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Modification and Manufacturing of Cereal Crop Harvesting Machine

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Abstract: Today the development of agricultural sector is increasing from year to year. The rice, wheat and other cereals are the focus of many farmers in Ethiopia. But to harvest on time the cereals, intensive human power is needed. Most of the time students starting from elementary level up to university level participate on harvesting of cereals due to unbalance rainfall. To solve this problem, harvesting machines are very essential. Harvesting machinery or equipment is a mechanical device used for harvesting different types of crops. The use of modern tractors, combine harvesters and related heavy machineries is still very limited in Ethiopia. On the other hand, a rising trend in the import of tractors and harvesters is being observed as of recent years. Small-scale farmers on their part are looking more into the use of small mechanically-powered equipment both for crop production and post-harvest activities. From the available machines in the world, different cereal crop harvesting machines were assessed. Using different selecting criteria mower is selected. The design and economic analysis is performed for the selected harvesting machine. Different parts of the machine are designed including material selection and different force analysis like bending, shear stress. Finally parts and assembly drawings are drawn and the prototype is manufactured from the available materials.

Keywords: Harvesting, Machinery, Mower, Cereal Crop, Modification

1. Introduction

In the 1850's, the industrial revolution spilled over to the farm with new mechanized methods which increased production rates. Early on, the large changes were in the use of new farm implements. Most of these early implements were still powered by horse or oxen. These new implements combined with crop rotation, manure and better soil preparation lead to a steady increase of crop yield in Europe. [8]

The Ethiopian agriculture is basically comprised of smallholder farming which accounts for more than 90% of the agricultural production and 95% of the total area under crop. 94% of crop and 98% of coffee is produced by smallholders. The remaining 6% of crop and 2% of coffee is generated from mechanized farms. [8]

The major crops grown are cereals, pulses and oil seeds in order of their importance. Considering the 1992 smallholder farmers' production, cereals (cereal crops, wheat, barely, maize and sorghum) accounted for 89% of the total crop production and 81% of the crop land. In the same year, pulses contributed about 10% of the total production, occupying 15% of the total land cultivated; while oil seeds production accounted for 1% of the total production occupying 4% of the total land under cultivation. [8]

The use of modern tractors, combine harvesters and related heavy machineries is still very limited in Ethiopia. The Nazareth Tractor Factory, with its limited capacity, is the only company that assembles tractors in the country. On the other hand, a rising trend in the import of tractors and harvesters is being observed as of recent years. Small-scale farmers on their part are looking more into the use of small mechanically-powered equipment both for crop production and post-harvest activities. Thus, great opportunities lie in the importation, assembly, manufacture and distribution of agricultural heavy machineries as well as of small-powered equipment such as irrigation pumps, sprayers, mowers, bailers, sellers, threshers, flour mills, powered fishing boats, etc. [5]

Harvesting is carried out by grasping the cereal crops

plants in one hand and cutting them with the sickle near the base of the plant. The cut plants are placed in piles on the ground. In some parts of Ethiopia, such as in Showa province, the farmer when harvesting the cereal crops, crouches and cuts the plants near the soil surface. This is done especially when the cereal crops plants are short.

There are two types of harvesting mechanisms; Traditional method of harvesting, the harvesting of crops is traditionally done by manual methods. Harvesting of major cereals, pulse and oilseed crops are done by using sickle whereas tuber crops are harvested by country plough or spade. All these traditional methods need intensive labor and consume long time. Mechanical harvesting equipment, timeliness of harvest is of prime importance. During harvesting season, often rains and storms occurs causing considerable damage to standing crops. Rapid harvest facilitates extra days for land preparation and earlier planting of the next crop. The use of machines can help to harvest at proper stage of crop maturity and reduce labor and operation time.

