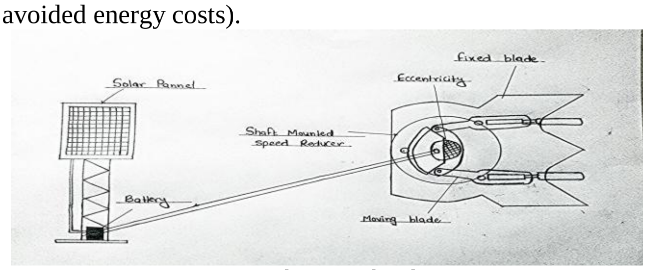

Fig. 1 Solar Agricultural Cutter

I. LITERATURE REVIEW

"Chiu-Fan Hsieh" in his paper titled "The effect on dynamics of using a new transmission design for eccentric speed reducers" has stated new transmission design for eccentric speed reducers that differs from that used with a traditional cycloid speed reducer. This paper proposes a new transmission design for eccentric speed reducers that differs from that used with a traditional cycloid speed reducer [1].

"R. Joshua, V. Vasu and P. Vincent" in his paper titled "Solar Sprayer - An Agriculture Implement" has stated that, Energy - demand is one the major thread for our country and finding solutions, to meet the "Energy - demand" is the great challenge [2].

"Ketchpel, „Jr. et al." in his patent has stated that, A shear for grass and the like includes a tooth plate on which is pivotally mounted a plurality of shearing members, each including a narrow and resiliently deformable blade element [3].

"Hemant Ingale, N.N.Kasat" in his paper titled "Automated Solar Based Agriculture Pumping" he stated that, Solar power is absolutely perfect for use with irrigation systems for gardens, allotments, greenhouses, and polytonal. When the sun is shining you need more water and so the solar power is there for the pump. By adding a suitable deep-cycle leisure/marine battery, power can be made available 24 hours per day enabling watering in the evening - the best time to water plants in the summer so that the water has a chance to soak into the ground [4].

II. DESIGN AND DEVELOPMENT

The development of concept is divided into three steps:

- Design of System
- Design of Parts

Design of system mainly concerns the various physical constraints and ergonomics, space requirements, arrangement of various components on main frame at system, man and machine interactions, No. of controls, position of controls, working environment of machine, chances of failure, safety measures to be provided, servicing aids, ease of maintenance, scope of improvement, weight of machine from ground level, total weight of machine and a lot more.

In design of parts the components are listed down and stored on the basis of their procurement, design in two categories namely,

- ✓ Designed Parts
- ✓ Parts to be purchased

A. Design of system

In system design we mainly concentrated on the following parameters:

- ✓ System Selection Based on Physical Constraints

While selecting any machine it must be checked whether it is going to be used in a large-scale industry or a small-scale industry. In our case it is to be used by a small-scale industry, so space is a major constrain.

- ✓ Arrangement of Various Components

Keeping into view the space restrictions the components should be laid such that their easy removal or servicing is possible.

- ✓ Components of System

As already stated the system should be compact enough so that it can be accommodated at a corner of a room. All the moving parts should be well closed & compact.

- ✓ Man Machine Interaction

The friendliness of a machine with the operator that is operating is an important criteria of design.
Following are some of the topics included in this section.

- Design of foot lever
- Energy expenditure in foot & hand operation
- Lighting condition of machine.

- ✓ Chances of Failure

The losses incurred by owner in case of any failure are important criteria of design. Factor safety while doing mechanical design is kept high so that there are less chances of failure.

- ✓ Servicing Facility

The layout of components should be such that easy servicing is possible.

- ✓ Height of Machine from Ground

For ease and comfort of operator the height of machine should be properly decided so that he may not get tired during operation.

- ✓ Weight of Machine

The total weight depends upon the selection of material components as well as the dimension of components.

B. Design of Parts

Mechanical design phase is very important from the view of designer .as whole success of the project depends on the correct deign analysis of the problem.

