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Design of agricultural mechanical weed mower

[#1]Mr. Amrutsingh J. Patil, [#2]Dr. Dhananjay Panchagade

[#1]M.E. (Design Engineering)

Savitribai Phule Pune Universitty

ABSTRACT

India is an agro-based country. The Indian people and Indian economy mainly depends on agricultural sector. The development in agricultural fields forms the basis for Indian growth. Nearly 70% population depends on agricultural. The Indian govt. is promoting to adopt mechanization & new ideas about farm machinery for the rapid development in the agricultural field.

The present project work titled "Design of Agricultural Mechanized Weed & Feed Mower" Is a step forward to the mechanization of a farming process, which is usually carried out by a manually operated machine. The mechanization of a weed & feed mowing process considerably reduces the efforts and time required by the operator. Seed movement is analyzed both from an agronomic and ecological perspective, focusing predominantly on horizontal seed movement. Abiotic (anemochory and hydrochory), as well as biotic (autochory, myrmecochory, epizoochory, and endozoochory) weed seed dispersal typologies are examined, highlighting the mechanisms involved, the specializations displayed by weed species that have evolved by exploiting a particular dispersal mechanism, and their adaptive interaction with the surrounding ecosystem. Emphasis is also placed on the crucial role of human activity (anthropochory), which can affect natural (biotic and abiotic) weed seed dispersal at several stages, partly via the worldwide commercial seed trade but, above all, by crop management operations, thereby potentially facilitating the entry and spread of alien weed species. This phenomenon, together with the invasive expansion of existing weeds that more successfully co evolve and adapt to the new environment, might exert an adverse effect on biodiversity. In-depth knowledge of weed seed dispersal, survival, and germination mechanisms is therefore essential for effective and eco-compatible management of the weed phytocoenoses present in the agroecosystem in order to promote a rational trade-off between agricultural productivity and environmental protection.

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I.INTRODUCTION

India is an agro-based country. The Indian people and Indian economy mainly depends on agricultural sector. The development in agricultural fields forms the basis for Indian growth. Nearly 70% population depends on agricultural. The Indian govt. is promoting to adopt mechanization & new ideas about farm machinery for the rapid development in the agricultural field.

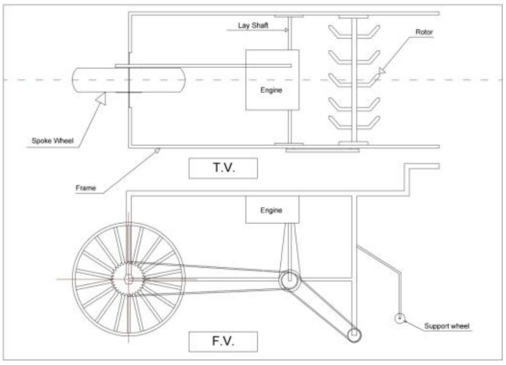
The present project work titled " Design of Agricultural Mechanized Weed Mower" Is a step forward to the mechanization of a farming process, which is usually carried out by a manually operated machine. The mechanization of a weed mowing process considerably reduces the efforts and time required by the operator.

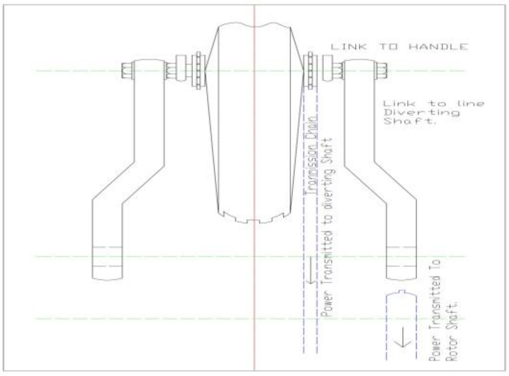
Working Principle of Weed Mower

- **Principle:** Weed mover is based on principle of 'conversion of engine power into mechanical work'.

- **Working:** The mover drives from an automobile engine capacity. A rotary motion of an engine output shaft is transmitted through pulley & chain drive to the cutter rotor, & the front wheel of a machine. The rotor is mounted with the cutting teeth, which rotate at a very high speed. Due to this speed power is effectively used to cut weed or wanted grass within crop line also useful for effective weeding.

