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DESIGN AND FABRICATION OF AUTOMATIC VERTICAL STORAGE SYSTEM

Yash Rode, HarshalDhepe, PrathameshThakare, AkashTalwekar

Yash Rode, Mechanical Engineering, DMIETR, Maharashtra, India, ***yash1437alot@gmail.com***
HarshalDhepe, Mechanical Engineering, DMIETR, Maharashtra, India, ***harshalroy2@gmail.com***
*PrathameshThakare, Mechanical Engineering, DMIETR, Maharashtra, India,****prathameshthakare90@gmail.com***
*Harish V. Katore, Professor Mechanical Department, DMIETR, Maharashtra,India,****harishkatore123@gmail.com***

Abstract

This paper presents review of design optimization of link mechanism in vertical carousel machine. An automatic vertical carousel would allow the maximum amount of space to be used, while granting an easier and safer way to retrieve items. The goal was to have a system that could go infinitely high, have high capability per shelf, and be able to rotate the high items down right to you. The 'Automated Shelves' is motor-driven vertical storage equipment that brings shelves up and down so that they can be easily available for the user. Design drawings are prepared and based on functionality, durability, cost and local availability, the components/materials selections is done. The system performance was tested on fabricated model. It has wide applications in material handling for industrial, domestic and commercial purpose. This paper focuses on study of mechanism of vertical storage machine

Keywords— Vertical Storage Machine Automated Shelves, Material Handling Equipment. Order picking.

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Introduction –

A system is designed in such a way so as to maximize the utilization of vertical air space and reduce the floor space consumption. The purpose of this work was to design and fabricate an automated vertical material handling system in order to ease the process of storing and handling the products stored at inaccessible heights. Vertical carousel consists of trays that travel vertical in front of an access window; one or several chains drive the tray, which are arranged according to the nature, dimensions and weight of items to be stored. This type of storage is generally associated with stock management. It also consists of a control and management panel.

Applications -
There are many uses of vertical carousel machine. Key areas where vertical carousel machines are used are as follows.
1) Storing medicine in pharmacies
2) Storing components in the electronics industry
3) Storing tools in machine tool sector
4) Storing fabric samples
5) Preparing orders in electrical industry
6) Storing laundry and linen in a nursing home or hospital
7) Filing documents in an administrative setting

The units are usually enclosed in housing and have openings where the stock is loaded and unloaded. Vertical units are typically used to store office files, parts along an assembly line, and large quantities of small parts, such as electronic components or nuts and bolts in a small controlled area.

The vertical carousel storage device –

The design of a vertical carousel storage device was considered as to satisfy the following customer needs.
1) Number of objects to be stored.
2) Length, width and height of the largest object to be stored
3) Weight heaviest object to be stored.
4) Small footprint.
Vertical carousel storage devices in which objects are stored in rotating shelves, so that each shelf is presented to the user, who has not to move, whether storing or retrieving the objects. In this manner, the shelves move towards the user instead of

the opposite.

The Ferris wheel is composed by two parallel wheels spinning on the same axle that is held by two masts. Seats or cabins are installed between the wheels and are held by bearings, so that they keep their orientation along the circular motion. Vertical carrousel storage units are a kind of modified Ferris wheels with a shape that is similar to chain bucket elevators, as to reduce their footprint.

As one can see, the main characteristics of the vertical carousel storage unit and of its support and displacement subsystem are listed below.

1) Number and size of selves.
2) Size of chains, sprockets and support bars for the shelves.
3) Overall dimensions of the vertical carousel storage, such as length, width and height.
4) Power required driving the machine.

The mechanical system for the translation of the shelves is the focus of this article.

By analysing the various design parameters, one can identify the relationships between them, which represent the system constraints that result from the geometry and kinematic laws of the linked mechanisms. These interdependencies allow grouping several design parameters into single design parameters. Among others, the most important system constraints are,

1) The size of shelves depends on the size of the largest object to be stored.
2) The pitch of the shelves depends on the height of the tallest object to be stored.
3) The number of shelves depends on the number of objects to be stored.
4) The length of the chains must be such that ensures the uniform distribution of the shelves.
5) For the same reason the pitch of the shelves must be a multiple of the chain's pitch.
6) The length of the chain corresponding to the pitch of the shelves must have an even number of links, as to preclude the use of cranked-link joints.

Besides the geometric relationships, specific values for some design parameters were also established.

