International Engineering Research Journal Page No 1899-1903

Automation of Warehouse Spraying System

Shrikant B. Girigosavi, Vishnu B. Ghagare and Prasad P. Dixit

***Abstract*— India is agricultural country; Seeds and grains produced in farm are stored in warehouses for the specific period from weeks to years as per the demands in market. The stored grains are chiefly subjected to attack of insects, mice and other micro-organisms. To avoid the increasing population of insects the toxic chemicals are spread on stored grains. The spraying operation of pesticides, insecticides and fumigants on seeds and grains is purely done by numbers of workers using old method and old equipment's likes manually operated sprayer and portable spraying pumps. Toxic chemicals may be swallowed by human worker when they are coming in contact with Toxic pesticides. It is very hazardous and harmful to human life and they cause some health effects like eye irritation, skin irritation. Some of chemicals are commonly used have been associated with birth defects, mutations and cancers. To avoid direct human contact during the spraying of toxic chemicals on stored seeds & grains in warehouse the automated Warehouse Spraying System is proposed. This paper presents the automation design study of Warehouse Spraying System. This system having remote control mobile platform and telescopic boom with flat-fan type nozzles. This system is used to spray the toxic chemicals on seeds & grains without direct contact of human during spraying operation. This system is capable to spray the chemicals in congested areas which are generally seen in warehouses. Warehouse Spraying System can efficiently spraying the chemicals at height up to 14 feet's.**

***Index Terms*— Agricultural, Grains, Insects, Toxic Chemicals, Warehouse, Warehouse Spraying System.**

I. INTRODUCTION

India is agricultural country; main business of Indian people is farming. The warehousing capacity available in India is near about 108.75 million MTs including in public, cooperative and private sectors. The grains produced in farm are stored in warehouses for periods of a few weeks to a few years before they are fed or processed as per market demand. The grains bins are stacked in warehouse at up to 14 feet height. The stored grains, Seeds are chiefly subjected to attack of insects, rats and micro-organisms. Regular spray of insecticide & pesticides is helping to clean up lingering infestations and prevent increasing population of stored-grain insects.

Traditional Spraying system of Pesticides, insecticide or a fumigant is purely done by Human workers.

Paper on Automation of Warehouse Spraying System is submitted for review on 10th May, 2016 to 2nd Mechanical Engineering Post Graduate Student's Conference which is going too held on 10th-11th June 2016, in Pune.

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In warehouse workers load pesticides in 10 to 15 litre tank and spray chemicals on grains bags which are stacking up to 14 feet height. In current Spraying method minimum three people required; one worker sprays, second person followed him with the pesticide mixture and guide the pipe, and a third person mixes pesticide powder with water as per requirement. Numbers of workers are increased with size and numbers of warehouses.

A pesticide is any substance or mixture of substances used for prevention, destroying, repelling and mitigation of pests. Pests can be insects and insect-like organisms, mice and other vertebrate animals, unwanted plants, fungi, bacteria and viruses that cause plant diseases [1]. Pesticides are toxic substances and are designed to harm or kill pests. Hazardous pesticides can harm or kill humans. Hazard depends on the toxicity of the pesticide [9]. It causes skin irritation, eye irritation and allergic skin reactions. When People came in contact with pesticides may they experience a number of health symptoms like defects in birth, mutations, effects on reproduction and cancers [10].

FIGURE 1. TRADITIONAL MANUAL SPRAYING SYSTEM

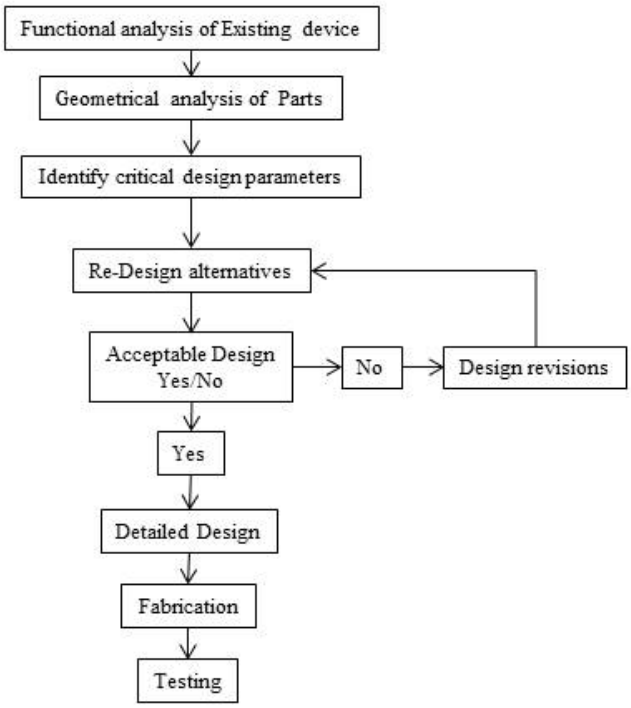
Reid J.F., Zhang Q., Noguchi N. & Dickson M., presents the study on adapt commercial agricultural machinery in autonomous agricultural platforms in Agricultural automatic guidance research in North America [3]. Astrand & Baerveldt studied the development of platforms built specifically for agricultural autonomous vehicles or robots [4]. Joost Gwinner, R Harnisch and Otto Mp Align provide the study about warehouse construction, types of insects and conventional surface treatment using Sprays in Post-Harvest Project [11].

