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A review paper on design and analysis of gearless transmission mechanism using elbow mechanism

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Abstract

This review paper gives information about the Strength, Speed, Torque Transmissibility of Elbow mechanism as this are very much important terms in defining applications of the mechanism in replacement of gears. It mainly focused on the theoretical, analytical and FEA method. Computation of various parameters like Number of pins, Material used, Dimensional difference of elements, Speed, Torque. Many previous approach were made to find out the optimum design in order to make this mechanism better then old mechanism by using different analysis software. It consist Theoretical & Analytical method for the design of elbow mechanism.

Keywords: Transmission System, Gearless Transmission, Elbow Mechanism, Orbital transmission.

1. INTRODUCTION

In today's world, as limited quantity of the resources available, it is necessity to utilize that resources in such way that it gives maximum of them. The major problem for the gear transmission is that the manufacturing of gear is complex process which consumes more time and takes very much precision and manufacturing cost is high .[1,2,4,7,8] The another major problem is that the

transmission having gear cause the jamming due to the backless error and produces more noise compared to other drives due to pitch mismatch.[3] This elbow mechanism is also known as Gearless transmission system, L-pin mechanism or Orbital transmission mechanism. This elbow mechanism is simple in construction and can be easily made with minor precision. This mechanism is mainly used in replacement of bevel gears where the motion is to be transmitted at 90°. So, in general elbow mechanism angle between rod is taken 90^0.[1,2,4,5,6,7,8,11,12,14] This mechanism can also be used to transmit power at varying angle by changing the angle of L-pins or by providing universal joint at the corner.[3,9,10,13] This mechanism consist mainly 3 L-pins, further increase into L-pins will increase the smoothness of the system.[8] Elbow Mechanism is being compact and portable equipment, which is skilful and is having something practice in the transmitting power at right angle without any gears being manufactured. This mechanism can be used for any diameter of the driving and driven shaft.[13] Maximum efficiency of gear drive is only up to 42% but, by this mechanism we can get up to 90 to 92% of efficiency.[12]

2. SYSTEM STUDY

In this transmission system Nos. of pins used are between 3,4,5,….which were inserted into the hole drilled on the cylindrical disc. If we use less than 3 pins then it will not work and will cause jamming.

The motion is transmitted by sliding and rotating movement of the L-pins simultaneously .

This L-pins are inserted into same angular distance of 120° on the cylindrical disc.

The Elbow mechanism consist of the following part :

- L-pins
- Cylindrical Discs
- Shaft
- Base Plates
- Arm Supports (Bearing)

General layout of this mechanism is as under :