It has been more than two and half decades since the government of Ethiopia had formally adopted Agriculture Development Led Industrialization (ADLI) as its development strategy. The main goal of this strategy is to attain fast and broad-based development within the agricultural sector and to make this sector's development to power broad economic growth. ADLI had been further rationalized as the basis of the poverty reduction program subsequently adopted by the government in 2002 (MoFED, 2002). A program is officially known as Sustainable Development and Poverty Reduction Program (SDPRP). [3]

With 85% of the population living in the rural areas and depending on agriculture for livelihood, there is no doubt for the economic importance of the agricultural sector for sustainable development and poverty reduction in Ethiopia. The agricultural sector accounts for more than 40% of national GDP, 90% of exports, and provides basic needs and income to more than 90% of the poor. A better performed agricultural sector has provided growth to the overall economy, improved the food security and reduced poverty in the recent years. [3]

2. Different Type of Mechanical Harvesting Tools / Equipment

i. Serrated blade sickle; It has a serrated curved blade and a wooden handle. The handle of improved sickle has a bend at the rear for better grip and to avoid hand injury during 0peration.

ii. Reapers; Reapers are used for harvesting of crops mostly at ground level. It consists of crop-row divider, cutter bar assembly, feeding and conveying devices.

iii. Strippers; the design of a tractor front mounted stripper is available for collection of matured grass seeds from the seed crops. It consists of a reel having helical rubber bats which beat the grass over a sweeping surface where the ripened seeds get detached and the seeds are collected in the seed box.

iv. Diggers; The design of groundnut and potato diggers of animal drawn and tractor operated types are available. The digging unit consists of V -shaped or straight blade and 1ifter rods are attached behind the share. These lifter rods are spaced to allow the clods and residual material to drop while operating the implement. The plant along with pods/tubers is collected manually.

v. Combines; various designs of combine harvester having 2 to 6 m long cutter bar are available. The function of a combine harvester is to cut, thresh, winnow and clean grain/seed. It consists of header unit, threshing unit, separation unit, cleaning unit and grain collection unit.

vi. Mower; One of the farm machineries used in agriculture field is rotary mowers. These mowers shear plant materials as a result of high-speed impact of a knife or hammer without need for a shear bar. The rotor may be a single blade rotating in a horizontal plan or a series of knife-tipped arms rotating in vertical planes. These rotary machines have almost completely replaced cutter bar mowers for weed mowing, brush cutting, and plant residue chopping

3. Selecting Criteria of the Machine

There are different selecting criteria to select the better harvesting machines. But for this research factor rating was selected based on its simplicity to perform. Factor rating has procedures to select different available alternatives.

1. Identify the important harvesting machine factors.
2. Rate each factor according to its relative importance, i.e., higher the ratings is indicative of prominent factor.
3. Assign each harvesting machine according to the merits of the harvesting machine for each factor.
4. Find the sum of each factor and select best harvesting machine having highest total score.

Based on the above procedure, the following factors were identified.

1. Initial investment
2. Operation cost
3. Ease of fabrication
4. Ease of operation
5. Durability
6. Maintainability
7. Harvesting Efficiency

Table 1. *Selecting criteria for selected harvesting machine and result of factor rating technique.*

No		Factor rating	Rating				
			Serrated blade sickle	Reapers	Strippers	Combines	Mower
1	Initial investment	10	10	5	8	5	8
2	Operation cost	6	6	4	5	4	5

No		Factor rating	Rating				
			Serrated blade sickle	Reapers	Strippers	Combines	Mower
3	Ease of fabrication	8	8	4	6	4	7
4	Ease of operation	8	8	5	3	5	7
5	Durability	6	5	4	3	5	5
6	Maintainability	7	6	5	5	3	5
7	Harvesting Efficiency	10	1	8	2	9	8
	Sum	55	44	35	32	35	45

Based on the result of the above table, the mower has the highest value which is 45 from 55. Therefore, the mower is selected for analysis and redesign.

