

Design, Development and Manufacturing of Hydraulic System for Self Propelled Onion Harvester

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ABSTRACT: India is well known for its agriculture which affects the country's economy most and India is the second largest country who produces the onion crop. But even though it is placed on 2nd number it is still lagging because India is still a developing country among the whole world and in the whole country around 80% to 90% harvesting is carried out by traditional method. Proposed event organised by SAE INDIA which focuses on optimizing the time required to harvest onion after the completion of crop. Our aim of the project mainly focuses on the time as well as the work efficiency. This may include the time and labour cost, thus indirectly it can be compared with machine efficiency against manual efforts required. By use of a digger and conveyor system the harvesting has been done. This is beneficial for more productivity of the crop. The traditional and most widely used method of harvesting onions involves undercutting and lifting onions when the foliage has collapsed to 60-70% of the plants. Onions are left on the ground to cure in the field for 1-4 weeks before the foliage is removed (topping). There is a lot of demand of Indian Onion in the world, the country has exported 14, 82,498.58 MT of fresh onion to the world, worth of Rs.3,169.63 crores, during the year 2018-19. The height of the onion crop during harvesting is 15-40 cm and the crop stem diameter is 1-2 cm. The number of shoots per plant is 10-15. During hot days when the soil is hard, bulbs are pulled out with a hand-hoe. The production of onion is 12-16 tonnes in 70 to 90 days. Manual harvesting of onions is a tedious, time consuming, labour intensive and costly operation so mechanization of harvesting is essentially needed. Mechanization of onion harvesting needs as traditionally, the well-matured bulbs are harvested by hand shovel (khurpa) which requires 21.4 percent of total expenditure of onion cultivation. About 12.5-man hours are required in manual de-topping operation of 1 MT onion bulbs. Hence, mechanical de-topping is required. Also, it is necessary to complete the harvesting operation within specified time limits, for reducing harvest losses and increasing storage life. In fact, early harvesting affects the keeping quality of onions adversely and reduces the yield, whereas delayed harvesting leads to infection caused by microorganisms. Harvesting of onion is more labour intensive and bulb damage is higher during harvesting. For the same, the optimization is done several times to make a robust and rigid design in order to withstand drag, tractive and torsional forces against the digging effort of the vehicle. This process includes designing as well as a simulation process that will give us a 99% accurate result and after various tests and analysis, we came to a conclusive result that it will work in real time as an Onion harvesting machine.

KEYWORDS: Text detection, Inpainting, Morphological operations, Connected component labelling.

I. INTRODUCTION

India is the second largest onion growing country in the world. Indian onions are famous for their pungency and are available round the year. Indian onions have two crop cycles, first harvesting starts in November to January and the second harvesting from January to May. The onion is a hardy cool-season biennial but usually grown as an annual crop. The onion has narrow, hollow leaves and a base which enlarges to form a bulb. The bulb can be white, yellow, or red and require 80 to 150 days to reach harvest. The major Onion producing states are Maharashtra, Madhya Pradesh, Karnataka, Gujarat, Rajasthan, Bihar, Andhra Pradesh, Haryana, West Bengal, Uttar Pradesh, Chhattisgarh, Odisha, Tamil Nadu, Jharkhand and Telangana in the country. Onion can be grown in all types of soils such as sandy loam, clay loam, silt loam and heavy soils. However, the best soil for successful onion cultivation is deep, friable loam and alluvial soils with good drainage, moisture holding capacity and enough organic matter. In heavy soils, the bulbs produced may be deformed. Onion crops can be grown successfully on heavy soil with application of organic manure prior to planting and preparation of the field for onion cultivation should be very good. The optimum pH range, regardless of soil type, is 6.0 - 7.5, but onion can also be grown in mild alkaline soils. Onion crop is more sensitive to highly acidic, alkali and saline soils and water logging conditions. Onions do not thrive in soils having pH below 6.0 because of trace element deficiencies, or occasionally, Al or Mn toxicity. By keeping all those points in consideration,

the onion harvesting machine has been developed. Onion is harvested depending upon the purpose for which the crop is planted. Onion crop is ready for harvesting in five months for dry onion. The process of onion harvesting with help of the harvester starts from losing the soil up to removal of onion with green leaves above the ground. In the manual process, most of the onion is removed without damaging any part of the onion. But this process is time consuming. In order to achieve the time as well as the clean removal of the onion this machine is developed.

