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Designing of a hand-held Combined Harvester for Indian Farming Markets

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ABSTRACT: *Harvesting is extracting the crop grains from the crop grown in the farms using harvesting techniques but with large consumer base for agriculture and related products in indian markets, the demand for crops grow every year, adding to that, a big contributor to indian annual GDP is agriculture and thus, agriculture requires a technological revolution in India. Foreign agricultural markets saw an introduction of combined harvesters which can harvest any crop unaffected by the various harvesting methods employed to harvest various crops. Indian markets didn't see the similar revolution by combined harvester mainly because of low earning farmers. Our design is based on research done over an extensive period of time on various components present in the combined harvester and we here furnish the re designed combined harvester suitable for indian markets.*

I. INTRODUCTION

Agriculture being the mass contributor to the overall contribution to the GDP of India is one of those fields which require contribution from the present generation and relies highly on it for further advancement in agriculture technology. A main part of farming is harvesting the crop grown. But, harvesting methods vary from crop to crop and thus a machine which could harvest any crop came into market – the combined harvester. Even though, machine was brought into the market, the machine could never really share the similar fame in indian market as it did in other markets around the world mainly because of two reasons – most of the population doing agriculture in india lives out of the touch of technological advancements worldwide and while the indian government tries to solve that problem, the second problem comes in play – even if farmers get an idea about the agricultural technology advancement can't really afford the present combined harvester.

Schemes for renting such harvester have been put forward by the indian government and while indian government addresses this issue by trying to make this awesome advancement in agricultural technology affordable to the farmers, we try to address this issue head on. In this paper, we put forward details of an original design done by us that reduces the cost of combined harvester and makes it possible for an average farmer to buy the product and indirectly help the country by harvesting crops faster and hence giving higher outputs.

Design

The idea: The basic constraints that bind the designing parameters were – minimal cost, maximum efficiency and a perfect imitation of the original combined harvester popular in markets abroad.

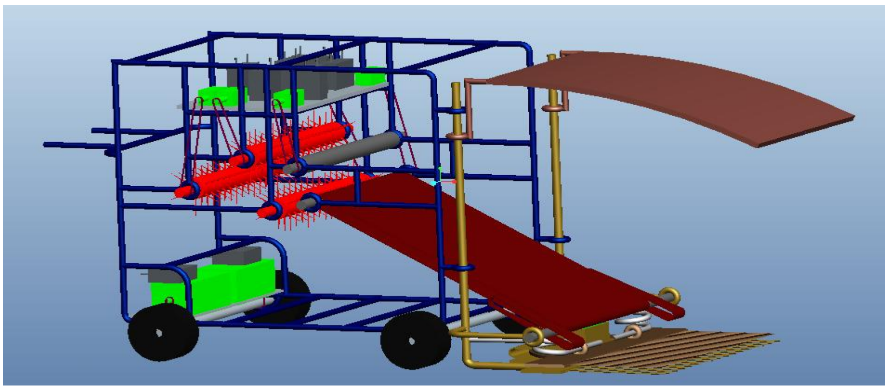

Figure 1: CAD Design for our harvester.

Components

Following components are a part of our design and are explained in detail.

I. The chassis
II. The wheels
III. The trimmer – cutting part
IV. The Conveyor belt
V. Crushers
VI. The steering
VII. Transmission
VIII. Electrical parts

I Chassis

Material

The main frame material is kept as ASTM-A36. ASTM A36 plate is a low carbon steel that exhibits good strength coupled with formability. It is easy to machine and fabricate and can be securely welded. The steel can be galvanized to provide increased corrosion resistance and hence, this reduces the production cost as well as gives the required strength for longer working hours.

II The wheels

A total of 4 wheels with diameter of 30 cm are incorporated in the design, supporting a load of 400 kgs at max. The driver wheels are kept at the rear end of the harvester while the driven and steering wheels are at the front end to provide support as well as direction change.

III The trimmer

A new approach to cutting crops while harvesting is incorporated in our design.

Two blades of 50x10x0.6 cm with spikes kept at minimal distance from each other are provided in the front end of the harvester. These two blades are attached to a servo motor which drives one blade of two supported by coil springs while keeping another blade stationary. This mechanism replaces the original crop cutting mechanism while reducing a lot of weight.