- **Proposed figure of Design of Agricultural Mechanized Weed Mower:**



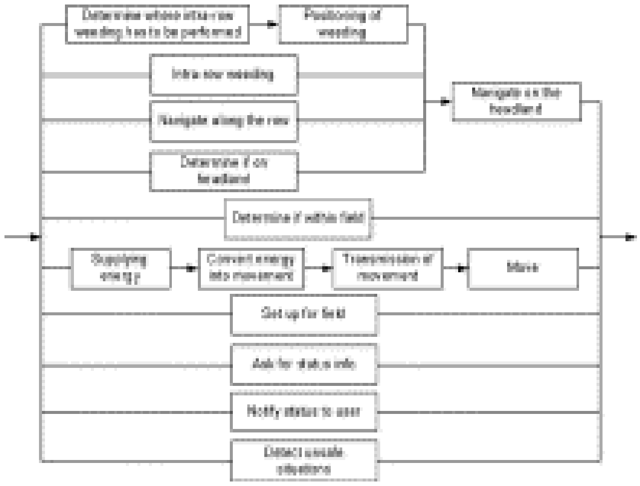


II.LITERATURE SURVEY

The autonomous weeding robot is desingned using a systematic design method. This method belongs to a class of methods using a phase model of the product design process. These methods describe the product design as a process consisting of different phases at different levels of abstraction .The phases are (1) ‘problem definition phase’, (2) ‘alternatives definition phase’ and (3) ‘forming phase’ .The results of the respective phases are a function structure, a concept solution and a prototype, respectively.

The problem definition phase starts with defining the objective of the design. In the problem definition phase a set of requirements is established, that can be split into fixed and variable requirements. A design that does not satisfy the fixed requirements is rejected. Variable requirements have to be fulfilled to a certain extent. To what extent these requirements are fulfilled, determines the quality of the design. The variable requirements are also used as criteria for the evaluation of possible concept solutions. The last part of the problem definition phase consists of the definition of the functions of the robot. A function is an action that has to be performed by the robot to reach a specific goal. In our case, important functions are ‘intra-row weeding’ and ‘navigate along the row’.

The functions are grouped in a function structure, which represents a solution on the first level of abstraction. The functionstructure consists of several functions.



Every function can be accomplished by several alternative principles, e.g. mechanical and thermal principles for weed removal.

The weeding robot must not cross the field boundaries.

•The weeding robot must be self restarting after an emergency stop.
•The weeding robot informs the farmer when stopped definitely, e.g. due to security reasons or when the task is finished.
•The weeding robot sends its operational status to the user at request.
•The weeding robot must function properly in sugar beet.

III. THE DESIGN PROCEDURE

3.1. METHOD: The autonomous weeding robot is designed using a systematic design method describe .This method belongs to a class of methods using a phase model of the product design process. These methods describe the product design as a process consisting of different phases at different levels of abstraction [14]. The phases are (1) ‘problem definition phase’, (2) ‘alternatives definition phase’ and (3) ‘forming phase’ (Fig. 1). The results of the respective phases are a function structure, a concept solution and a prototype, respectively.

The problem definition phase starts with defining the objective of the design. In the problem definition phase a set of requirements is established, that can be split into fixed and variable requirements. A design that does not satisfy the fixed requirements is rejected. Variable requirements have to be fulfilled to a certain extent. To what extent these requirements are fulfilled, determines the quality of the design. The variable requirements are also used as criteria for the evaluation of possible concept solutions. The last part of the problem definition phase consists of the definition of the functions of the robot. A function is an action that has to be performed by the robot to reach a specific goal. In our case, important functions are 'intra-row weeding' and 'navigate along the row'.

The functions are grouped in a function structure, which represents a solution on the first level of abstraction (Fig. 2). The function structure consists of several functions. Every function can be accomplished by several alternative principles, e.g. mechanical and thermal principles for weed removal.

3.2 RESULTS OF THE DESIGN PROCESS:

The following alternatives to determine where intra-row weeding has to be performed were taken into consideration

3.2.1. Seed mapping:-During seeding the positions seeds can be recorded by RTK–DGPS. A seed sensor senses the seeds while they are falling from the machine into the soil. Griepentrog et al. [15] found that the mean deviation between estimated sugar beet seed position and true plant position ranged from 16–43 mm, which means that for targeting weeds close to the crop plants additional sensing would be required.

