Multiple Arms Automated Excavator

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Abstract— Now a days in this fast growing industrial age every company needs speed in manufacturing to cope up with the customer's requirements. Every industrialist cannot afford to transform his unit from manual to semi-automatic or fully automatic as automation is not that cheap in India. The basic objective of this project is to develop a versatile and low cost robotic arm which can be utilized in any industry to eliminate this problem. Our robotic arm can be used in number of application by changing the program of controller and the structure is designed in such a way that it is capable to lift light loads but can also lift medium loads. This robotic manipulator would be used mainly in the packaging department and automatic assembly lines.

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I. INTRODUCTION

An excavator is a machine used for construction activities. The excavator consists the following parts

1. house,
2. undercarriage,
3. boom,
4. arm and bucket.

The under carriage has a motor and gears which aid in movement of the equipment. The house contains an engine, oil and fuel cylinders. The house is connected to the under carriage through a cylindrical gasket enabling it to revolve freely at a 360^0 angle. A boom is attached to stick which in turn lifts the bucket. Ancient excavators consisted of long counter weight that was situated at the back of the machine to enhance digging and lifting. This was not suitable for areas with limited space. *Yanmar* the excavator, introduced the line of zero tail swing excavator in1993.The zero tail swing was designed in such a way that the counter weight was limited to the area of tracks during its operation. This machine was much safer and easier to use in confined areas. Now the modern types of excavators borrow their design and features from the zero tail swing.

Figure 1. Multiple arms automated excavator

A. *Various kinds of Excavators*

Excavators are used in forestry, dragging rivers, heavy lifting, mining material handling, driving piles and demolition. There are various kinds of excavators. The main types includes, compact long reach, suction excavators and power shovels.

B. *Compact excavators*

They are wheeled machines weighing at least 7 tones. The movement of compact lifters is enhanced by hydraulic fluid powered by hydraulic cylinders. The compact excavators consist of a work group, under carriage and house. The house is used for slewing while the undercarriage is a major support to the workgroup and house. The work group consists of a boom, arm and bucket.

C. *Crawler excavators*

These are the main excavators on the market. They are usually very big and very large and they always come with high horsepower. These are one of the most well-known types of excavator in the world.

II. LITERATURE SURVEY

A. *The Gradall Legend*[1]

Manpower shortage during World War II prompted invention of the world's first hydraulic excavator. The legendary Gradall excavator traces its roots back to the early 1940s — a time when World War II created a scarcity of laborers for delicate and necessary grading and finishing work on highway projects. That was the exact dilemma faced by Ferwerda-Werba-Ferwerda, a Cleveland, Ohio, construction company. Ray and Koop Ferwerda, brothers who had moved to the U.S. from the Netherlands, were partners in the firm that had become one of the leading highway contractors in Ohio. Because so many men had left the workforce and joined the military, the Ferwerdas set out to create a machine that would save their company by performing what had been manual slope grading work.Their first attempt was a device created with two beams set on a rotating platform which was affixed atop a used truck. A telescopic cylinder moved the beams in and out, enabling the fixed blade at the end of the beams to push or pull dirt. [1]

XL Series hydraulics changes everything, The introduction of XL Series hydraulics in 1992 marked the

single most dramatic change in Gradall excavators since their invention. These state-of-the-art hydraulics systems enabled Gradall excavators to deliver high-productivity production on a level that was realistically comparable with conventional excavators.

XL Series hydraulics marked the end of the traditional Gradall power drawn from gear pumps and low pressure hydraulics — a system that effectively handled grading and finishing work but had difficulty competing for high-productivity jobs.

The new XL Series models were equipped with a piston pump, high- pressure hydraulics system, making dramatic improvements in boom and bucket breakout forces. With this increased power, Gradall excavators were armed with a remarkable increase in their ability to dig and lift.

In addition, the XL Series hydraulics system was designed with a load-sensing advantage. While most conventional excavators require an operator to select a working model, the Gradall system automatically adjusts the hydraulic power for the job at hand, making the operator's job easier and conserving fuel.

XL Series hydraulics effectively thrust Gradall into the larger, highly competitive market of machines designed to handle excavating, demolition, pavement removal and other difficult jobs. The telescoping, tilting boom further advanced the Gradalls marketability because of its exclusive ability to better position attachments and work in low-overhead spaces.