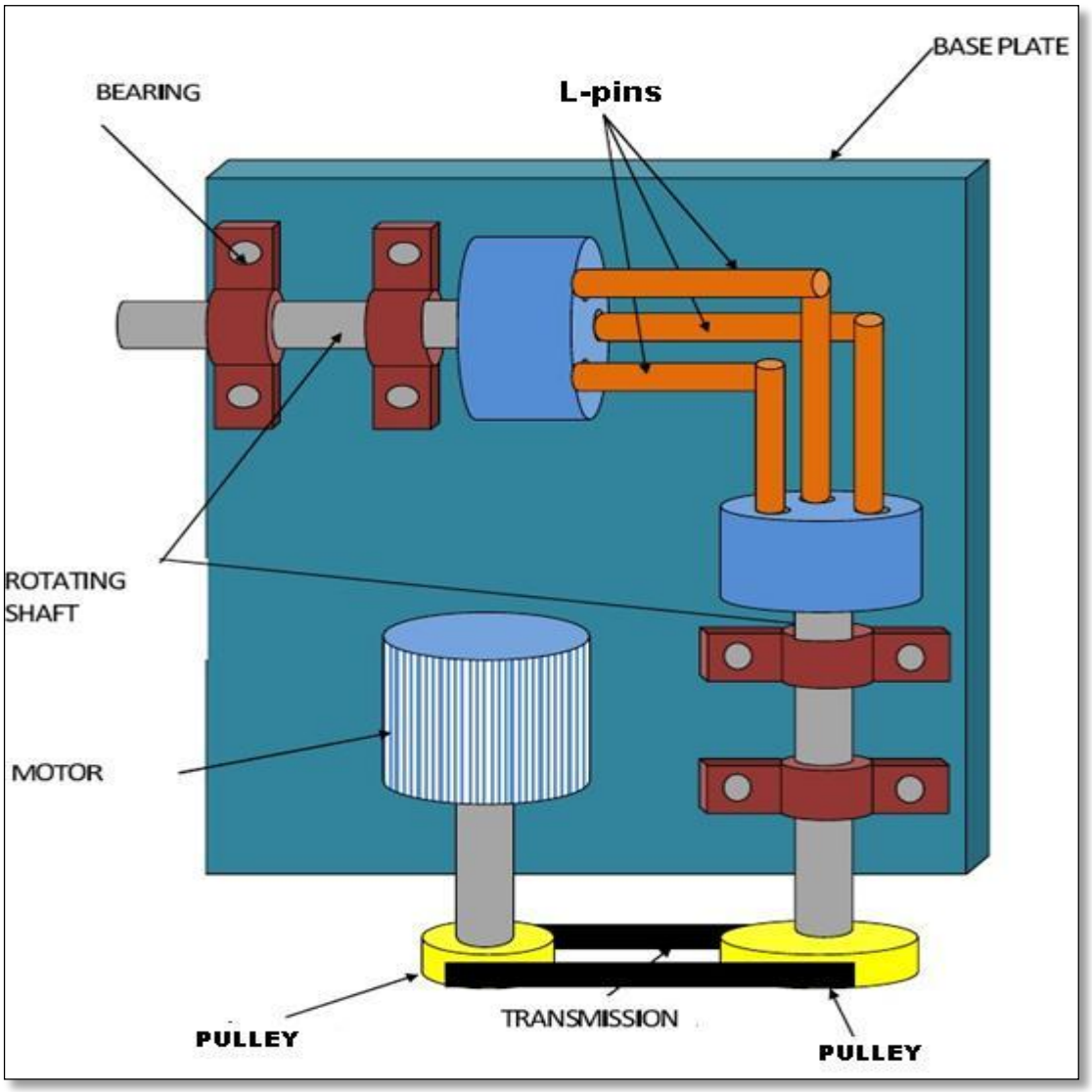

Figure 1: General Layout Of Mechanism

3. WORKING

After studying synthesis of mechanism it get revealed that this system consist of 3,4,…up to 8 pins and increasing the Nos. of pins mechanism will work more smoothly. Power to this mechanism is supplied with motor. Motion is transmitted from driving to driven shaft with the help of L-pins. This L-pins starts TO and FRO motion when power is supplied. The motion is transmitted through the S-R-R-S pair made by L-pins and cylindrical disc.