2.2.3. Shape and color:-Plant species can be identified based on characteristic shape, colour and texture features using image analysis. Gerhards and Christensen [16] report an average identification rate of 80% using image analysis when plant species were grouped into five different herbicide classes. Åstrand and Baerveldt [17] were able to classify beets with a classification rate of 98% using image analysis. Extraction of individual plants out of a scene was done manually and the colour features used may change due to differences in soils, nutrients and sunlight. Excluding colour features, the classification rate of beets classified as beets was reduced to 80%. Åstrand [18] reports also the results of a combination of using plant pattern information and the individual plant features derived from image analysis. Crop plant classification rates of 92% and 98% on a dataset are reported using a classifier trained offline. Åstrand [18] expects that variations in plant appearance within and between fields could easily reduce the performance in a real-time field application.

2.2.4. Pattern recognition of plant spacing:

Row crops like sugar beet have approximately equal intra-row distances. Therefore, crop plants can be identified based on this regularity. Bontsema et al reconstructed individual positions of crop plants in a row successfully with Fourier transform on a signal made by a low cost infrared light barrier. The quality of detection was decreasing with a decreasing distance between the crop plants, an increasing standard deviation of the distance between the crop plants, an increasing number of weeds per meter and decreasing width of the crop plants. In experiments 80–97.5% of the crop plants were detected correctly

2.3 POSITIONING OF WEEDING

The following alternatives to position the weeding actuator at the location indicated by the plant detection system were taken into consideration:

2.3.1 GPS:

The position of the actuator can be measured by mounting a GPS antenna above the actuator position. It is questionable whether the maximum position update frequency of about 10 Hz is sufficient for a precise actuator positioning.

2.3.2 Dead reckoning:

With a wheel encoder the position of the actuator relative to the crop plant location can be measured. Accumulation of inaccuracies over the distance between sensors and actuators occurs but is limited if the distance between both is small.

2.3.3 Machine vision:

A machine vision system could track both the actuator position and the position at which it should become active. To do this a specially developed image processing algorithm is needed.

The following alternatives to perform intra-row weeding have been taken into consideration:

2.3.4 Mechanical:

Weeds can be cut or removed from the soil by mechanical actuators. Actuators for intra-row weeding are described by several authors and Some of them are specially designed for operation in sugar beet and A disadvantage is the inertia of the mechanics limiting the capacity of the machine.

2.3.5 Air:

Pressured air can be used to remove weeds from the intra-row area. Lütkemeyer applied pressured air through two horizontal air nozzles at both sides of the crop row about 2 cm under the soil surface, removing weeds from the intra-row area when moved in row direction.

2.3.6 Flaming:

The plants in the field are exposed to flames generated by burning fuel in such a way that the heat injury causes the weeds to die but the crop plants to survive.Recently developments are reported on intra-row flaming with an array of small burners that can be turned on and off rapidly

2.3.7 Electric Discharge:

Weeds can be killed by producing an electrical discharge. Blasco et al applied an electrode producing electrical discharges of 15 kV and 30 mA during 200 ms for a single leaf. The system was able to eliminate 100% of the small weeds, but on bigger plants only the affected leaves showed some kind of damage. Safety with these high voltages is also a concern.

2.3.8 Hot Water:

Weeds are exposed to hot water so that heat injury causes the weeds to die. Hansson and Ascar conclude that hot water weed control has potential on urban surfaces and railroad embarkements.

The size of the vehicle was determined by the standard track width used for mechanical weeding in sugar beet in the Netherlands which is 1.50 m. This track width also makes the design versatile in the sense that it is suitable for crops grown in beds like carrots and onions. Sugar beets are grown at a row distance of 50 cm so the weeding robot covers three rows. The engine power is chosen so that sufficient capacity is available for driving and steering under field conditions and for operating three weeding actuators. The required power for the actuators was calculated based on an actuator specially designed for intra-row weeding by Bontsema et al The engine is a 31.3 kW Kubota V1505-T.

The ground clearance is about 50 cm to prevent the crop from being damaged by the vehicle. The vehicle is 2.5 m long to have enough space for mounting actuators under the vehicle in the middle between the front and rear wheels. The tire width of 16 cm leaves enough space for steering in-between crop rows while soil compaction is expected to be acceptable. The weight of the vehicle is about 1250 kg.

The engine powers a hydraulic pump. It supplies the oil for steering and driving, while another pump can be mounted for driving the actuators. The oil for driving and steering flows to an electrically controllable valve block with eight sections. Four sections are used for steering and four are used for controlling wheel speed, so wheel speeds and wheel angles can be controlled individually. The wheels are driven by radial piston motors. The driving speed ranges from 0.1 to 1.8 m/s. A maximum travel speed of 3.6 m/s for fast moving of the robot from field to field could be realized by switching to two wheel drive by combining the oil flows of four wheels into two flows.