B. Swing Energy Recuperation Scheme for Hydraulic Excavators

Due to the high demand of fuel efficient construction equipment, significant research effort has been dedicated to improving excavator efficiency. Electric and hydraulic hybrids designs have shown to greatly improve fuel efficiency but require drastic design changes. The redesigned systems thus require many hours of operation to offset the manufacturing costs with fuel savings. The simulation results show that an optimum configuration reduces the swing energy consumption by 48% and the total excavator energy by 17% during digging and dumping operations.[2]

C. The Gradall Tractor

The Gradall tractor was invented by Ray and Koop Ferwerda of Cleveland, Ohio. Ferwerda is known for creating a telescoping-boom excavator that was unique for being mounted on a truck. The Ferwerda brothers, who moved from the Netherlands to the U.S., became partners in a highway contracting firm. Due to many men leaving the workforce for the war effort, the Ferwerda brothers were in need of a machine that could perform slope grading work. Their first design, a tractor-mounted excavator, had two beams that sat on a rotating platform and a telescopic cylinder that moved the beams forward and back, producing the excavation motion. Although not produced for commercial purposes until a later date, the hydraulic excavator, available in 15, 24, 36 and 60-inch bucket sizes, was launched in 1941. The success of this led to the production of three more between 1942 and 1944. [3]

D. Pallet Trucks[4]

For the product delivery the vehicles normally proceed down the path to specific destinations in storage areas, pull off onto a spur, lower their pallet forks to the floor and pull out from under the pallets, then automatically return empty to the loading areas. Many applications have been done whereby the vehicles are manually boarded in the loading areas and driven off the path to load staging areas where they are manually loaded. The vehicles are backed up under the loads, driven back to the path, given a destination by an operator and automatically proceed to the drop off spurs in the warehouse areas. Automatically reversing a guided pallet truck adds considerable expense to the system and the necessity for accurate positioning loads on the floor for pickup. They can only be justified in limited applications at this time. Manually loading the vehicle gives operators flexibility to position loads anywhere off the path and still be able to retrieve them with the vehicles which then automatically proceed without operators into the warehouse drop locations.

E. Automated guided vehicles

An AGV and guidance system for transporting material between at least two pickup and delivery stands. The AGV has a chassis for carrying objects. A computer processor is supported by the chassis for controlling and monitoring AGV operation. An interactive display is connected to the computer processor and mounted on the chassis for displaying status, current assignment and diagnostic information relating to AGV operation.[5]

III. NEED OF MULTIPLE ARMS EXCAVATOR

A. Material handling

Materials handling is loading, moving and unloading of materials. To do it safely and economically, different types of tackles, gadgets and equipment are used, when the materials handling is referred to as mechanical handling of materials. Since primitive men discovered the use of wheels and levers, they have been moving materials mechanically. Any human activity involving materials need materials handling. However, in the field of engineering and technology, the term materials handling is used with reference to industrial activity. Materials handling as such are not a production process and hence do not add to the value of the product. Mechanical handling reduces the cost of manual handling of materials, where such materials handling are highly desirable.

B. Need of material handling in industry

- Material handling activity includes:
- Picking up the material
- Transporting the material
- Setting down the material

The cost and time for picking up the material and setting down the material is almost fixed. Moving the material from one location to another is a time and cost variable. Attempts have been made to reduce this cost and time. Selection of suitable material handling device can solve this purpose to a great extent. Out of total production time merely 20% time is

spent on actual processing. Remaining time is spent in movement; waiting etc. thus proper arrangement of material handling system can improve means faster production higher plant capacity, lower shocks in process and less damage to product in all stages.

IV. COMPONENTS USED

A. *Body (frame) of the project*

The plywood box is used for making the base of the EXCAVATOR. In which one face of the box is open. Two D.C motors (60rpm) placed below the bottom of wooden box and connect to the wheels for giving motion to EXCAVATOR. This can move forward, reverse, left & right direction. We use the material wood for making our EXCAVATOR light in weight. This wooden box is 280mm long, 220mm wide & 80mm height. The thickness of box is 8mm.

Figure 2. Wooden box.

B. *Wheels*

Plastic wheels with a diameter of around 70mm. The wheels come with a plastic rubber tire which provides good friction with most surfaces. The wheel is around 15mm thick. The wheel has a center shaft hole of 6 mm diameter and can be used with our DC Motors which come with a 6 mm shaft. The wheel comes with a set screw at the shaft hole for easy attaching to motors and axles.

C. *D.C. gear motor*

DC Motors convert electrical energy (voltage or power source) to mechanical energy (produce rotational motion). They run on direct current. The Dc motor works on the principle of Lorentz force which states that when a wire carrying current is placed in a region having magnetic field, than the wire experiences a force. This Lorentz force provides a torque to the coil to rotate.

A geared DC Motor has a gear assembly attached to the motor. The speed of motor is counted in terms of rotations of the shaft per minute and is termed as RPM .The gear assembly helps in increasing the torque and reducing the speed. Using the correct combination of gears in a gear motor, its speed can be reduced to any desirable figure. This concept where gears reduce the speed of the vehicle but increase its torque is known as gear reduction. This Insight will explore all the minor and major details that make the gear head and hence the working of geared DC motor.

D. *Spur gear:*

The most common type of gear is called a spur gear. When most people think of gears, they think of spur gears. Spur gears transfer motion between two shafts running parallel to each other. Spur Gears are characterized by their teeth, which are straight and parallel to the gear's axis of rotation. These are the primary form of mechanical power transfer used in the VEX Robotics Design System.

