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Functional Design, Fabrication and Testing of Book Stacking Machine

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Abstract: ***Library is an organized collection of sources of information and similar resources, made accessible to a defined community for reference or borrowing. It provides physical or digital access to material, and a physical building or room Libraries range in size from a few shelves of books to several millions of books where at least 1 worker to 100's of workers are required just to stack the books. Since last 20 years man power cost is tremendously rising due to rapid globalization. To reduce this man power requirement, we can automate libraries with book picking and stacking robots. These are equipped with the mechanisms namely Jaw Pulling mechanism, Jaw Rotary mechanism, Lifting and Lowering mechanism and Travelling mechanism and sensing elements. Similar kind of mechanisms can be used in super markets and warehouses to stack the material in right place. The book stacking machine can be assisted as a mini librarian and the project concentrates on the mechanisms which can be employed in a stacking robot.***

Keywords: library automation, stacking machine, electrical operation of mechanisms, robot mechanisms

1. Introduction

The book stacking machine is next level of binary automation. It has wide variety of employability and it decreases man power. The book stacking machine is mobile and can be employed in a library where a huge crowd visits a library daily. The library not only has books but also magazines, cassettes and a lot more. So, this machine can also be employed for those usages of returning objects to their shelves and also can bring it back to a customer. As a part of this project, the mechanism to be employed in the machine is completely explained. The following are the mechanisms that form the machine.

1) Jaw pulling mechanism
2) Jaw rotary mechanism
3) Travelling mechanism
4) Lifting and lowering mechanism

These form the major part of the machine. In brief the machine looks in the way below.

Figure 1: Brief model of machine

Figure 2: 3d model of machine

2. Fabrication of Book Stacking Machine

Jaw Pulling Mechanism

As per the development made in the project, the jaw pulling mechanism has been successfully achieved and the time it takes to complete the mechanism is less than 1 minute; to pull and relieve the book. The fabrication of the machine includes mostly mild steel material and some parts are made using G.I.sheet to reduce the weight of the machine. The following are the components used in achieving jaw pulling mechanism;

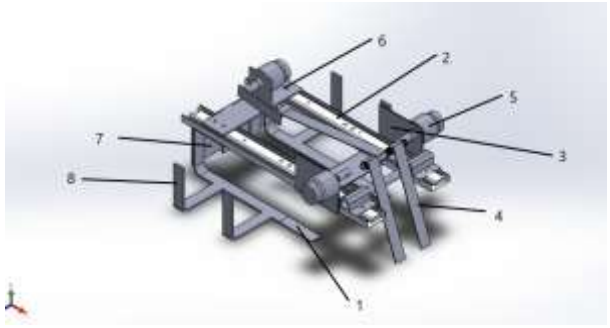

Figure 3: Jaw pulling mechanism

1) Forks
2) Telescopic sliders
3) Motor fixing plate
4) Pulling plate
5) Geared motors
6) Relieving plate
7) Angle plate
8) Supporting plates
9) Screws and nuts of different size as per usage

Rotary Mechanism

The jaw rotary mechanism is designed in such a way that the jaw rotates about 360 degrees. The following are the components that are used in accomplishing the jaw rotary mechanism;

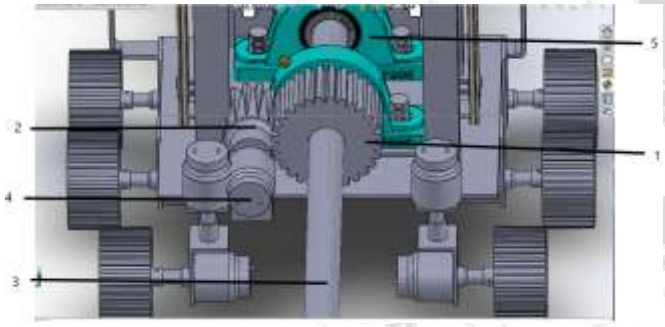

Figure 4: Rotary mechanism

1) Gear
2) Pinion
3) A 3mm thickness shaft
4) Gear motor
5) Pillow block bearings

Travelling Mechanism

The travelling mechanism helps the machine move front and back and also it helps in steering left and right. The below components are used in making travelling mechanism;

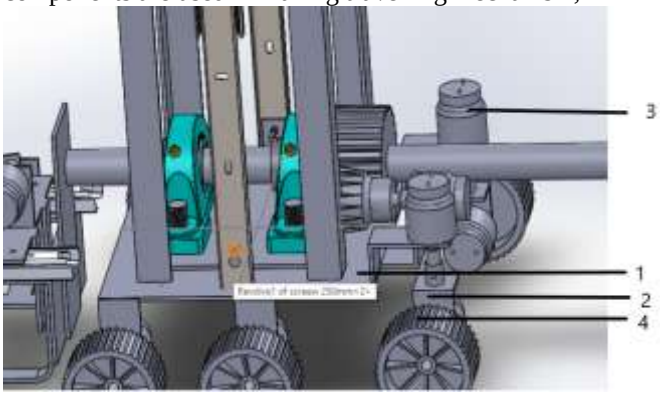

Figure 5: Travelling mechanism

1) Base plate
2) Steering mechanism
3) Geared motors
4) Robotic wheels

Lifting Mechanism

The most difficult and efficient part of the machine is the lifting and lowering mechanism. And it is successfully achieved. The following are the components in the mechanism.

