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Design and Development of Box Shifting Mechanism Using Gearless Power Transmission System

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Abstract:- This paper represents the study of the two different mechanisms, namely, Box Shifting Mechanism and Gearless Power Transmission Mechanism. Our idea is to combine and integrate these two different mechanisms into one. So, they are very important for our project. In this paper, we have covered various aspects of these mechanisms. The main objective of this study is to learn and understand about these two very interesting mechanisms. Their Designs, Working Principle, Calculations, Applications etc. are also covered in this paper.

Keywords:- *Gearless Power Transmission, Linkage Mechanism, Bent-Link Mechanism, Crank, Conveyor.*

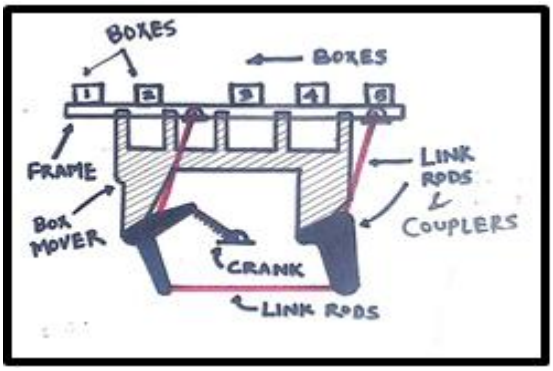
I. INTRODUCTION

In this project, as discussed in the above paragraph, we are trying to combine the two different mechanisms, namely, Box Shifting Mechanism and Gearless Power Transmission Mechanism. These mechanisms are very unique yet simple in nature and have their own significance in industrial applications.

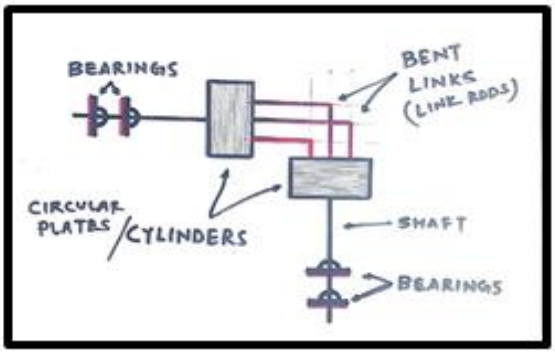
So, starting with the Box Shifting Mechanism, it is a simple mechanism which is operated with the help of a crank and link arrangements. In this mechanism, the rotary motion of a Crank results into the back and forth linear motion of the Linkage Mechanism. This back and forth linear motion of Linkage Mechanism helps boxes on the conveyor to move further.

Now, coming to the Gearless Power Transmission Mechanism, which can also be called as the Bent-Link Mechanism. It is very simple yet unique Mechanism. In this, the Links, which are connecting the two cylindrical plates, are bent at 90°. Thus, it is a very useful mechanism for transmitting the power at right angles. This Mechanism is further connected to the Linkage Mechanism which we have discussed above.

II. DESIGNS



Diagrammatic Representation of Linkage Mechanism



Diagrammatic Representation of Gearless Power Transmission Mechanism

The above diagrams represents the two different mechanisms. The first one is the Linkage Mechanism and the other one is Gearless Transmission Mechanism. The diagrams are neatly labelled so that they are understood properly.

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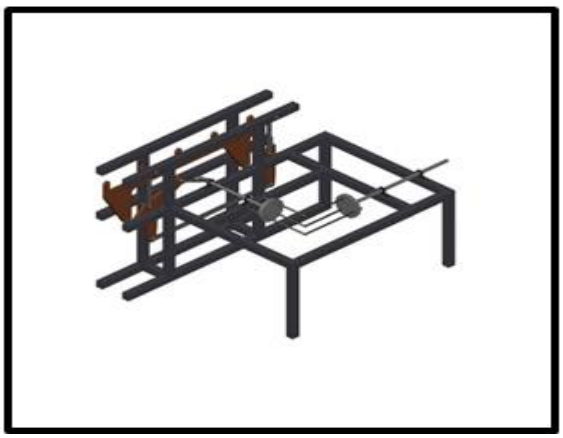
III. WORKING PRINCIPLE

The project, as discussed, is the combination of two different mechanisms. One is Box Shifting Mechanism and the another one is Gearless Power Transmission Mechanism. The set up consists of similar Circular Plates with drilled holes at the Pitch Circle Diameter of 100mm. The two circular plates are then connected with the help of three Links. These three links are bent at an angle of 90°. There are two shafts connected to the two circular plates. These shafts can also be called as driver and driven shafts. The links and circular plates are connected to one side into the driver and the other in the driven shaft. Further, the driven shaft is extended towards the Crank of the Box Shifting Mechanism. Box Shifting Mechanism consist of Linkage Mechanism which include Upper Structure, Couplers and connecting rods. Upper Structure is a very important component of this mechanism which will be used for the movement of boxes. Both of this Mechanisms are supported on the Base Structure.

When the power is transmitted to the shaft, it starts rotating. This is a driver shaft which is already connected to the first circular plate. This circular plate starts rotating with the help of driver shaft. As we have stated earlier that the three bent links are connected to these two circular plates. So, because of this, the power transmission to the second circular plate becomes possible. While transmitting the power from one circular plate to another, the bent links starts reciprocating inside the drilled holes of these plates. This allows the two circular plates to move smoothly. Thus the power can be transmitted to the second Shaft which is a driven Shaft. Driving and driven shafts rotate continuously. There is very less to no friction in the moving parts of the transmission system. When the power is Transmitted through the Gearless Transmission Mechanism to driven shaft, because of the rotation of the Shaft, Crank connected to it also rotates. The rotary motion of the crank is transferred to the Couplers and then the power gets transmitted to the upper structure. This way the rotary motion gets converted into the linear motion. Now, because of this, the Upper Structure starts moving back and forth resulting into the linear movement of the boxes.