Each wheel is steered by a hydraulic motor with a planetary reduction gear. The maximum steering speed is 180 deg/s. The angles of the wheels are measured by angle sensors. The oil for driving the wheels flows via a turnable oil throughput. This makes it possible to turn the wheels in any angle from 0° to 360°.

The weeding robot electronics consists of six units connected by a Controller Area Network (CAN) bus using the ISO 11783 protocol. In a schematic overview of this system is given with vehicle control related sensors and valves. In every wheel a cogwheel is mounted with 100 cams thus giving 100 pulses per revolution via magneto-resistive sensors. Per wheel two of those sensors are mounted such that their signals are 90° out of phase, thus permitting both speed and direction detection. Per wheel steering unit an analogue angle sensor is mounted with an accuracy of 1° and a range of 180°. The sensors are connected to four micro controllers located near the four wheels which transmit the wheel speeds and the wheel angles via the CAN bus. A laptop processes images supplied by the front sight camera and transmits the location of the crop rows in relation to the vehicle position in a CAN bus message. An embedded controller running a real time operating system (National Instruments PXI system) also connected to the CAN bus performs the vehicle control. The GPS receiver and a radio modem are connected with the PXI via RS232. The radio modem interfaces the remote control used for manual control of the weeding robot. The PXI system gathers wheel angles, wheel speeds, crop row location data, GPS data and remote control data and controls the vehicle by sending messages to two micro controllers connected to the valve block. The user interface of the weeding robot software running on the PXI system can be visualized on a laptop via a wireless connection (Ethernet). Besides the sensors that are directly related to navigation and control, there are some more sensors connected to the modules. These sensors, indicating oil filter status, oil temperature and oil level are also interfaced to the PXI via the micro controllers and the CAN bus. In case a sensor indicates an emergency, the weeding robot will switch off automatically. Devices for the communication related functions

Designing Factors & Aspects:-
The machine is designed by considering all aspects as much as possible.
The main designing aspects involved are

1) Build mainly for Indian farmer.
2) The machine reduces the manpower required and overheads.
3) The cost of machine is comparatively low cost & light weight.
4) The machine is power driven hence reduces the efforts of an operator to a large extent.
5) The machine maintenance is kept in consideration as low.
6) Taking the help of Ergonomics consideration for comfort ness of operator.

List of Component which are required for machines

1) Tyre tube.(20x175).
2) Rim(20x175)
3) Handle
4) Cycle fork
5) Bearings
6) Sprocket 44 teeth-1
7) Sprocket 28 teeth-1
8) Sprocket 18 teeth-1
9) Sprocket 16 teeth-1
10) Supported Wheels-2
11) Lay shaft
12) Rotor shaft
13) Height Adjustment screw
14) Metal bushing
15) Knuckle joint
16) Transmission Chain-2
17) Luna Engine-Power 3HP,3000 r.p.m.
18) Luna Engine foundation bolts,other Nut& Bolts.

- 19)Etc.

A. Power Transmission Stage I:

Drive:- V-belt pulley drive/chain & sprocket/coupling drive.
Engine Specifications:-3HP,3000 rpm(N1)
Engine pulley dia. (D1)=50 mm
The drive transmitted to lay shaft through V-belt pulley.
Lay shaft Pulley dia (D2)=180 mm
The speed of lay shaft is as follows
D1N1=D2N2
N2=D1N1/D2
N2= 834 rpm.

B. Power Transmission Stage II:-
Drive Sprocket Chain Arrangement
The sprocket chain arrangement
The sprocket dia. (lay shaft (D3))= 85 mm
The sprocket dia of spoke wheel (D4)=140 mm
The speed of lay shaft (N3) = 834 rpm
The speed reduction is obtained
The speed of spoke wheel is calculated as follows
D3N3=D4N4
N4=D3N3/D4
N4=394rpm
Drive-sprocket chain arrangement
The sprocket dia.(lay shaft(D5))=120 mm
The speed of lay shaft(N5)= 834 rpm
The sprocket dia of rotor(D6)= 60 mm
The speed enhancement is obtained
The speed of rotor shaft is calculated as follows
D5N5=D6N6
N6=D5N5/D6
N6= 1668 rpm