1) The dimensions of chains, spacing bars, fastening systems of shelves, sprocket wheels and support bearings of the shafts, among others, are not yet known at the initial stage of the design. Thus, it is assumed that the space occupied by those components corresponds to 10% of the length of the largest object to be stored. Because those components are replicated in both sides of the shelves, then the length of the shaft linking the sprockets should be 20% larger than the length of the longest object to store.
2) The hinges of the shelves must be located well above the position of the centre of mass of the loaded shelves, typically at 75% of the height of the load, for a matter of stability.
3) To avoid collisions, a gap of 10% of the height of the loaded shelves should be adopted.
4) For power calculation, it was assumed that the mass of each shelf is taken as 20% of the total mass to displace.
5) It is also assumed that the maximum linear speed of the chains is 0.5 m/s.

Current industrial uses –

Vertical rotating shelving systems are already readily available, but only mainly in an industrial setting. These systems are robust and powerful. These systems can hold up to 800 pounds on one shelf, can reach over thirty six feet tall, automation controlled, and fully enclosed. Vertical shelving systems have been proven to save 70% on floor space and increase productivity.

Technology

Rotation –

The first requirement in creating a rotating shelving system is how to get the shelves to rotate. This can be done thru gears, chains, belts, or other means. When deciding which drive system to use, one must compare many factors. These factors include cost, installation, lubrication required, speed, weight capacity, efficiency, and others. One of the most important factors to consider is the balancing of the shelves. The shelves must remain balanced even around the curve of the rotation. Also, in current use this rotation is done automatically using a motor, but a crank system is also viable for low weight applications.

Motor –

In most applications a motor is used to automatically rotate the shelves. In industrial use, these motors are very strong to accommodate heavy weight and a large amount of shelves. In current household use, the motors are small and quiet, in order to work inside and accommodate a low weight and number of shelves. When selecting a motor many things need to be taken into account. First, you must know the load characteristics of the motor. Will the motor be constant torque, torque that changes abruptly, or torque that change over time? For a rotating shelving system, our motor would fall into the torque changes abruptly. The motor must be capable going from rest, to moving the max weight in a fraction of a second. Secondly, we must get a handle on the horsepower required. In this the rule of thumb is to select only what you need. Thirdly, you need to consider the power required to get the motor moving from rest. Inertia for a rotating shelving system will be high due to the weight on each shelf that must be moved from rest. Fourthly, one must look at the duty cycle. Duty cycle is the load the motor must handle from start, running, and stopping. In our application, the duty cycle will be intermittent duty. This means the motor will not run continuously, but rather on a needs basis. Lastly, the environment the motor runs in. We must look at things like temperature, altitude, humidity, and other factors to make sure the motor can run efficiently.

Balance –

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Likely the largest issue to solve in rotating shelves is balance. The shelves must be able to hold its items weight, and keep it balances as it rotates from side to side. The shelves must be balance when rotating vertically, as well as around the curve to the opposite side. This poses many problems. If the shelves are balanced the items will fall off and could damage the items and more importantly the operator. The best solution to this issue has been a non-rigid approach. The shelves need to be hung at their centre of gravity. Once they are suspended at their centre of gravity, then gravity can balance the shelves throughout the rotation. This can be successful in balancing the shelves through the rotation, but still has issues that need to be solved. First, the shelves can lose their centre of gravity by the loads and placement of the items put on the shelf. Therefore the shelf must have a way to limit the maximum movement of the self. This movement of the shelves, no matter how slight, can lead to less safety to the operator.

Equations –

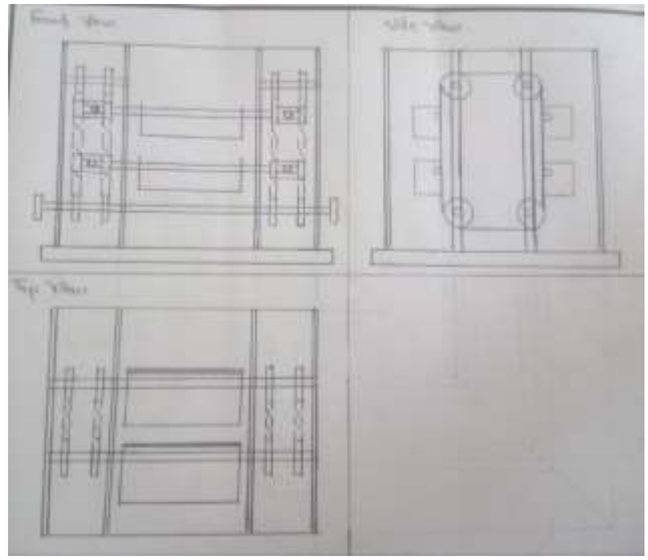
Required torque = force *distance
= 6 *25*3
= 450kg.ft