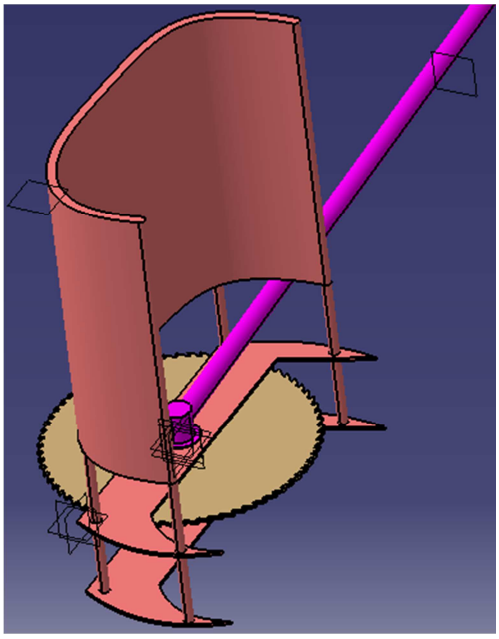

Figure 1. *3D diagram of Mower machine.*

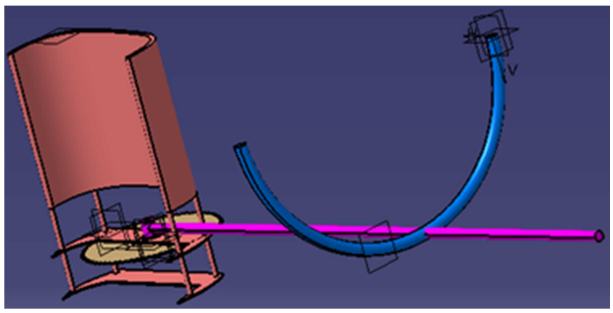

Figure 2. *3D diagram of mower machine.*

Analysis and design

Steps that should be taken are.

1. Performing a design by specifying the design capacity, maximum weight, price, material type, etc.
2. Testing for performance evaluation, including capacity, fuel consumption, ease of operation (handling test), work efficiency, and operational cost estimates.
3. Financial analysis to estimate the fixed cost using the assumption of capacity, investment, and cost variables, such as wages, fuel prices, cost of repairs, and maintenance.

The engineering materials consisted of aluminum plate, circular blade that is enriched with a layer of carbide, belt carriers, aluminum pipes, and engines.

The material selected for the frame should possess: -

Considerably high strength
Good process ability
Wear resistance
Low cut sensitivity
Nearby availability
Low manufacture and maintenance cost
Tough and durable
High load absorbing ability

4. Economic Analysis

To harvest one hectare of wheat, it needs in average 30 labor*8 hour=240 labor hour. The average birr per labor hour is 12.5 birr.

The data collected from farmers and agriculture sector of north shewa zone shows, to harvest one hectare of wheat costs

12.5 birrX240 labor hour =3000 birr excluding cost of lunch.

But using the harvesting machine, the fuel consumption of the machine is in the range of 0.60-0.86 lit/ha and work capacity of the machine is in the range of 18.54-26.3 hours/ha. The machine life time is expected 5 years. (3) The total manufacturing cost is not more than 15,000 birr. The depreciation cost can be calculated by converting the service year to working hours. Assume the machine works 60 days*8hours =480 working hours per year. Within five years it has 5*480 = 2400 working hours. Therefore the depreciation cost is 15000/2400 = 6.25 birr per hour.

From this result the payback period of the machine is calculated. The payback period is calculated as the initial investment divided by net annual cash flow. In this case the cash flow is calculated per hectare (cash flow per hectare = costs harvesting manually – costs harvesting using machine).

Net cash flow = 3000birr per hectare – 323.25birr per hectare = 2676.75.

Therefore payback period = 15000 birr/2676.75birr per hectare = 5.6 hectare. This means after harvesting around 5.6 hectare, the machine will return its initial investment.

5. Conclusion

With 85% of the population living in the rural areas and depending on agriculture for livelihood, there is no doubt for the economic importance of the agricultural sector for sustainable development and poverty reduction in Ethiopia.

The agricultural sector accounts for more than 40% of national GDP, 90% of exports, and provides basic needs and income to more than 90% of the poor. A better performed agricultural sector has provided growth to the overall economy, improved the food security and reduced poverty in the recent years.

To develop the agriculture sector as expected, use of different technology is very essential. Harvesting machine is one of the important technologies. From different harvesting machines mower is very important for small scale agriculture sector. But for large scale agriculture sector combiner is preferable. In Ethiopia, most of the agriculture activities are in small scale. Therefore, mower will be effective cereal crop harvesting equipment.

The design and manufacturing process of the mower harvesting machine is not that much difficult and complex. It is possible to manufacture in any work shop. But some parts of the machine are not available in local market. So it needs to communicate global markets.

6. Recommendations

In different countries for rice and wheat cultivator like china, the mower is available sufficiently and it solves farmer's problem. But in Ethiopia there are no enough harvesting machines. However, there is a great problem on harvesting different crops on time. Therefore, the government should help farmers by motivating different stockholders to manufacture different harvesting machines specially mower.

The prototype of the machine wasmanufactured and DBU should arrange workshop for mass production of the machine.

There is agriculture mechanization department in ministry of agriculture and in region level but it should be available up to Woreda level.

The agriculture mechanization department should work with different universities and Technique College and help financially for the manufacturing of different agricultural machines including harvesting machines.

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