Development of Vertical Carousel System

Dnyaneshwar Avhad[1], Ganesh Kanawade[2], Prafull Kawade[3] , Kunal Rathod[4] , Prasenjit Fulzele[5]
Department of Mechanical Engineering
[1,2,3,4] Student, Bharati Vidyapeeth College Of Engineering, Navi Mumbai, India
[5] Guide, Professor, Bharati Vidyapeeth College Of Engineering, Navi Mumbai, India

Abstract- *In order to enhance productivity, quality and atomization, automated storage retrieval system plays an important role. This method also optimizes the time variable as it reduces human error and can operate continuously without any breaks. However, the vertical carousal system used for inventory storage is not yet utilised in manufacturing firms in India. This research paper delivers just that. It consists of design and analysis of the abovementioned storage system. The basic structure is similar to that of a Giant wheel having a number of racks to house the jobs. These racks are fixed onto the chain using link mechanism because of its high DOFs and are operated on a motor input. The design is drafted to avoid failures of the system under static as well as working conditions. The project was atomized using Arduino. Arduino was chosen because of its user friendly coding system to allow room for further development. This paper is focused on enlightening the workers along with the engineers to understand this product to reduce time and increase accuracy of procurement, both of them being key parameters of any industrial system.*

Keywords- ASRS, productivity, accuracy, Arduino, shelves, mechanism, design.

I. INTRODUCTION

The design of a vertical carousel storage device was considered as to satisfy the following customer needs:

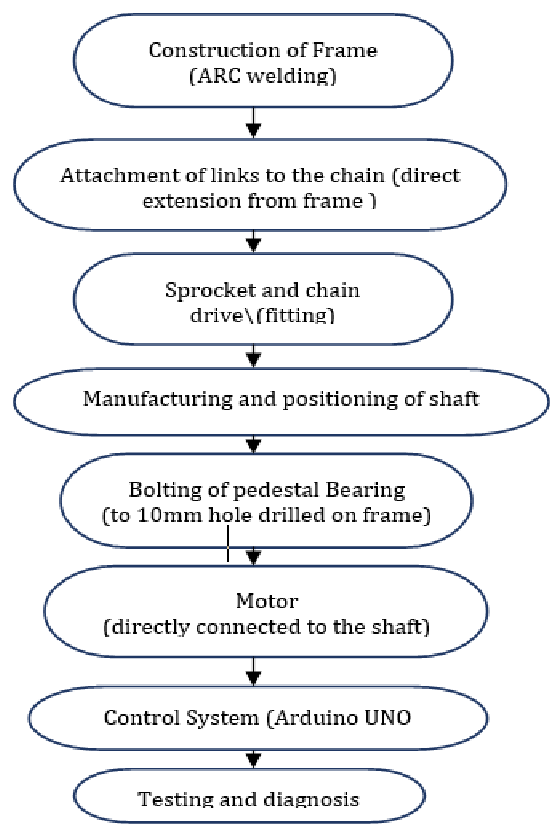
- Number of objects to be stored;
- Length, width and height of the largest object to be stored;
- Weight heaviest object to be stored.
- Small footprint

Vertical carousal storage system is a part of the conveyor family. The concept of this system is very familiar and similar to the well-known system called Ferris wheel. Materials/items/products are stored in a discrete way according to the worker into the shelves/ racks which rotates along an elongated and guided oval track. Well, this resides over the vertical height of the place instead of using the floor-space. Accordingly, the required items will be accessible in each shelf and allowing to recuperate the necessities from the receiver’s point which is designed at an expedient height. It solves various problems in different domains of the industry if it is being used. It is also not the most favorable system for small scale applications due to one of the reasons being the whole system has to move if a single item is needed to be procured.

II. PROBLEM STATEMENT

- Development of an intelligent system which utilizes the maximum vertical space.
- Elimination of the process of handling the items manually.

III. FABRICATION METHODOLOGY



IV. DESIGN CALCULATION

4.1 ASSUMPTION

Center to center distance is assumed between shaft. a=500mm
Both the sprocket is of same diameter

4.2 CALCULATION

Center to center distance relation, a=50p
Where, a=center to center distance
p=pitch of chain.

$P=\frac{a}{50}=\frac{508}{50}$=10 mm

So pitch =12.7 mm

Trail error method for chain selection-

1. For next pitch- 12.7 mm/0.5 inch
2. Sprocket selection according to width of system= no of teeth-44 , PCD-177.8mm/7inch
3. No of links of chain=$2(\frac{a}{p})+(\frac{z_1+z_2}{2})+(\frac{z_2-z_1}{2\pi})(\frac{p}{a})$
   $=2(\frac{500}{12.7})+(\frac{44+44}{2})+(\frac{44-44}{2\pi})(\frac{12.7}{500})$
   = 124 links of chain
4. Length of chain = no of links * pitch
   a. L= 124 * 12.7
   b. L= 1574.8 mm