II. LITERATURE REVIEW

There are four major area of work say kinematics, dynamics, soil-tool interaction and FEA and optimization on which the literature review carried out for development of kinematic model, dynamic model, utilization of soil-tool interaction model for resistive force calculations, FEA for strength based design and to develop optimized design of backhoe excavator attachment.

P. K. Vaha and M. J. Skibniewski (1993), have described the kinematics of the excavator with the coordinate frame. To describe the position of the points on the mechanism of an excavator, coordinate systems are first defined. A fixed Cartesian coordinate system is assigned to the body of the excavator. The local coordinate frames are assigned to each link of the mechanism. A systematic method to define the local coordinate systems for the serially connected links (upper structure, boom, arm, and bucket) of the excavator is accomplished by applying the Denavit and Hartenberg procedure.

M. Bodur, H. Zontul, A. Ersak, A. J. Koivo, H. O. Yurtseven, E. Kocaozlan, and G. Pqa Mehmetoglu (1994), have control of the cognitive force for the automation of the land excavation that is developed to include the kinematics of the excavator arm. During digging at a certain point on the excavation trajectory, both the crawler and the rotational super-structure bodies are stationary, and thus the kinematic model is reduced to 3 degrees of freedom.

J. Koivo, M. Thoma, E. Kocaoglan and J. Andrade-Cetto (1996) developed a dynamic model for an excavator that is needed for the controller design can be derived by applying NewtonEuler equations to each link.

B. Fox, L. S. Jennings, and A. Y. Zomaya (2002) have presented the dynamics of actuator mechanisms using a multibody modeling approach to concisely express the structure of the system equations. The model is general in nature and caters for arbitrary mechanism connectivity and physical properties.

H. I. Torres-Rodriguez, V. Parra-Vega, and F. J. Ruiz-Sanchez (2004) a complete nonlinear excavator model was presented. This model considers the actuator dynamics effects, and is used for simulation in a virtual environment developed in Java 3D. The dynamic model of the excavator obtained from the Euler Lagrange equations, innovates precedent models, introducing the dynamics of the hydraulic actuators.

ISO Standard 4409 Defines the necessary measurements, symbols, measurement accuracy and suggested tests for pumps and motors.

ISO Standard 8426 Presents a method of determining the actual displacement of a pump or motor during a test. For a certain displacement set point, several pressure measurements are used to extrapolate a line whose intercept is the actual displacement.

III. METHODOLOGY

The methodology plays a very important role in project planning. The methodology gives the accurate direction to the work.

Phase 1: Data collection phase involves the collection of reference material for the project concept and the collection of research papers regarding the project topic.

Phase 2: System design the system design comprises development of the mechanism so that the project can perform the desired operation.

Phase 3: Mechanical design the parts mentioned in the part list will be designed under the given system of forces and appropriate dimensions will be derived. The standard part will be selected from the design handbook.

Phase 4: Production drawing preparation production drawings of the parts are prepared using cad software, catia with appropriate dimensions.



Phase 5: Material procurement and process planning materials are selected as per the required dimensions and properties. Part process planning is done to decide the process of manufacturing an appropriate machine for the same.

Phase 6: Manufacturing parts are produced as per the parts drawing.

Phase 7: Assembly of parts and trial assembly of machine is done as per assembly drawing and trial is conducted on project device for evaluating performance.

Phase 8: Report preparation report preparation activity is carried out during the above phases.

IV. CALCULATIONS

1. Total Load Acting On Actuator –

In case of the digging system of the harvester there will be a two type of load present

1.soil load

2.digging blade self weight.

so the load on the hydraulic system is the sum of the both load.Mathematically it is represent ,

$$\text{Total load} = \text{soil load} + \text{digging blade weight}$$

considering soil weight ,

soil weight = 40 kg

blade weight = 40 kg

$$\begin{aligned} \text{Total load} &= 40 + 40 \\ &= 80 \text{ Kg} \end{aligned}$$

consider factor of safety as 2,

design of the hydraulic system with 2 FOS.

$$\begin{aligned} \text{System design to carry load} &= 2 \times 80 \text{ kg} \\ &= 160 \text{ kg} \\ &= 352.74 \text{ pounds} \end{aligned}$$

2. PUMP SELECTION –

We are selecting the pump form standard pump catalogue provided by the pump manufacturer.

We are designing a gearbox through which we get the output for the pump. The rated rpm available at that shaft will be the 400 to 500 RPM.The input RPM of the pump should be less than the 500 RPM,so we need a pump which fulfills our requirement at 500 RPM.