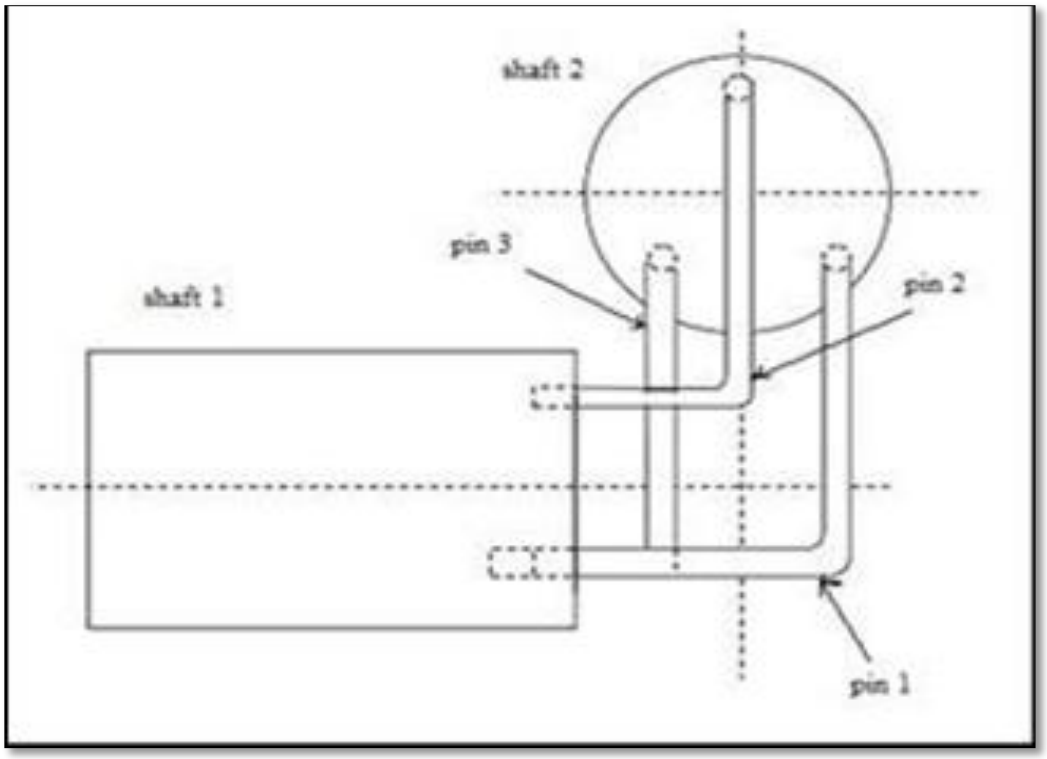

Figure 2: Setup of L-pins

Let at the starting instant shaft 1 starts rotation with 3 pins in anticlockwise direction and a reaction force developed at the pin surface which in contact with the shaft and this force transferred to the other end of the pin which is in the shaft and applying on the shaft 2 due to which shaft 2 starts rotating in the same direction as shaft 1, after 120 degree rotation pin 1 comes at the place of pin 2 & pin 2 comes at the place of pin 3 & pin 3 comes at the place of pin 1 by sliding in shaft and self-adjusting. This motion repeated for next 120 degrees and further for next 120 degrees and pins are exchanging the position in successive order.

4. LITERATURE STUDY

R. Somraj et al. [1] Analyzed the Design and Fabrication of Gearless Transmission For Skew Shafts. 3 Nos. of L-pin rods were used. Overall mechanism is considered to be running on 0.25 HP motor with 140 RPM and Torque of 1238 N-mm. Design of Hub is done by Considering a hub of internal diameter is 32mm and outer diameter is 92mm, length is 82mm. Design of shaft was done by taking maximum tensile stress of 60 N/mm^2 and maximum shear stress of 40 N/mm^2. Diameter of elbow rods was 8mm. It Was Concluded that given arrangement can be used for any set of diameters with any profile of shafts

for skew shafts of any angle but the shaft's must be having the rotational motion about his own axis, transmission of motion is very smooth and desirable and used only for the equal R.P.M. of driving shaft and driven shaft by employing links or given type of links for appropriate joints for revolute pair. It was also found that successful mechanical devices function smoothly however poor fly they are made while other does this only by virtue of an accurate construction & fitting of their moving parts.

Neeraj Patil et al. [2] Researched on Gearless Transmission Mechanism and its Applications. link of C-45 was used. Links bent at required angle slide inside the holes in the hub Mechanism can transmit at any angle 0 to 180.The mechanism is studied and a possible go-kart transmission layout is fabricated and few future applications are suggested. Into This weight of model along with rider Assumed 1500 N. Kart was loaded with 4 Nos. of tires each with 375 N of load. Co-efficient of friction between road and tire was Considered 0.7. Tire of radius 0.1778m Taken. Torque required to move Was 46.67 N-m with Torque on each link 15.55 N-m Tangential force of 311.15N was acting on links. Diameter of each link was 10mm. After study of the mechanism it was concluded that this mechanism is mainly applicable to low cost applications where torque is low to medium. With future development in low friction materials (graphene coating) and stronger composite materials, the efficiency and capacity of this mechanism can be increased. Also if instead of bent links, bolted links or links held by universal joints are used then transmission is possible even when angle changes on the go.

Ashish Kumar et al. [3] performed study on Multi Angular Gearless Drive. The mechanism was loaded with 3 Nos. of L-pins. Parts of mechanism were modeled on Solid Works and The analysis of the mechanism was carried out on ANSYS. The study of mechanism was carried with 0.63 Moment of Inertia (Provided by Solid Works). Behavior of system is plotted on different charts i.e. Velocity vs. Time, Acceleration vs. Time, Angular Acceleration vs. Time, Separation Distance vs. Time. From This it was concluded that The final design thus obtained is capable of transmitting torque and power at varied angles depending on the angular limitation of the hooks joint. With further research and advanced analysis in the design wide-ranging applications of the drive can be discovered.