IV. PROJECT MODEL



Three Dimensional View of Project Model

V. METHODOLOGY

- Identification of Need and Aim.
- Going through various research papers.
- Taking Ideas and notes from research papers.
- Identifying problems.
- Selecting appropriate materials for fabrication purpose.
- Performing Calculations.
- Computer Aided Designing of a proposed model.
- Fabrication of a proposed model.

VI. CALCULATIONS

Let's consider the weight of the model = 30 kg.
Therefore, 30 × 9.81 = 294.3 N. (300 N Approx.)
There are two different circular plates in this model, so, Force on each = 300/2= 150 N.
Now, Torque = F × R = 150 × (140/2) = 10.5 N.m.
Calculating Torque on Each Link,
No. of links = 3,
Therefore, 10.5/3 = 3.5 N.m
The Pitch Circle Diameter = 100 mm
So, Tangential force 10.5/0.05 = 70 N.
The Shaft is subjected to both Twisting Moment and Bending Moment,
Therefore, Torque equivalent (Te)needs to be calculated,
$T = \pi/16 \times \tau \times d^3$
$M = \pi/32 \times \sigma b \times d^3 f$
$Te = \sqrt{[T^2 + M^2]}$
While Designing a Shaft, there are two important theories, i.e. Maximum Shear Stress Theory and Maximum Normal Stress Theory,
So, According to Maximum Shear Stress Theory,
Equivalent Twisting Moment, $Te = \pi/16 \times \tau \max \times d^3$
And, According to Maximum Normal Stress Theory,
Equivalent Bending Moment, $Me = \pi/32 \times \sigma b \max \times d^3$
Since, the material of shaft is ductile, we'll apply Maximum Shear Stress Theory.
Bending Moment (M) = W × L
M = 60 × 10^3 N.mm.
$Te = \sqrt{[(10.5)^2 + (60)^2]}$
Te = 60.91 N.m
From the above Maximum Shear Stress Theory,
Diameter of Shaft = 17.29 mm.
For Bearing Calculations,
There is no Axial force/ Thrust on this bearings.
Hence, Axial force/Thrust = 0.
There are two bearings A & B,
So by support reactions, we've calculated the radial forces on each bearing.
Hence, Radial force on bearing A = 600 N
And, Radial force on bearing B = 300 N
Calculating Dynamic load capacity, but for that we need Equivalent Dynamic Load,
So, Equivalent Dynamic Load (P) formula,
P = X.Fr + Y.Fa …….{X= Radial load factor & Y= Axial load factor}
Dynamic load on Bearing A = 600 N
Dynamic load on Bearing B = 300 N
Now, Calculating Dynamic load capacity (C),
C = P (L10)^(1/3)

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We're assuming the expected bearing life is around 10000 Hrs.
Converting it to Million Revolutions, L10 = 60.n.L10h/ 10^6
L10 = 60 × 60 × (10000) / 10^6 = 36 Million Revolutions.
We're having two bearings on a Shaft,
So, Dynamic load capacity of Bearing A = 600 × (36)^(1/3) = 1981.15 N
Now, Dynamic load capacity of Bearing B = 300 × (36)^(1/3) = 990.57
Therefore, The dynamic load capacities of Bearings A & B are around 1981.15 & 990.57 respectively.

VII. OBJECTIVES

- To fabricate a Mechanism which can move objects from one place to another with a specific time lag.
- To learn and understand how Power Transmission is possible even without gears.
- To develop a much more efficient system for moving objects and also for power transmission.
- To reduce some labor cost which is, off course, a major challenge for industries.
- To understand various mechanical components, tools, and various fabrication processes.
- To learn and understand about the Design procedure of various mechanical components.
- To fabricate a mechanism which move objects or, boxes in our case, at a slow speed.
- To reduce the friction problem that occur in gears during power transmission.

VIII. APPLICATION

- The main application of this mechanism is in the industries where the production is in smaller scale.
- In industries, where the continuous conveyor systems are not suitable.
- In industries, where the use of gears in operation becomes difficult or complicated.
- In operations, where modifications to the objects or products are very frequent.

IX. FUTURE SCOPE

- Simulation techniques are not performed in this project, but still it will be very useful in many such projects. Therefore it is highly recommended.
- Torque requirements are high in this project. So, more work needs to be done in order to reduce this torque requirements.
- Use of motors of different rpm and horsepower is needed for different operations, so this can be managed using different mechanical tools such as pulley, gear drives etc.
- Use of Wood as a material looks cheaper, so more work can be done in order to include other low weight materials in this project.
- Work needs to be done in order to check the possibility of gearless power transmission with less than three Bent-Links.
- This project aims for the movement of light weight objects, so we believe that work can be done in order to achieve the movement of heavy objects as well.

X. CONCLUSION

After studying these two different mechanisms, we learned and understood that these mechanisms are suitable for light duty operations. Which also means that this Mechanisms are for low cost applications. This project may or may not be useful for the heavy duty operations because of size and shape restrictions. But , there is a scope for improvements in some areas which we have already covered in this paper. Working on the areas that have been discussed in this paper will definitely help in increasing the efficiency and applicability of this project. The transmission of power in this Gearless Power Transmission Mechanism is considerably smooth. It is also helping with the reduction in friction as compared to the geared power transmission techniques. We tried to build a model ensuring the maximum use of available resources. We tried to apply our basic Mechanical knowledge for this project. We learned and understood various Designing Procedures and various fabrication processes and tried to implement them into our project. So, with this, we conclude that our work in this project is satisfactory.

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