Material

The spikes are made up of 5160-SPRING STEEL. It exhibits excellent toughness and high ductility, with a high tensile-yield ratio.

IV Conveyor belt

Belt of 300x80x1 cm made with warped and wefted carcass of polyester and a cover of rubber is used. The cover of the belt is provided with grip so that the cut crops by trimmer can be lifted and sent over to the crushers for crushing out the grains and storing them in storage area.

V Crushers

The crushers design can be divided in two parts – a rolling part, and spikes – the crushing part which are on top of the strips that are incorporated in the design of our crushers.

The mainframe of rolling part is made up of 6061 Aluminium while the hollow strips are made of PVC with High Carbon Steel spikes on top of them constituting the crushing part.

The roller is of 80 cm in width and 11 cm in diameter, strips are of 5.9 cm diameter placed at even intervals of 2 cm along the circumference. The height of each spike on each strip is 5 cm and are randomly distributed on the strip.

VI Steering mechanism

The steering mechanism is provided to the front two wheels via basic pitman arm having a 90 degree relationship with the knuckles.

The central rod rotates, moving the base in the rotated direction and thus knuckles push the two wheels in the direction of rotation of the base.

Wheel base =155cm
Wheel track = 95cm
Turning angle =53degrees

VII Transmission

Normal spool drive transmission is used which is powered by two motor and two batteries. The motorsare 48volts 20ah which is connected to two batteries of same configuration. The two motors are connected to two sprockets placed on a shaft. The motors and sprockets are connected to each other via chains of length 130cm while the smaller motor sprocket is 13 cm in diameter, the bigger sprocket on shaft is 36 cm in diameter.

The transmission can run the entire vehicle full with crop harvested for 5 to 6 hours atleast at a stretch with the speed of 2 kmph.

VIII Electrical system

The electrical system consists of 6 motors attached to the 3 crushers and 3 rollers of 5 Kgs which run on a battery each weighting average 0.5 kg while one battery is attached to the trimmer servo motor weighting 0.5 kg again. Each motor weights around 1kg can run on a 24 volt battery and requires an average of 5ah to run. The motors have an overall torque of 5kgcm.

The whole electrical system employs the use of lead acid rechargeable batteries and on one charge lasting for around 3 hours, whole system can run for upto 7 hours.

Working

A curved surface at the front end of the harvester is provided. Based on various data gathered for different plants, the average crop length was found to be 1.08 m. The curved surface was provided with its front end part at such a position that it touches the crop at the height of 0.75m which is the height at which when the crop is pushed, it bends and due to its tendency to regain its position back to being straight, it rebounds back and stands straight hence forcing the crop to re-enter the curved region which allows it a gradual safe extension up-to its original height and also puts it in the region for where trimmer can effectively cut the crop.

As soon as the system is switched on, all the electrical systems are switched on and the servo motor gives life to the trimmer which cuts the crops and the crops are fed up on the conveyor that passes it between crushers strategically placed to extract out the grains from the crops. The crushers then pass the remaining waste crop out the back of the machine through a hopper and the grains fall through a net into the storage area. Dimensions of the storage area are – 108x80x21cm. The volumetric capacity of the storage area is – 53000cm^3.

On an average the harvester can store upto 300kgs of grains. The curb weight of the vehicle is 120 kgs and thus the max weight possible for this harvester to have is 420 kgs. Crushers and rollers revolve at 100 – 150 RPM. The conveyor belt moves at a speed of 0.75 m/s.

On an average the harvester can sweep upto 13 m^{2}area in 1 minute and thus 3120m^2 area can be swept and cleared in one time charge.

Calculations

1) *Calculation of design power of the belt drive.*

Arc of Contact factor k = 1.08
Small pulley factor k_d = 0.7
Load correction factor k_s= 1.2

Design kW = 100x1.2/1.08 x0.7 = 158.7kw

2) *Velocity of the belt*

Diameter of pulley = 11cm
Velocity of belt = 3.14x0.11x130/60
= 0.75m/s

3) *Load rating correction factor*

High speed duck belting is selected.
Capacity = 0.023kw/mm/ply.
Load rating at 0.75m/s = 0.023x0.75/10
=0.0017kw

4) *Length of the belt*

Centre distance, C = 135cm
Diameter I, D = 11cm
Diameter II, d = 11cm

$$L = 2C + \left(\frac{\pi}{2}\right)(D + d) + \frac{(D - d)2}{4C} = 304\ cm$$

Analysis

Various tests were run on the chassis design that was made and the results were analysed based on various parameters.