4.3 LOAD CALCULATION

Mass of the system

1. Material load= 0.5kg/rack
2. Chain load= 0.1kg/feet
3. Total=0.1*$(\frac{2a+PCD}{300})$ =0.45kgf
4. Bearing load=no. of bearing*300gms=1.2kgf
5. Link mechanism load=0.5kgf
6. Total load=4.15kgf
7. Total load=4.15*FOS=5kgf
8. Total load=5kgf*9.81=49.1N
9. Load due to friction=μ(overall friction)*total load
   1. = 0.1*49.1 =4.905N

10.Total load + friction load= 49.1+4.905=54N

4.4 TORQUE CALCULATION

T=F*r
= 54*0.0889
=4.8006 Nm=48.06kgf-cm

4.5 POWER CALCULATION

Linear velocity= 0.15m/sec

Linear velocity=$\frac{\pi*D*N}{60}=\frac{\pi*.1778*N}{60}=0.15m/sec$

N=16 rpm

Angular velocity (ω) =$\frac{v}{r}=\frac{0.15}{0.0889}$=1.687 rad/sec

Power=$\frac{2\pi NT}{60}=\frac{2\pi*15*4.79}{60}$=8.09W=0.01084hp

4.6 CHAIN CALCULATION

From PSG 7.77

$P=\frac{QV}{102\ n\ k_s}$

Where, P=Power
Q=breaking load of chain
V=linear velocity
n= factor safety=7 from psg 7.77

k_s= service factor=2.34375……..from psg 7.77

$0.00809=\frac{Q*0.15}{102*7*2.34375}$

Q=90.25 kgf
Selecting standard chain from psg 7.77
Chain no ISO/DIN 082-1 R1224 pitch=12.7 Q=820kgf

4.7 BEARING CALCULATIONS

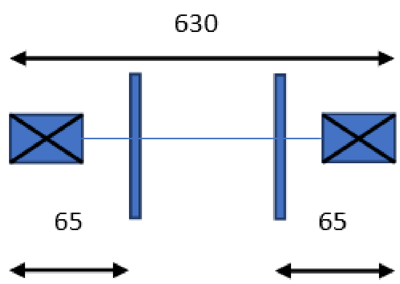


Figure 1. Bearing Layout

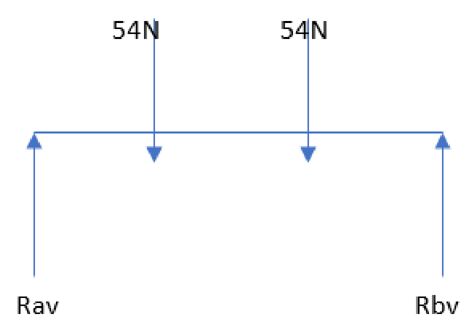


Figure 2. F.B.D for bearing calculation

Ma=0
Rbv(630)-(54*565)-(54*65)=0
Rbv=54 N
Similary, Rav=54 N………for tangential loading

Fr=Ft tan(20)=54 tan(20)=20 N

Similarly, Rbh=20N
Rah=20N

Ra=$\sqrt{Rav^2 + Rah^2} = 57.5847N$
Rb=57.5847N

Peq=57.5847*load factor
Load factor for chain drive bearing
Pg. 1.5 (Bhandari)
Therefore, Peq=57.5847*1.5=86.376 N

$L_{10}=\frac{60*n*Ln}{1000000}$

Assuming Ln=100000 hrs.

$L_{10} = \frac{60*15*100000}{10^6}$

L_{10}=90mr (because of the change in design the life of the bearing increases by 12%)
C= Peq*$(L_{10})^{1/k}$
C=86.376*$90^{1/3}$……………….since K=3 ball bearing
C=386.99 N …………Dynamic load capacity

As the load acting on the bearing is pure radial but roller bearing cannot be used due to the increase in cost therefore selecting SKF6005 deep groove ball bearing.

4.8 SHAFT CALCULATION

Selecting material C35 $\tau = 30N/mm2$
Taking diameter of the shaft equal to inner diameter of the bearing D=25mm

D=$\sqrt[3]{\frac{Mt*16}{\pi*\tau}}$

25=$\sqrt[3]{\frac{4800*16}{\pi*\tau}}$

$\tau = 1.56N/mm2$
Hence shaft is safe

4.9 LINK CALCULATION

Link material C 35 having σ =$60N/mm2$
Considering cantilever link
Taking moment over the fixed point, taking load of 4.905=5N
Tensile stress- σ =$\frac{force}{area}$ =$\frac{5}{\pi 4^2}$ =$0.099N/mm2$
Hence link is safe

PROCEDURE FOR THE FABRICATION AND ASSEMBLY

All the components of the vertical carousel system are designed and selected based on standard components. All components are assembled together to form assembly and then tested for the design load.