To avoid direct human interference during spraying of toxic chemicals in warehouses the unmanned manually operated Warehouse Spraying System is proposed.

This is first automated mobile system which is newly introduced for warehouse to improve work quality by safe and smart work with minimum time consumption during operation. This system is very useful to spray any kinds of liquid chemicals like pesticides, insecticide and a fumigant on stored grains. Unmanned Warehouse Spraying System is manually operated by using remote control unit or programmed computer interface. Warehouse Spraying System consist of two Lead acid & Lithium-ion batteries, two BLDC motors for drive, two powered wheel at rear, one caster wheel at front, spring suspension system, liquid tank with pump and vertical telescopic boom with flat fan type nozzles. This system can be used in rough terrain which is generally observed in warehouse. Warehouse Spraying System is able spray chemicals at height up to 14 feet's. This system is capable for very safe and efficient work in warehouse.

II. METHODOLOGY

Warehouse Spraying System (WSS) methodology include the standard part selection, analysis of existing devices, analytical and computational CAD design, manufacturing and finally testing of system in working environments. Following flow chart shows the steps in WSS methodology for designing.



Standard parts are selected as per the application requirements & specification of parts. CatiaV5 CAD designing tool is used for modelling, packaging and assembling of CAD structural & standard parts. Important structural parts are analysed by using Ansys software tool.

III. EXPERIMENTAL SETUP

Warehouse Spraying System (WSS) consists of a mobile platform and telescopic boom. Mobile platform is a special vehicle with three-wheel drive; motion of the vehicle is controlled by two powered wheels and one caster wheel. Mobile platform is designed to have a 100 mm clearance (distance from the base) with independent suspension of each wheel and they are attached to two individually controlled motors. For designing of Warehouse spraying system Structural parts are designed as per design requirement like Base plate, Top plate, links, wheel shafts, pillars, mountings, Telescopic boom and side covers. Standard parts are purchased as per requirement, like BLDC Motors, Battery, Wheels, Nozzles, Valves, Pump, Tank, Bearings, etc. WSS mobile base having two independently controlled powered wheels with BLDC motors and one caster wheel assembled with chassis by using two helical compression suspension springs.

A. Design and Construction

Size of mobile base is 600 mm length, 400 mm width and 350 mm height. Total platform weight is 60 Kg.

Base plate size= 3 mm X 400 mm X 600 mm
Top Plate = 3 mm X 400 mm X 600 mm
Material = Stainless steel 304/316

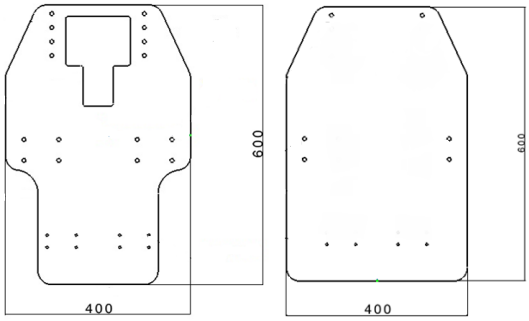


FIGURE 2. SIZES OF BASE PLATE & TOP PLATE

Two 12V 17Ah Lead acid battery pack is used to drive two BLDC motors having independent suspension system. Two rear wheels of 200 mm diameter carrying 80% of total load of the system and tyre pressure coming at ground is near about 80 kPa.