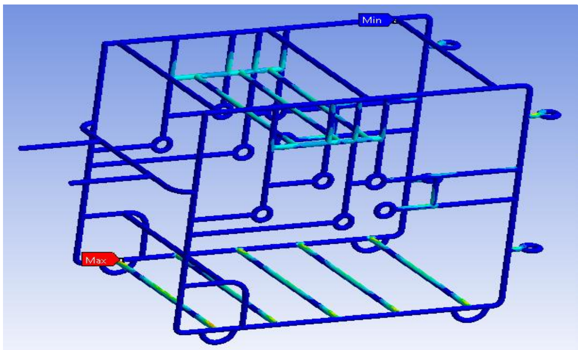

Figure 2: Equivalent stress

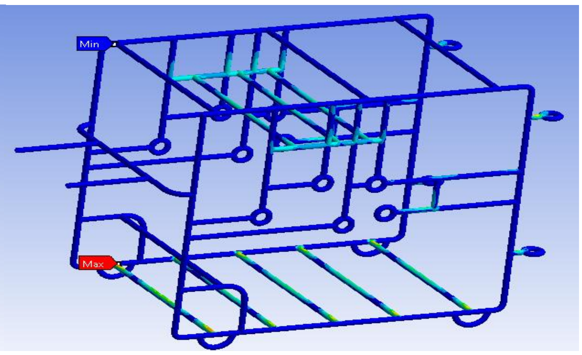

Figure 3: Equivalent elastic strain

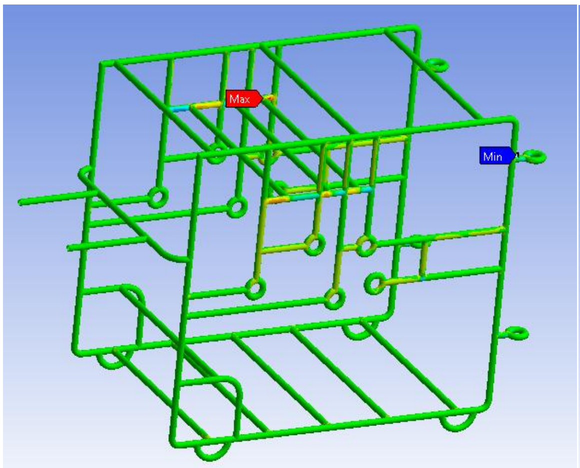

Figure 4: Shear elastic stress

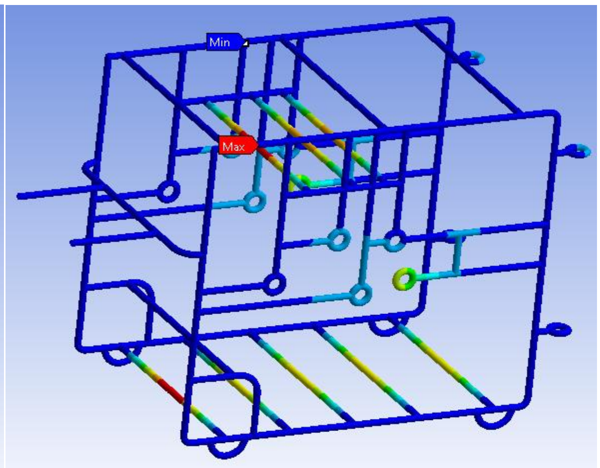

Figure 5: Total deformation

II. CONCLUSION

The paper concludes based on the analysis that the design of the chassis for our harvester is safe and since the harvesting mechanism is a variation of already threshing mechanism in place, the harvester will work while the cost of manufacturing and thus cost of working as well as cost to customer is reduced significantly. The whole harvester will be of much less cost to the customer than the current price for combined harvesters in Indian market.

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