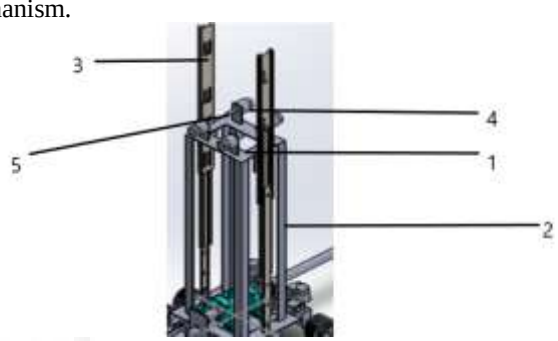

Figure 6: Lifting and lowering mechanism

1) Column plates
2) Holding angle flats.
3) Telescopic sliders
4) Geared motors
5) Drilled shafts

3. Working of Mechanisms

The working of the mechanisms is a lot simple as it looks but a lot difficult in achieving it. The total working starts with the jaw pulling mechanism where the book is pulled on the finely grinded forks attached with supporters at two sides. and then is locked with the puller mechanism and then it can be relieved by using relieving plates. The locked book is then lifted up by using the telescopic sliders and the ropes attached to the motors up at the top of the machine by the rods attached to the motors of 3.5rpm capacity. The lifted book is then made to rotate by using the rotary mechanism. The rotary mechanism is achieved by using a pillow block bearing attached to the column plates, mesh gear and pinion as shown in the above figure. It helps in rotating the pulling arm through 360 degrees. The travelling mechanism is a lot simpler to construct and achieve. The machine can move freely in all the directions. The problem with the book stabilisation starts when there is a requirement of counter weight. The counter weight can either be in the form of a bucket placed at the side of the machine using pulley or can be placed at the far end of the rotation shaft.

The motors used for the pulling mechanism are of 10rpm and for the rotary mechanism is 3.5rpm capacity. The motors required for the lifting mechanism are of high capacity and about 4 motors of 3.5rpm are required to lift a book of 2kg. the total mechanisms are operated using the robotic switches. The switches are separated for the pulling mechanism and other mechanisms.

The battery is of 2.5ah and of 12v output. The power assisted with the battery can run the machine for about 8hrs and needs

a recharge of 2hrs. This battery section also acts as a counter weight for the book.

4. Testing Results

The book stacking machine is working with minimum errors and a lot of future scope to be believed after success of final testing of machine. The following are some of the test results of the machine.

1) The machine can lift a book up to a height of 500mm as per the test results.
2) The machine completes the pulling operation in 30 seconds and the lifting operation in 2 mins. The rotation of 360 degrees is completed in 15 seconds.
3) The weight of the machine is about 30 kgs.
4) The weight of the book it can lift is up to 1kg
5) The battery assisted with the machine is MF 12.5v 2.5ah. it can also be recharged.
6) Extra wheels are required for over weight of book.
7) The motors are under safe loads to be carry out the working operations.

5. Limitations

The following are the some of the limitations of the machine;
1. Manual loading and adjustment of weight is required for the prototype made above, which can be reduced when it comes to a more precision manufacturing through machines.

6. Future Scope

- The future scope of this machine continues on when it can be automated by including sensors with a working programme assistance, the telescopic sliders used for lifting can also be replaced with rack and pinion mechanism.
- The material of light weight and which can be easy for industrial machining can be employed.
- As said earlier operating is done with robotic switches hence this can also be replaced with remote controls and it is possible that it can be replaced with a programmable sensing elements.

7. Equations

Book Pulling Mechanism Power Calculations:
Weight of the book = 1kg
Weight of pulling arm and other shafts = 530g
Radius of puller arm = 0.15m
Total weight = book weight + puller arm weight
= 1500g
Force F = m x g
= 1.5 x 9.81
= 14.715 N

Torque = F x radius of puller arm
= 14.715 x 0.15
= 2.2 Nm
Power = $2\pi NT/60$
= 2 x 3.14 x 10 x 2.2 / 60
= 2.3 Watts

ROPE PULLEY ARRANGEMENT:
Weight of the book = 1kg
Weight of the pulling arm arrangement = 0.5kg
Weight of telescopic slider = 0.4kg
Radius of pulley = 30mm
F = mg = 2.5 x 9.81 = 24.525 N
Torque = F x radius of pulley
= 24.525 x 0.03 = 0.733Nm
Power = $2\pi NT/60$
= 2 x 3.14 x 10 x 0.733
= 0.77 Watts

Lifting and Lowering Mechanism:
Total weight in rotary = 6.55kg
Weight of pillow block bearing = 1kg for each
Weight of plate and sliders = 1 kg
Total weight = 8.55 kg
weight of counter weight = 2kg
F = 10.55 x 9.81 = 103.4955N
Torque = F x radius of pulley
= 103.4955 x 0.012
= 1.241 Nm
Power = $2\pi NT/60$
= 2 x 3.14 x 3.5 x 1.241 / 60
= 0.45 Watts.

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