Design of Lay shaft & Rotor Shaft
T1=
T2=
We know that
N= rpm
D= mm
T=(T1-T2)R
Neglecting the wt on pulley, total vertical load acting on shaft
W=T1+T2
Bending moment M=W*L
d= dia. Of shaft in mm

Power Transmitted From Lay shaft To Spoke Wheel:

Drive sprocket(T)= 44 teeth
Pitch standard =(P)=D sin (180/44)
D= 133.53mm
We take D=180 mm
P=D*sin(180/18)
9.525=D sin10(0.1736)
D=54.56 mm
We have taken 85 mm dia, sprocket which is available in the workshop.
Power 3HP= 2250 watt
Pitch line velocity=Pi.D.N/60
Vp=(Pi. X 0.180x197)/60
Load on chain=rated power/Vp
W=2250/3.29.
=683.89
Load on chain(w)= 683.89 N
F.0.5=WB/w
W.B=Breaking load of chain
=900 kg of 0.6 B.chain
(900x10)/683.89
=13.16 F.O.S.
Principle Dimensions of Tooth Profile
1.Tooth Flank Radius (rc)
2.Roller Seating radius-(ri)
3.Roller seating Angle(A)
4.Total height above pitch polygon(hg)
5.PCD=P/sin(180/T)
6.Top dia(Da)
7.Root dia(Df)
8.Tooth Width(bf1)
9.Tooth side radius(rx)

The header consists of a V-shaped guide and a cutter/feeder mechanism which in turn consists of a cutter, two feeder belts, and four identical pulleys . The rear pulleys drive the front ones via the feeder belts. The cutter consists of two wheels (a notched wheel and a grooved counter-cutting wheel) each of which rotates as a unit with one of the front pulleys. The diameter and thickness of the cutter wheel are 125 and 1·5 mm, respectively. The diameter of each pulley is 100 mm. The distance between the front and the rear pulleys is 300 mm. The distance between the left and right side pulleys is adjustable to control the contact pressure (between the feeder belts) required to hold the stalks. The header is well covered so that only the working area of the cutter and feeder belts is exposed to prevent seeds and stalks from falling to the ground or entering in the spaces between the moving elements of the header and causing jamming. The V-shaped guides force the stalks towards the cutter. As the plants are being cut, they are also being held between the feeder belts, which carry the cut stalks to the elevator conveyer at the rear of the header.

Fig. View of the cutter/feeder mechanism without its covers. Motion from engine is provided to the gear on top of the left-rear pulley. Two in-mesh-gears (under the rear pulleys), each of which rotates as a unit with one of the rear pulleys, ensure positive drive of the feeder belts

The elevator conveyor is an endless chain with reinforced brushes which sweep the cut plants, seeds and straw which fall onto the header, along the inclined surface of the conveyor into the tank.

The power unit consists of a 4·1 kW petrol engine, a slip clutch and two gear reduction units (5:1 and 15:1). The slip clutch controls flow of power from the engine to the gear reduction units.reduction-gear directs power to the rear pulleys of the header, while the 15:1 reduction-gear drives the central-drive unit that

IV.ADVANTAGES

1. The machine is easy to operate.
2. Requires less efforts
3. Requires less maintenance
4. Economic aspects well considered
5. Reduces man power
6. Can be used for variety of crops

V.CONCLUSIONS

The research vehicle was designed using a structured design method. The advantage of using this method is that it clearly structures the design process. It provides a good overview of the complete design and because of the structured sequence of design activities, it is easy to keep track of the progress of design. Another advantage of the structured design method is that it forces the designer to look at alternative solutions and this decreases the probability of heuristic bias and increases the quality of the outcome. Although the designer is forced to thoroughly judge the identified alternative solutions when selecting the final concept, the outcome is still depending on the available knowledge of the designer about the alternative solutions. So, while the method can not guarantee that the absolute best solution possible will be selected, it certainly is superior to a trial and error approach. In a research context it is easy to identify alternative subjects that are worthwhile to investigate further, while in the same time the main line of the research remains clear.

The result of the design is a versatile research vehicle with a diesel engine, hydraulic transmission, four wheel drive and 360° four wheel steering. The robustness of the vehicle and the open software architecture permit the investigation of a wide spectrum of research options regarding solutions for intra-row weed detection and weeding actuators. The result of the design is a reliable concept for an autonomous weeding robot in a research context.

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