Solanki Nehal et al. [4] studied Design And Analysis Of Gearless Transmission Through Elbow Mechanism which can be used into the replacement of the bevel gears. 4 Nos. of L-pins was used into this fabricated model. With input of 1HP motor. Links of 10mm diameter were used of S.S , M.S material. Shafts are rotating with speed of 1440 RPM and 4947.066 N.mm of Torque. Stimulation is done by the ANSYS 16.2 and analysis of mechanism was done at 50,100,150,200 RPM for both the material. It is been concluded from that analysis that the

mechanism with 6 elbow rods made up of mild steel material is works perfectly. The mechanism runs smoothly when it is kept at 150 RPM Also it can be concluded that as the no of elbow rods increases smoother the operation would be.

Shiv Pratap Yadav et al. [5] performed Real time Study for Design, Analysis and Fabrication of Gearless Power Transmission by using Elbow Mechanism. They used 3 Nos. Of elbow rods inclined to the 90^0.Modeling and rendering of mechanism is done into the CATIA V5 and the analysis was carried on ANSYS. The mechanism was working between 80 to 100 RPM. after this it was concluded that It has a high scope in future to replace the cumbersome usage of gears which will be replaced simple, elegant usage of the shafts that will change the overall cost management of the industries using gear technology presently to gain more profits.

Navneet Baradiya et al. [6] had done Analysis and Simulation of Gearless Transmission Mechanism. The system is to be analyzed in Solid Works package software to watch the response of the elbow rods and the also the hub (coupled with shaft). Motion analysis is performed by running the mechanism at 15 revolutions per minute and higher speeds, reaction forces and reaction moment are plotted against clock run of 5 seconds by using post processor. Theoretical calculations are made to obtain allowable stress by making use of design data values. As a result, response of elbow rod and hub is investigated to find the permissible speed of mechanism. Elbow rods of diameter 7.55mm of stainless steel were used. It is Concluded that for smooth and safe running of mechanism it should be kept below 140 rpm. With this study it is concluded that gearless transmission mechanism is capable of running up to 120 rpm under normal conditions. Further fatigue analysis are recommended for gearless transmission mechanism.

Amit kumar et al. [7] Introduced gearless power transmission arrangement used for skew shafts. 3 Nos. of L-pins were used and the elbow mechanism was compared with S-R-R-S links. During working on experimental it is concluded that proposed arrangement used for any set of diameters with any profile of shafts for skew shafts of any angle but the shaft's must be having the rotational motion about his own axis, transmission of motion is very smooth and desirable and used only for the equal R.P.M. of driving shaft and driven shaft by employing pins or given type of links for appropriate joints for revolute pair.

Jagushte G. S et al. [8] had done research about Design, Analysis and Fabrication of Gearless Transmission by Elbow Mechanism. This system was loaded with 3 L-pins each at 1200 of the cylindrical disc. The L-pins are made up of the Stainless Steel (X6cr17). The rod diameter was taken 12.6mm. part modeling was done in Solid Works and Analysis is carried on Autodesk Inventor (2016).It Was

Concluded after analysis and Fabrication 140rpm to 160rpm is safe for gearless transmission system. Thus simulation results satisfy motion analysis results. Also The model works correctly as per the design. With the help of this system, we can efficiently reduce the cost in power transmission and Further advancement in this technology can be made.