Motor Type = BLDC Motor with gear head (Drive motor)
Speed = 144 rpm (at output shaft)
Reduction Ratio = 1:10
Torque = 8.5 Nm
Power = 120 watt

Helical compression springs are used for suspension.
Spring materials = Stainless steel (AISI316/ASTM A313)
Ultimate tensile strength = 1476 N/mm²
Spring index = C = 6
Wire Diameter = d = 8 mm
Mean coil diameter (D) = C x d = 6 mm x 8 mm = 48 mm
Numbers of active coils (N) = 6
Spring Ends = Squared and Ground Ends Coiled left-hand

Standard Skf bearings are used for to reduce friction between shaft & links.
Shaft diameter = d = 15 mm
Expected life of bearing = 16000 Hrs
Selected Bearing = SKF series 6005
Bearing size = d x D x B = 15mm x 24mm x 5mm

According to application 120° flat-fan nozzle are selected for spraying. The standard flat-fan nozzle are operates between 30-60 pounds per square inch (psi). The even flat-fan nozzles smaller droplets cover the entire width of the nozzle's spray pattern [17]. Total 4 flat-fan nozzles are mounted on 12 feet telescopic boom which cover the height up to 14 feet from ground. 16 litre tank mounted on mobile base with 12V battery operated electric pump which delivered the fluid up to 14 feet with 40 PSI pressure. Discharge from each nozzle is 840 ml/min.

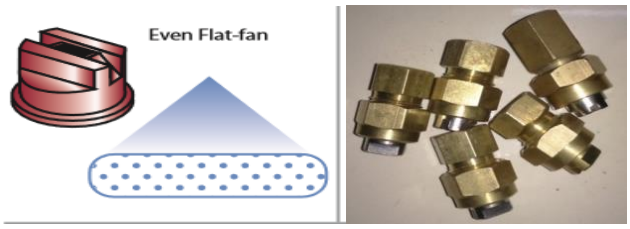


FIGURE 6. FLAT-FAN NOZZLES

Base plate & Top plate are modelled in CatiaV5 and then analysed by using Ansys software, analysis images are shown in figure 3, 4 & 5.

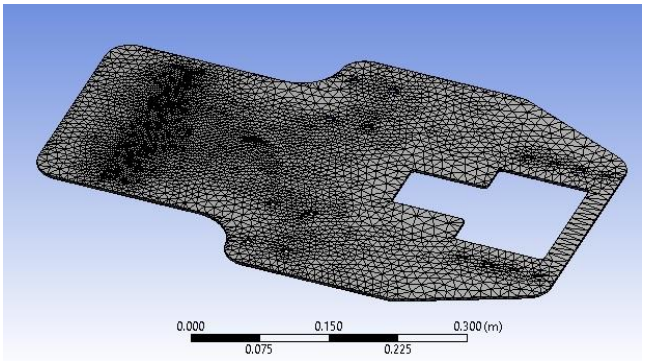


FIGURE 3. MESHED MODEL OF BASE PLATE

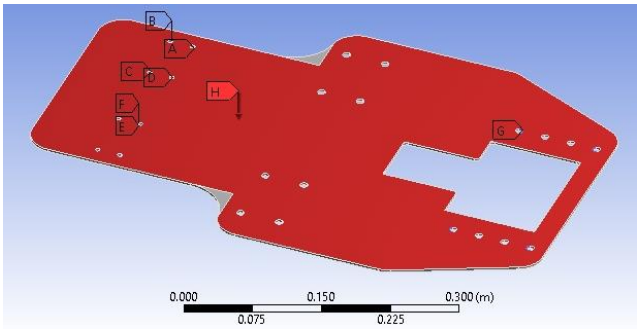


FIGURE 4. LOADING OF BASE PLATE

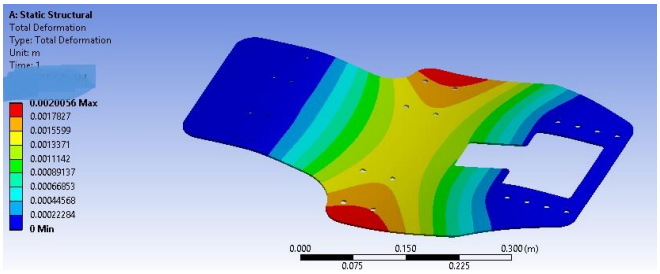


FIGURE 5. TOTAL DEFLECTION

CAD design of warehouse spraying system mobile platform is shown in figure 7.