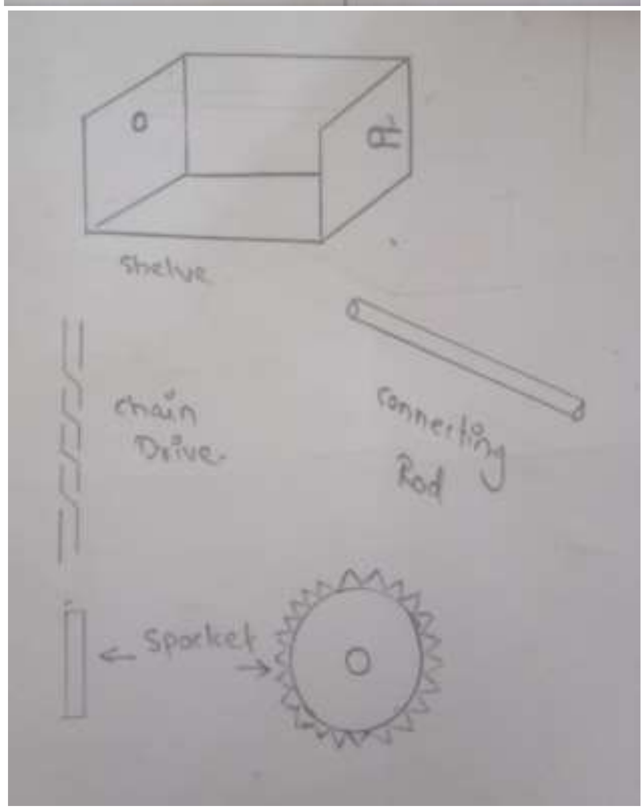
Chain distance =4*straight distance +2*∏ *radius
=4*3.33+2*3.14*0.0833
=13.32+0.52
=13.84 ft

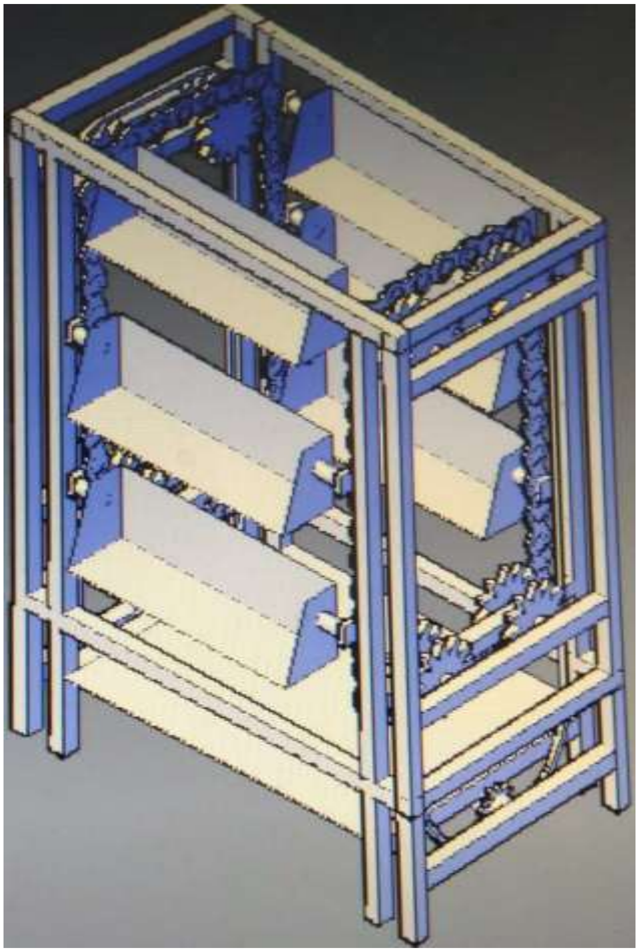
RPM =2 time around per min
=2*(Chain distance)/(gear circumference)
= 2*13.84/0.52
=53.23 rpm

Power required = (torque * Rpm)/5250
= 450*53.23/5250
= 4.56 Hp

Design –







CONCLUSION

The above-described procedure made it possible to develop a compact mathematical model with a squared design matrix that allowed defining the main dimensions of the vertical carousel storage unit and of its support and displacement subsystem. The system constraints allowed finding a mathematical model, which details are not in the scope of this paper, in order to define the main characteristics of the machine. The paper shows that it is relatively easy to use the Axiomatic Design framework to help in the design of complex machines, taking into account the existing geometric and kinematic system constraints.

The automated shelves are an efficient system which will transfer the material from higher to lower level. It can be used in wide applications for material handling for domestic, industrial as well as commercial purpose. It can be easily tailored to the applications individual needs. It optimizes the use of vertical space and also reduces the time and effort needed to bring the items kept at elevated height. Development of comprehensive evaluating and improving procedures would seem to be necessary in order to simultaneously address all these issues. In addition, regardless of the actual improving and optimization procedures, a system of performance measurement is needed to evaluate the overall performance of the resulting system at every stage

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