MODEL	Theoretical Displacement		Nominal Delivery at 1450 rev/min		Rated Pressure (bar)		Max speed at max Pressure rev/ min
	in ³ /rev	cm ³ /rev	Imp gal/ min	l / min	Rated	Max	
1P-1017	0.31	5.14	1.7	7.7	200	250	3000
1P-1020	0.43	7.03	2	9.1	200	250	3000
1P-1028	0.58	9.46	2.8	12.7	200	250	3000
1P-1036	0.73	11.9	3.4	16.4	200	250	3000
1P-1044	0.88	14.33	4.4	20	200	250	3000
1P-1052	1.02	16.77	5.2	23.6	200	250	3000
1P-1060	1.17	19.22	6	27.3	200	250	3000
1P-1072	1.4	22.84	7.2	32.4	200	250	3000
1P-1090	1.72	28.12	9	40.9	200	250	3000

1.Table: Catalogue for pump

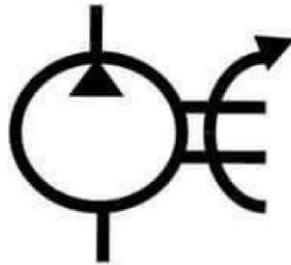
3. Horsepower Required to Drive Pump = GPM x PSI x .0007 (this is a 'rule-of-thumb' calculation)

Where ,

$$\text{GPM} = 3.4$$

$$\text{PSI} = 483.41$$

$$\begin{aligned} \text{Horsepower Required to Drive Pump} &= \text{GPM} \times \text{PSI} \times .0007 = 3.4 \times 483.41 \times .0007 \\ &= 1.15 \text{ horsepower} \end{aligned}$$



(a)

4. Pump Displacement Needed for GPM of Output Flow = $231 \times \text{GPM} \div \text{RPM}$

Where,

$$\text{GPM} = 3.4$$

$$\text{RPM} = 1450$$

$$\begin{aligned} \text{Pump Displacement Needed for GPM of Output Flow} &= 231 \times \text{GPM} \div \text{RPM} \\ &= 231 \times 3.4 \div 1450 \\ &= 0.54 \text{ cubic inches per revolution} \end{aligned}$$

5. Pump Output Flow (in Gallons Per Minute) = $\text{RPM} \times \text{Pump Displacement} \div 231$

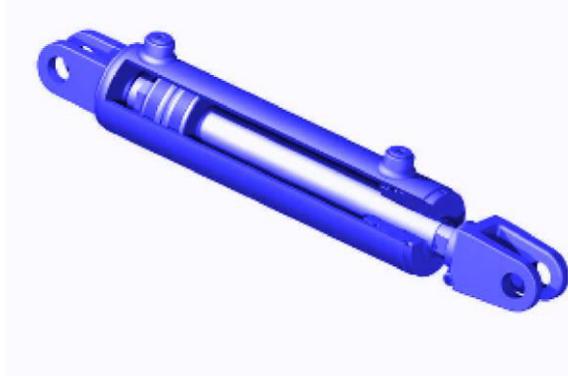
Where,

$$\text{RPM} = 500$$

$$\text{Pump Displacement} = 0.08591 \text{ cubic inches}$$

$$\begin{aligned} \text{Pump Output Flow (in Gallons Per Minute)} &= \text{RPM} \times \text{Pump Displacement} \div 231 \\ &= 500 \times 0.085 \div 231 \\ &= 0.1859 \end{aligned}$$

Hydraulic cylinder calculation :



(b)

1. Cylinder Rod End Area (in square inches) = Blind End Area - Rod Area

Where,

$$\text{Cylinder Blind End Area} = 0.76077 \text{ square inches}$$

$$\text{Rod Diameter} = 0.3937''$$

$$\text{Radius} = 1/2 \text{ of rod diameter} = 0.19685''$$

$$\text{Radius} = 0.19685'' \times 0.19685'' = 0.03874''^2$$

$$\pi \times \text{radius} = 3.14 \times 0.03874 = 0.1216 \text{ square inches } 2$$

$$\begin{aligned} \text{Cylinder Rod End Area (in square inches)} &= \text{Blind End Area} - \text{Rod Area} \\ &= 0.76077 - 0.1216 \\ &= 0.6391 \text{ square inch} \end{aligned}$$

2. Cylinder Blind End Area (in square inches) = $\pi \times \text{cylinder radius}$

Where,

$$\text{Radius} = 1/2 \text{ of diameter} = 0.4921''$$

$$\text{Radius} = 0.4921'' \times 0.4921'' = 0.2421''^2$$

$$\begin{aligned} \text{Cylinder Blind End Area (in square inches)} &= \pi \times \text{cylinder radius} \\ &= 3.14 \times 0.2421 \\ &= 0.76019 \text{ square inches} \end{aligned}$$