- Specification:-
- No. of Teeth =25.
- Diameter=40 mm.
- Center Shaft Diameter=6mm.
- Teeth Face Width=12.5mm.
- Pitch circle diameter=37.5mm
- Module =1.5mm

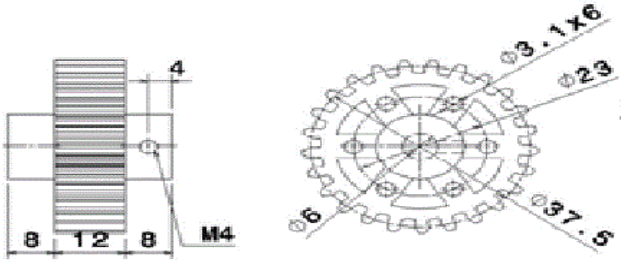

Figure 3. Spur gear

E. *Worm gear*

Worm gears come in pairs: worm gears and worm wheels that mate together to transfer power between perpendicular shafts that have axes of rotation offset from each other. Worm gears resemble screws; as they spin, they turn their mating worm wheel. This type of gear pair is very useful for creating a high mechanical advantage in a small form factor. In this type of gear pair, the worm gear can drive the worm wheel forward, but it is very difficult for the worm wheel to drive the worm gear. For this reason, these gears are useful for applications where the designer doesn't want a mechanism to be back-driven.

F. *Some other components*

- Ribbon wire
- DPDT & SPDT switches
- L-clamps
- Fiber sheets

V. WORKING OF MECHANISMS

In this mechanism one worm and worm gear is connected to D.C gear motor and two spur gears are connected on either side of worm and worm gear and continuous mesh with it. The tolerance between them is 0.1cm. The rotary motion of D.C. motor is converted into linear motion of robotic arm. In vertical block there are two mechanisms, first for up and down motion (i.e. for robotic arm & trolley) and other left and right

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motion of vertical block.

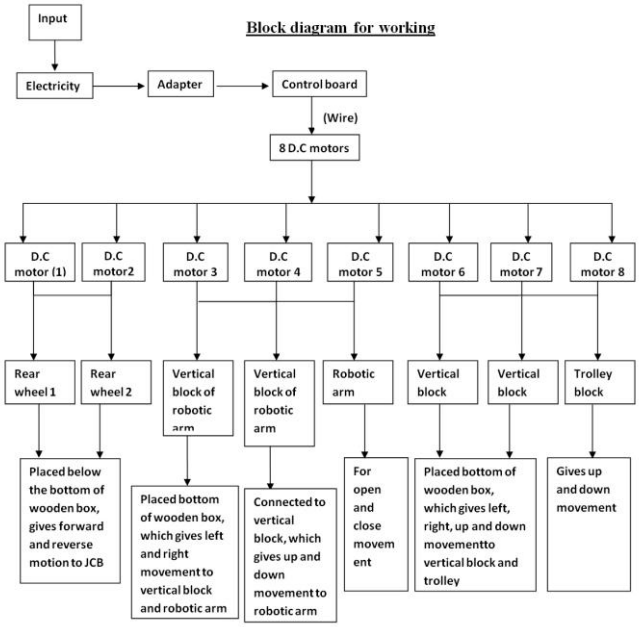

Figure 4. Block diagram for working

In both mechanisms worm and worm gear, spur gear assembly is used.

A. *Operation of robotic arm*

This robotic arm is multidirectional, it opens at 180^{o}.It is used for holding, lifting and moving the object from one location to another. The

Trolley moves 180^{0} left and right and also moves upward and downward up to 60^{0}. It is used to collects the scrap materials after operation and also lifts and transports the raw material from one place to another in industry. We can use this trolley for loading the raw materials in hopper in plastic and steel industry. Forklift is used in industry for lifting the packing boxes or containers and loading it into transportation vehicles. Fork lifter having movement forward, reverse, up and down.

VI. CALCULATIONS

A. *Calculations for robotic arm*

5N load applied on the free end of the robotic arm.

P=5N

$$\sigma = P/A$$

$$\sigma = \frac{5}{\frac{\pi}{4}\times(55^2-50^2)}$$

$$\sigma = 0.0121N/mm^2$$

B. *Bending moment of robotic arm*

Consider a robotic arm fixed at one end and load acting on other end i.e. cantilever beam

Maximum bending moment at point A

$$M_A = w_b \times P$$

$$M_A = w_b \times P$$

$$\therefore M_A = 1050N.mm$$

C. *Calculations for trolley*

$$\sigma = P/A$$

$$\sigma = \frac{5}{160\times70}$$

$$\sigma = 0.44646 \times 10^{-3} N/mm^2$$

VII. CONCLUSION

This project is basically used for industrial purpose. This model of EXCAVATOR use as a multipurpose material handling device in industry, which includes:

- Less material handling to workers.
- Less traffic.
- Fewer accidents.
- Less time required for handling raw material and finished product.
- Production increase.
- By function of multipurpose several operations done by single unit.

REFERENCES

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