Many preliminary alternatives are eliminated during this phase. Designer should have adequate knowledge above physical properties of material, loads stresses, deformation, and failure. Theories and wear analysis, He should identify the external and internal forces acting on the machine parts.
Selection of factors of safety to find working or design stress is another important step in design of working dimensions of machine elements. The correction in the theoretical stress values are to be made according in the kind of loads, shape of parts & service requirements.

The parts to be purchased directly are selected from various catalogues & specification so that anybody can purchase the same from the retail shop with the given specifications.

Following are the various design components:

- Design of multipurpose agricultural cutter.
- Design of Shaft mounted speed reducer.
- Motor selection.

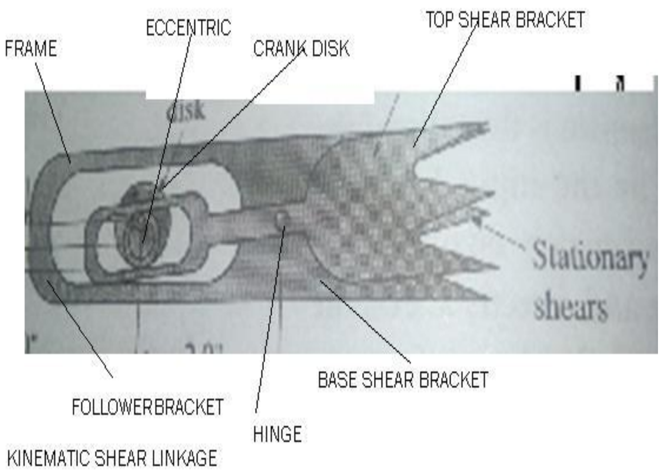

Fig. 1 Agricultural Cutter

Designation	Ultimate Tensile Strength N/mm^2	Yield Strength N/mm^2
EN 24	800	680

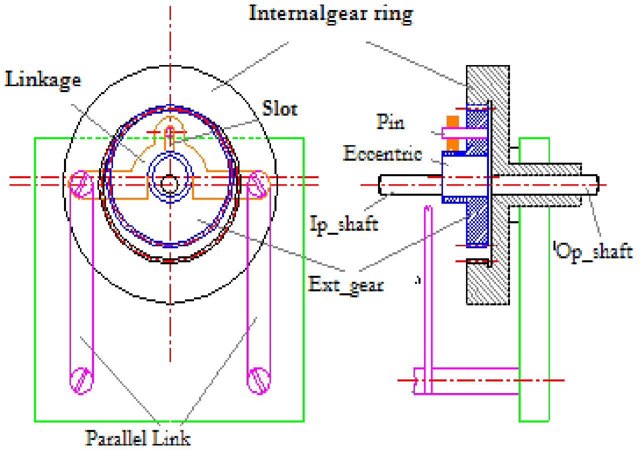

Fig. 2 Speed Reducer

Design of input shaft
As Per ASME Code

fs_{max} = 0.18 fult
= 0.18 x 800
= 144 N/mm^2

OR

fs_{max} = 0.3 fyt
= 0.3 x 680
= 204 N/mm^2

Where,

fs_{max} = Maximum factor of safety.

considering minimum of the above values;

⇒ fs_{max} = 144 N/mm^2

Shaft is provided with key way; this will reduce its strength. Hence reducing above value of allowable stress by 25%

⇒ fs_{max} = 108 N/mm^2

This is the allowable valve of shear stress that can be induced in the shaft material for safe operation.

To Calculate Input Torque

$$POWER = \frac{2\pi NT}{60}$$

$$\Rightarrow T = \frac{60 \times P}{2\times\pi\times N} = \frac{60\times 50}{2\times\pi\times N}$$

Assuming operation speed = 800 rpm.

$$= \frac{60\times 50}{2\times\pi\times 800}$$

⇒ T = 0.5968 N.m

Assuming 100% overload.