Mahantesh Tanodi et al. [9] Researched about Gearless Power Transmission- Offset Parallel Shaft Coupling. 4 holes were drilled into the shafts and Z-links were inserted into the each hole on shafts. This paper was part of a study investigating the Gearless power transmission for parallel shafts. Gearless Transmission which is compact and portable equipment, which is skillful and is having something practice in the transmitting power between parallel shafts without any gears being used. This Couplings for parallel shaft gives variety of displacement and torque from a minimum of 1 to 500 mm and from 5.4 to 80000 Nm respectively. Analysis of Z-pins done for the different angles and variation in length of pins is checked. By the geometric analysis of configuration it was analyzed that the size of the Z-link connector decreases, as the off-set to shift ratio increases. And hence the strength of the connector comes down. Hence it is advisable to maintain smaller offset to shift ratio for the rigid and stronger Z-link connector. By this study they have concluded that hat the proposed conceptual design can be applied for the transmission of power between two parallel shafts having proper shift and off-set by employing different geometries of Z-pins

Anand C. Mattikalli et al. [10] researched on Gearless Power Transmission- L Pin Coupling. 4 pins are used for each 45° , 90^{0} , 135°.The design was checked by varying the Nos. of pins from 1 to 4 and to find out the optimum Nos. of pins used for better transmission. Analysis is done in CATIA V5. Analysis is done only for two intersecting shafts. At the end of the study By CATIA® analysis, It can be concluded from the results that the proposed conceptual design can be applied for the transmission of power between two Intersecting shafts having proper angular misalignment by employing different geometries of L-pins and it is found that minimum number of L-Pins required are 3, for continuous smooth power transmission.

Atish Lahu Patil et al. [11] had studied Gearless Mechanism in Right Angle . The mechanism was consisting 3 pins bent equally at 90^{0} . It was found from study that the more the Nos. of link will make the operation smoother. The pins were made up of bright bar with a excellent surface finish. The wood cutter was mounted on the output shaft which can cut up to 250mm width of wooden sheet. By working on experimental setup and after a long Study it is Concluded that proposed arrangement used for any set of diameters with any profile of shafts for skew shafts of any angle but the shaft's must be having the rotational motion about his own axis, transmission of motion is very smooth and desirable and used

only for the equal R.P.M. of driving shaft and driven shaft by employing links or given type of links for appropriate joints for revolute pair.

M. Lokesh et al. [12] had fabricated model for Gearless Power Transmission Mechanism using 6 Elbow Rods. From the study it is been stated that this mechanism can transmit the power with 92% of efficiency. The mechanism was consisting 6 Nos. of L pins bent equally at 90^0. The compressor and pump also introduced into project when the links inside the drilled holes reciprocates as well rotate inside cylinder. It gives pumping and compression effect. Among the 6 links first pin goes at inner dead center it sucks the air and start moving outer dead center when further revolving. After study it was concluded that Elbow transmission mechanism is possible in almost for short lengths and also it is suitable for medium length by increasing the housing diameter and The setup indicates that by increasing the elbow a rod in account increases the smoothness of the transmission also The absence of friction ultimately raises the efficiency of the mechanism.

Amit Kumar et al. [13] Presented An Arrangement for Power Transmission Between Co-Axial Shafts of Different Diameter. In that arrangement motion is transmitted between the co-axial **18** shafts of different diameters. Up to 8 Nos. of pins was used. If more pins used motion will be smoother, but increase in no. of pins not at the cost of strength of shaft. Holes drilled very accurately & the axis of both the shafts was co-axial. The designed arrangement can be work for parallel shaft displacement up to 500 mm and torque capacities from 5.4 to 80000 Nm. It was concluded that the Proposed arrangement can be used for any set of diameters with any profile of shafts but the shaft's must be co-axial and having rotational motion along the common axis, transmission of motion is very smooth and desirable and used only for the equal R.P.M. of driving shaft and driven shaft by employing different geometries of Z-pins and Elbow pins or link.

5. CONCLUSION

- Any set of Diameter with any profile and skew shaft too can be used, but it should have rotation about it's own axis.
- Both the driving and driven shaft should run on the same RPM.
- The rods should be equally radially spaced on the Cylindrical disc. (If 3 pins then $360/3=120^0$ each rod).
- The mechanism transmit the motion efficiently up to 150 RPM .
- Generally Stainless Still is used as the Rod material.
- Minimum 3 Nos. of pins should be used for to make transmission possible.

- This mechanism can give up to 92% of efficiency (Gears can give maximum 42% of efficiency).
- The links are bent to 90^0, but it can also be varied by using the universal joint.
- General Diameter of Rod used is 8 to 10 mm.
- General length of the rod used is 250mm.

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