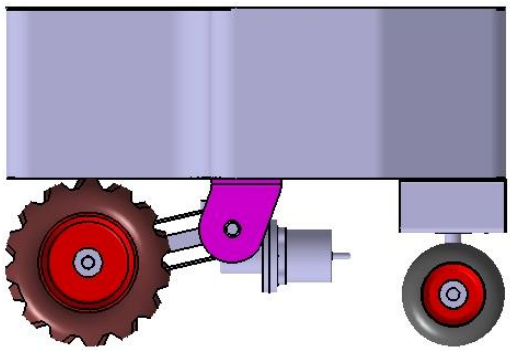


FIGURE 7. WSS MOBILE PLATFORM CAD DESIGN

Total mass of system = M = 60 Kg
Velocity of system = V = 1.5 m/sec.
Acceleration = A = 0.1 m/sec²
Wheel radius = r = 0.1 meter
Torque required at each wheel= 6 Nm (Min)

B. Working of WSS

Warehouse spraying system is operated on 24V battery power. Two BLDC geared motors and two powered wheels are used for locomotion. These two wheels have independent suspension system. Chain driven mechanism is used to transmit power from motor to wheel. One wheel is mounted on front which is steered by steeper motor. A 12 feet long telescopic boom is used for mounting the 4 to 5 nozzles for spraying the chemicals on grains bags. Flat fan type nozzles are connected with solenoid valves having parallel pipe connection from Chemical tank. Chemical tank of 16 litre capacity with electric pump sprayer is mounted on system.

Users can controlling the system by using wireless remote control, and sending appropriate signals to system according to signals and results coming from system and path of lane in which spray is required. User can control and guide the Warehouse spraying system from distance location near about 300 meters away from system. User can monitor the system through display unit and accordingly control the system in desired environment [8]. System should travels between two rows of stored grains bags; the area available for movement is near about 60 to 80 cm, which is very congested for movement, so system should be design according to the available space.

FIGURE 8. COMPLETE WAREHOUSE SPRAYING SYSTEM

IV. RESULTS AND DISCUSSION

In current traditional system minimum peoples are required to spraying the chemicals in warehouse approximately time taken is 40 min to 50 min for 300 feet 4 rows. This same task can be done by automated Warehouse spraying system in 20-25 min and for handling the system only one man is sufficient. As compare to existing spraying methods the automated Warehouse spraying system is to much better, safe and efficient.

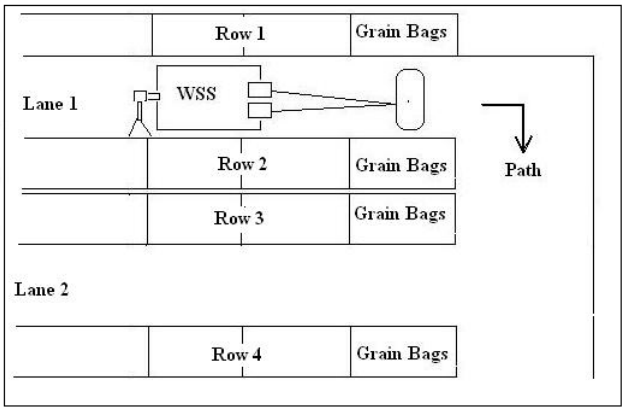


FIGURE 9. WAREHOUSE SPRAYING SYSTEM WORKING ENVIRONMENT

Warehouse spraying system will performing very important role in warehouse. This system is very safe and reliable for warehouse to performing any kinds of spraying operation. For controlling & handling the Warehouse spraying only one person is sufficient. One person can control more than one spraying systems at a same time. Time required for spraying by using Warehouse spraying system is 2 to 3 time less than current traditional system.

Warehouse spraying system initial investment cost is more than traditional system but working and labor cost is to much less. WSS is capable to handle very hazardous chemicals. WSS is avoiding over or extra spray during operation which is less possible in traditional spraying system. WSS cover the height form 0 feet to 14 feet at a time by using numbers of nozzles spray on vertical boom which is not possible in Traditional system. WSS is very safe and cost effective than current traditional system.

V. CONCLUSION

This paper presents the design & construction of Warehouse spraying system. The mechanical assembly with base, motors, wheels, springs, telescopic boom, nozzles, battery & pump. Warehouse spraying system is very helpful in warehouse to spray the toxic chemicals on stored grain bags without direct human contact with toxic chemicals. Warehouse spraying system can spray chemicals very safely and efficiently at height up to 14 feet's. There is very large scope seen to add autonomous intelligence in Warehouse spraying system.

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