⇒ T design = 2 x T
= 2 x 0.5968 x 10^3
= 1.19 x 10^3 N.mm.

- **Check for Torsional Shear Failure of Shaft.**

Assuming minimum section diameter on input shaft = 16 mm

⇒ d = 16 mm
Td = Π/16 x fs_{act} x d^3

$$\Rightarrow fs_{act} = \frac{16\times Td}{\pi\times d^3} = \frac{16\times 1.19\times 10^3}{\pi\times 16^3}$$

⇒ fs_{act} = 1.47 N/mm^2

Where,

fs_{act} = Actual factor of safety.

As $fs_{act} < fs_{all}$

⇒ I/P shaft is safe under torsional load

Design of output shaft
Using ASME code of design;

fs_{max} = 0.18 fult
= 0.18 x 800
= 144 N/mm^2

OR

fs_{max} = 0.3 fyt
= 0.3 x 680
= 204 N/mm^2

considering minimum of the above values;

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Shaft is provided with key way; this will reduce its strength. Hence reducing above value of allowable stress by 25%

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Designation	Ultimate Tensile Strength N/mm^2	Yield Strength N/mm^2
EN 24	800	680

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⇒ T = 0.5968 N.m

Assuming 100% overload.

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- **Check for Torsional Shear Failure of Shaft.**

Assuming minimum section diameter on input shaft = 16 mm

⇒ d = 16 mm
Td = π/16 x fs_{act} x d^3

$$\Rightarrow fs_{act} = \frac{16\times Td}{\pi\times d^3} = \frac{16\times 1.19\times 10^3}{\pi\times 16^3}$$

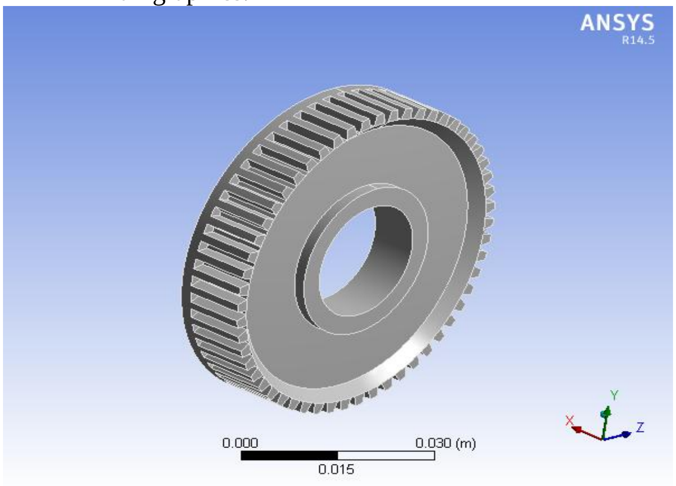
⇒ fs_{act} = 1.47 N/mm^2

As $fs_{act} < fs_{all}$

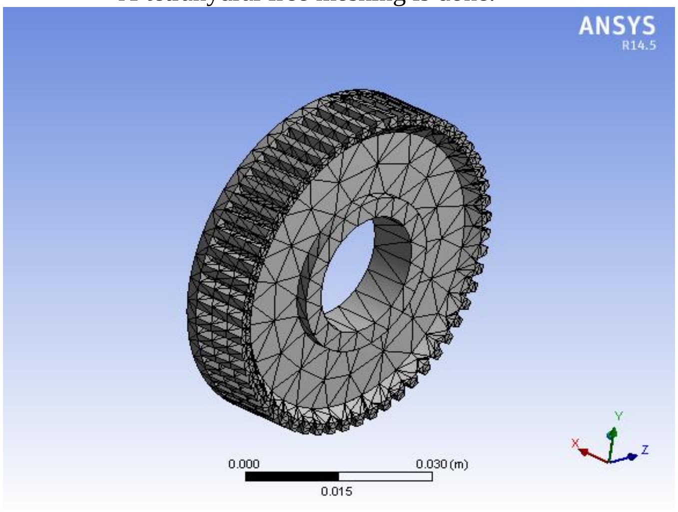
⇒ 0/P shaft is safe under torsional load