1. The whole fabrication and assembly was made in the 2 stage.
2. First the extension links were gas welded to the chains at 6 equidistance points.
3. The whole assembly consisting of chain and sprocket was made separately.
4. Secondly it was then lifted using a light weight overhead crane and placed inside the frame.
5. The frame was constructed by using arc welding process.
6. Once the chain sprocket assembly is positioned at the required place shaft is passed through it.
7. Once positioned shaft is welded on to the sprocket.
8. Pedestal bearings are bolted on the frame.
9. Any kind of adjustments can be done by inserting required thickness of strips under bearing and lifting the assembly to avoid slacking of chain in future.
10. Then a plank was attached at the side of the frame by using the link by drilling hole in the wooden plank and bolting it.
11. The whole control system was mounted in the plank which consisting of arduino, Bluetooth module and motor drive.
12. Hall-Effect sensor was mounted in on the frame at one side.
13. Neodymium magnets were attached to the racks which would be sensed by the sensor for counting purpose

V. CONTROL SYSTEM

The automated shelves will work on an electronic system that will control the movement and position of the shelves. This control system works on a program which will enable the user to control the motion of the shelves.

5.1 Components Of Control System

I. Arduino microcontroller and interface
II. Hall effect sensor
III. Drive
IV. Input module

VI. CONSTRUCTION AND WORKING

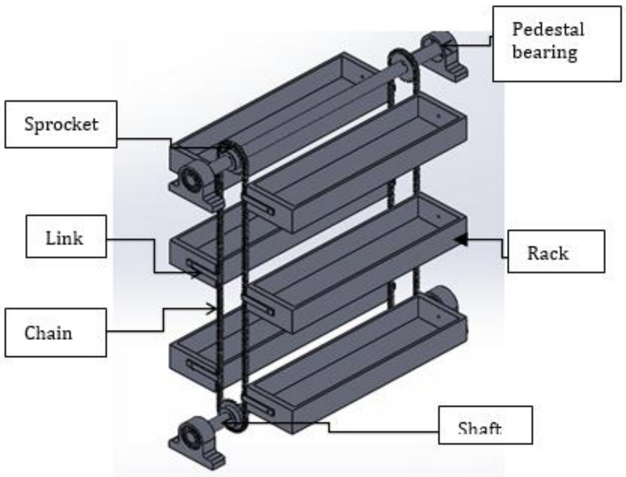


Figure 3. Assembly drawing

Frame is the main skeletal support for the entire system. It consists of two tie bars on each side for rigidity. The top and the bottom tie bars have Pedestal bearing on it for mounting of sprockets. Main chain drive consists of four sprockets on each side, two on the bottom and two on top. Sprockets on each side are driven by single strand roller chain. For mounting of shelves on the chain attachment links are used. One side of the link is inserted in the roller pin hole of the chain and the other end in the holes drilled on the shelves.

Control System consists of Arduino UNO Board, Input Module and Hall Effect sensor. The Arduino board interfaces with three components namely, sensor, Drive Motor and Input Module. The eight shelves are assigned magnets. These colours are assigned to their individual number on the input module. When a specific number button is pressed on the input module, microcontroller will send Start command to the motor. It will also simultaneously command the sensor to detect the specific magnet. When the shelf with the desired magnet comes in front of the sensor, it will send a signal to the microcontroller which in turn will stop the motor. This will result in the desired shelf stopping in front of the user and its contents becomes easily accessible. This is been carried out using the codes which is been designed and controlled using the count logic. We had also used the IR sensors (Infrared sensors) instead of the magnetic sensors. But the problem that we came across was the accuracy of the automated shelves stopping at the desired time and for the desired delay as per the program's input says. We realised that it was the intensity of the atmospheric light which has a direct impact on the LED

VII. CONCLUSIONS

The mechanism for the selected application is designed and modeled. It takes very less amount of time for the shelf to complete one full rotation. The speed of the shelf is 10 m per minute. Arduino software will help the system to automate.
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 for commercial purpose. It can be easily tailored to application's 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.

FUTURE SCOPE

1) In case of power breakdown, there can be a lever which can be operated in order to move the carousel system without any time wastage.
2) This system can also be designed for the production process and controlling.
3) Underground storage can also be fulfilled using this ASRS system.
4) Apart from these, we can also use this system for keeping the orders in stack without losing time for the carousel system

REFERENCES

[1] Antonio gabriel-santosa, joao rollab, alberto martinhoa, joao fradinhoa, antonio goncalves-coelhoa & antonio mouraoa (2016), "The rational footsteps for the design of the mechanism of vertical carousel-type storage device." IJRPET, Volume 3, May 2016.

[2] Farah hanani mohammad khasasi, abdul malik. m. ali, dr. zulkhairi mohd Yusuf (2015),"Development of an automated storage and retrieval system in dynamic industrial environment." ICBAPS, Volume 2, May 2015.

[3] Sammed arinjay patil1 prof. v. j. khot (2015), "Review paper on design optimization of link mechanism in vertical carousel machine" IJSRD, Volume 3, June 2015.

[4] Sammed arinjay patil, prof. v. j. khot (2015), "Synthesis of link mechanism in vertical carousel machine." IJESRT, Volume 5, June 2015.

[5] Sammed arinjay patil1, v. j. khot2 (2015), "Finite element analysis of link mechanism in vertical carousel machine." IJSR, Volume 4, July 2015.