3. Cylinder Blind End Output (GPM) = Blind End Area ÷ Rod End Area x GPM In

Where,

$$\text{Cylinder Blind End Area} = 0.76019 \text{ square inches}$$

$$\text{Cylinder Rod End Area} = 0.6391 \text{ square inches}$$

$$\text{GPM Input} = 0.1859 \text{ gpm}$$

$$\begin{aligned} \text{Cylinder Blind End Output (GPM)} &= \text{Blind End Area} \div \text{Rod End Area} \times \text{GPM In} \\ &= 0.76019 \div 0.6391 \times 0.1859 \\ &= 0.22 \text{ gpm} \end{aligned}$$

4. Cylinder Output Force (in pounds) = Pressure (in PSI) x Cylinder Area

Where,

$$\text{Cylinder Rod End Area} = 0.6391 \text{ square inches}$$

$$\text{Pressure} = 526.9231 \text{ psi}$$

$$\begin{aligned} \text{Cylinder Output Force (in pounds)} &= \text{Pressure (in PSI)} \times \text{Cylinder Area} \\ &= 526.9231 \times 0.6391 \\ &= 336.7564 \text{ pounds} \end{aligned}$$



(c)

5. Cylinder Speed (in inches per second) = (231 x GPM) ÷ (60 x Net Cylinder Area)

Where,

$$\text{GPM} = 0.1859$$

$$\text{Net Cylinder Area} = 0.76019 \text{ square inches}$$

$$\begin{aligned} \text{Cylinder Speed (in inches per second)} &= (231 \times \text{GPM}) \div (60 \times \text{Net Cylinder Area}) \\ &= (231 \times 0.1859) \div (60 \times 0.76019) \\ &= 0.9414 \text{ inches per second} \end{aligned}$$

6. GPM of Flow Needed for Cylinder Speed = Cylinder Area x Stroke Length in Inches ÷ 231 x 60 ÷ Time

Where,

$$\text{Seconds for one Cylinder Area} = 0.76019 \text{ square inches}$$

$$\text{Stroke Length} = 11.81 \text{ inches}$$

$$\text{Time for 1 stroke} = 12.54 \text{ seconds}$$

$$\begin{aligned} \text{GPM of Flow Needed for Cylinder Speed} &= \text{Area} \times \text{Length} \div 231 \times 60 \div \text{Time} \\ &= 0.76019 \times 11.81 \div 231 \times 60 \div 12.54 \\ &= 1.818 \text{ gpm} \end{aligned}$$

Cylinder Area = 0.6391 square inches
Stroke Length = 11.81 inches
Time for 1 stroke = 10.64 seconds

$$\begin{aligned} &= \text{Area} \times \text{Length} \div 231 \times 60 \div \text{Time} \\ &= 0.6391 \times 11.81 \div 231 \times 60 \div 10.64 \\ &= 1.50 \text{ gpm} \end{aligned}$$

7. Fluid Pressure in PSI Required to Lift Load (in PSI) = Pounds of Force Needed ÷ Cylinder Area

Where,

Pounds of Force = 400 pounds

Cylinder Blind End Area = 0.76019 square inches

$$\begin{aligned} \text{Fluid Pressure in PSI Required to Lift Load (in PSI)} &= \text{Pounds of Force Needed} \div \text{Cylinder Area} \\ &= 400 \div 0.76019 \\ &= 526.18 \text{ PSI} \end{aligned}$$

Pounds of Force = 337.56 pounds

Cylinder Rod End Area = 0.6391 square inches

$$\begin{aligned} &= \text{Pounds of Force Needed} \div \text{Cylinder Area} \\ &= 337.56 \div 0.6391 \\ &= 528.180 \text{ PSI} \\ &= 38.39 \text{ bar} \end{aligned}$$

Fig. (a) Hydraulic Pump , (b) Hydraulic Cylinder cut section , (c) Hydraulic Cylinder 3D

V. CONCLUSION

This process includes designing as well as a simulation process that will give us some accurate results and after various tests and analysis, we came to a conclusive result that it will work in real time as an Onion harvesting machine. The hydraulic system generates the required amount of power (Pressure). Also the Ergonomics consideration solves the problem arising during Manufacturing as well as during functioning of the Onion Harvester

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