C. Modelling and Analysis of Components

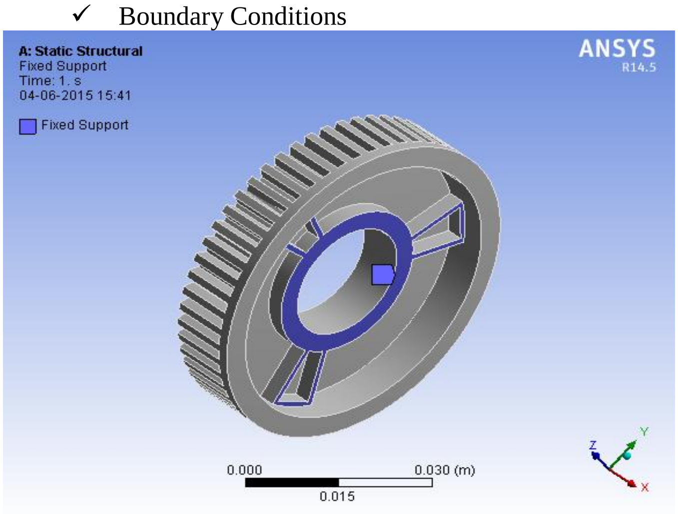
- Design of Delrin Gear
  - ✓ Modelling of Delrin Gear is done in unigraphics.



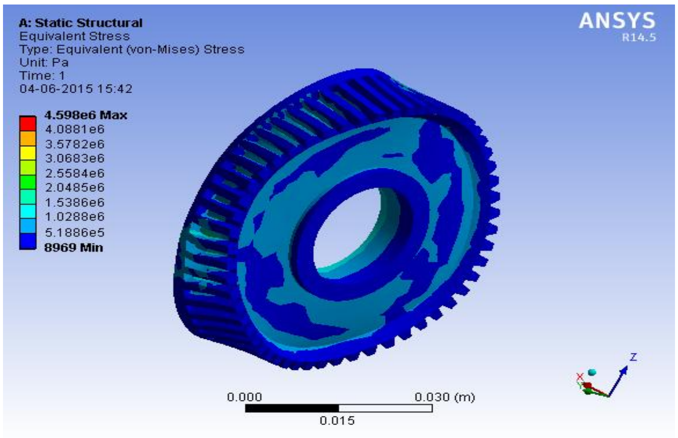
  - ✓ A tetrahydral free meshing is done.



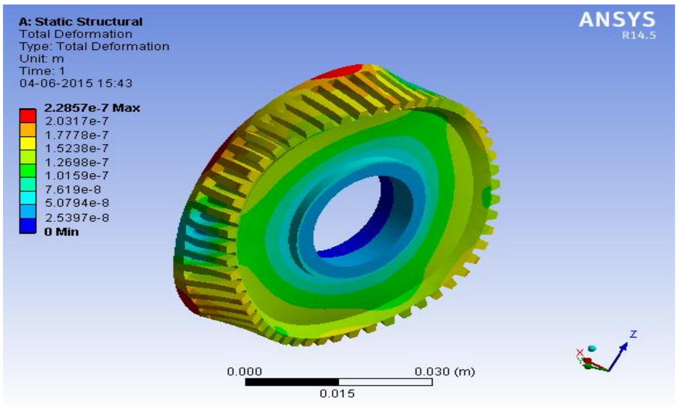
  - ✓ Boundary Conditions



  - ✓ Results

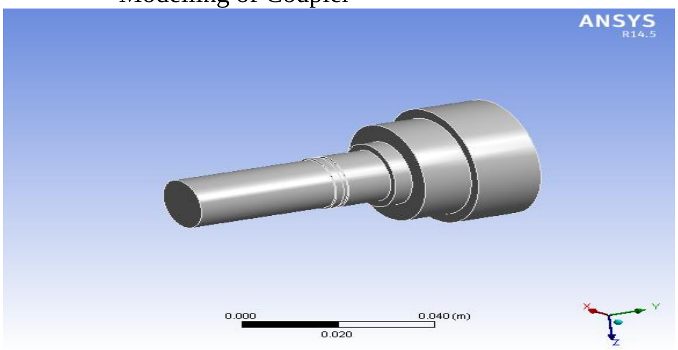


Equivalent Stress

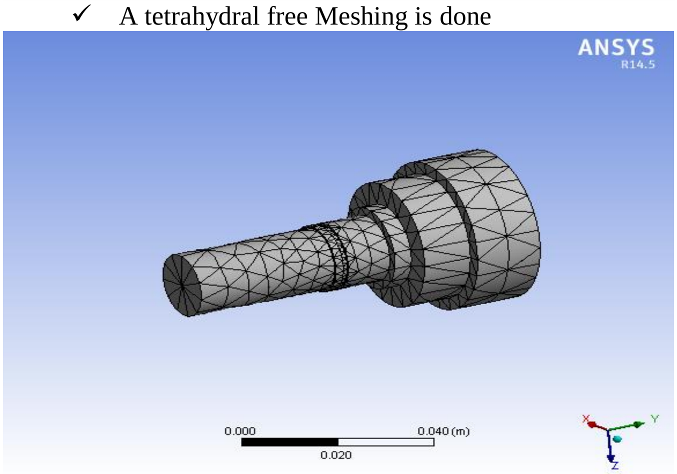


Total Deformation

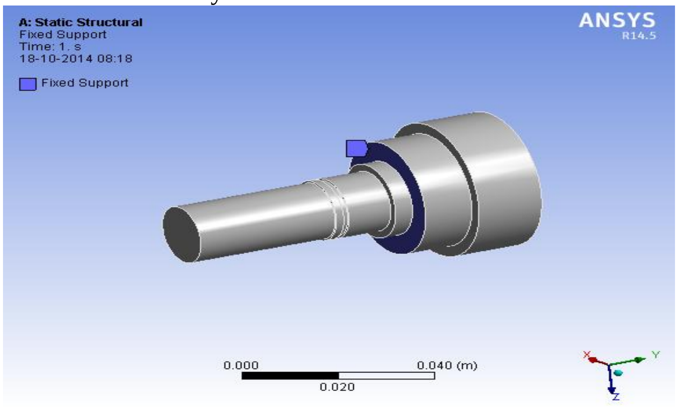
- Design of Coupler
  - ✓ Modelling of Coupler



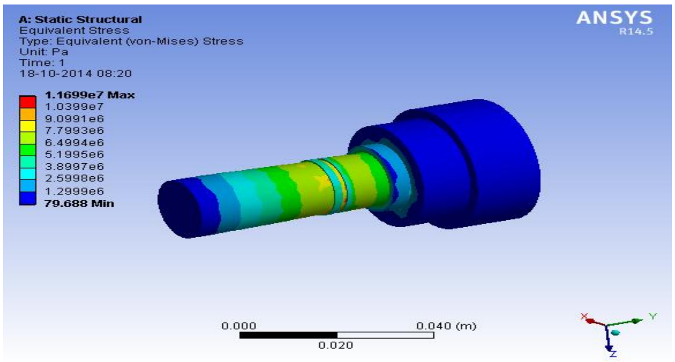
  - ✓ A tetrahydral free Meshing is done



- ✓ Boundary Conditions at one end



- ✓ Results



Equivalent Stress

III. Conclusions

Testing of the agriculture cutter cum shear mechanism to determine

- ➢ Maximum admit between blade capacities of cut.
- ➢ Maximum number of cuts per minute for various item sizes.
- ➢ Comparison of the newly developed agriculture cutter cum shear mechanism with conventional practices on grounds of productivity improvement, savings in labour cost and payback time of mechanism

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