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An Arrangement for Power Transmission Between Co-Axial Shafts of Different Diameter

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***Abstract*— In this arrangement motion is transmitted between the co-axial shafts of different diameters. The synthesis of this mechanism reveals that the no. of pins used in this arrangement should be even ,..2,4,6,8. If more pins used motion will be smoother, but increase in no. of pins not at the cost of strength of shaft. Pins are fixed(may be permanent of temporary) in the drilled holes at the both shaft ends due to which motion is transferred .elbow pins or Z-pins or link used for this arrangements. The bent angle for the all pins are given very precisely , holes drilled very accurately & the axis of both the shafts must be co-axial.**

Proposed arrangement used *for any set of diameters with any profile of shafts but the shafts must be co-axial and having rotational motion along the common axis.* Working of this arrangement is very smooth & use very effectively with very minimum amount of power losses.

***Keywords*— Shaft , force couple , driving/driven shaft, co-axial, elbow and Z pins, connector, reaction force.**

I. INTRODUCTION

Power transmission between the shafts in a machine is very common or we can say there almost in all machines rotating shaft is present for transmitting the motion .

Since in this series sometimes we deals with the shafts of different diameter for transmitting the power from one to other . So a belt pulley arrangement or gears are used .where some disadvantages associated with these, like for gear system, small amount of energy losses due to friction. In belt pulley system speed ratio is not constant (slip or stretch) , heat accumulation, limited speed, limited power, failure of belt and some belts required special attention to install. Also for transmitting motion between shafts of different diameter some manufacturing companies are also made some special type of coupling but these are not easily available & although some times costly or sometimes not suitable for arrangement. So there is a need of modify the arrangements to reduce the losses ,cost & save the time .

Here ,in this paper we just introduce a solution for the power transmission between shafts of different diameter, which is very effective , cheap , easy installation and less skill required for making the arrangement. In this arrangement *Elbow* type or *Z*- pins are used which connect the driving shaft to the driven shaft and motion transferred between the shafts.

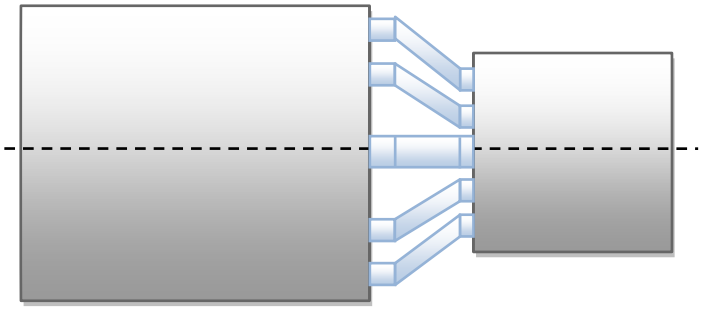

Fig 1.1:- pins arrangement for shafts.

II. LITERATURE REVIEW

1- *Shaft* :- The term “shaft” , used in this standards has a wide meaning and serves for specifications of all outer elements of the part , including those elements , which do not have cylindrical shapes.

2- *Belt and pulley*_- A belt is a loop of flexible material used to mechanically link two or more rotating shafts , most often parallel. Belts may be used as a source of motion, to transmit power efficiently. Belts are looped over pulleys and may have a twist between the pulleys. In a two pulley system, the belt can either drive the pulleys normally in one direction (the same if on parallel shafts), or the belt may be crossed, so that the direction of the driven shaft is reversed (the opposite direction to the driver if on parallel shafts). pulleys and belts transfer rotating motion from one shaft to another. Essentially, pulleys are gears without teeth that depend on the frictional forces of connecting belts, chains, ropes, or cables to transfer torque.[fig 2.1]

3- *Gears* - A gear is a rotating machine part having cut *teeth*, or *cogs*, which *mesh* with another toothed part to transmit torque between shafts, in most cases with teeth on the one gear being of identical shape, and often also with that shape on the other gear. Two or more gears working in tandem are called a *transmission* and can produce a mechanical advantage through a gear ratio and thus may be considered a simple machine. Geared devices can change the speed, torque, and direction of a power source .The gears in a transmission are analogous to the wheels in a crossed belt pulley system. An

advantage of gears is that the teeth of a gear prevent slippage.[fig 2.2]

4- *Zero Backlash Jaw Coupling* - Ruland manufactures zero-backlash jaw couplings with bore sizes ranging from 1/8" to 1-1/8" and 3mm to 30mm. Jaw couplings feature a highly customizable three-piece design, have low inertia, and are well suited for applications that require dampening in industries such as semiconductor, solar, machine vision, liquid handling, and medical.[fig 2.3]

Manufacturing company - Ruland Manufacturing Co., Inc

5- Reducer Couplings -*A full line of steel and stainless steel rigid clamp-type couplings for mating different size shafts, especially for high load applications, is available from* Stafford Manufacturing Corp. of Wilmington, Massachusetts. *Stafford Stepped Bore Couplings solve the problem of mating different size shafts and are available machined from steel or stainless steel. Suitable for connecting shafts from ¼" to 2" bore, including inch-to-metric combinations, these rigid clamp-type couplings.*

6- *Keyed tapered bushings*- A common device for attaching pulleys to motors, gearboxes, and shafts is a keyed tapered bushing, which is typically made of gray iron, steel, ductile iron, or sintered steel. For a given bushing OD, manufacturers offer several different bore sizes to accommodate different shaft diameters. For example, flanged bushings with a 2-in OD are available with bore sizes ranging from ½ to $1^{3}/_{16}$ in. One bushing can also be used for pulleys of different widths, and pulleys grooved for different belt cross sections[fig 2.4]

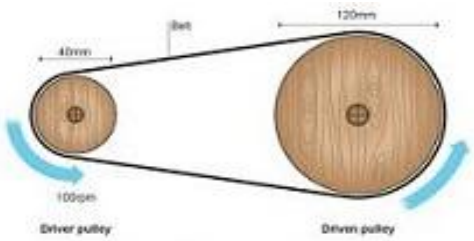

Fig 2.1:- Belt-pulley arrangement .

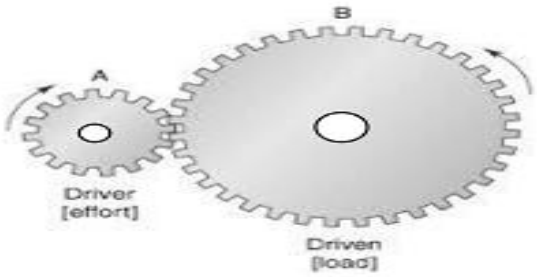

Fig 2.2:- Gears.

Fig 2.3:- Zero Backlash Jaw Coupling

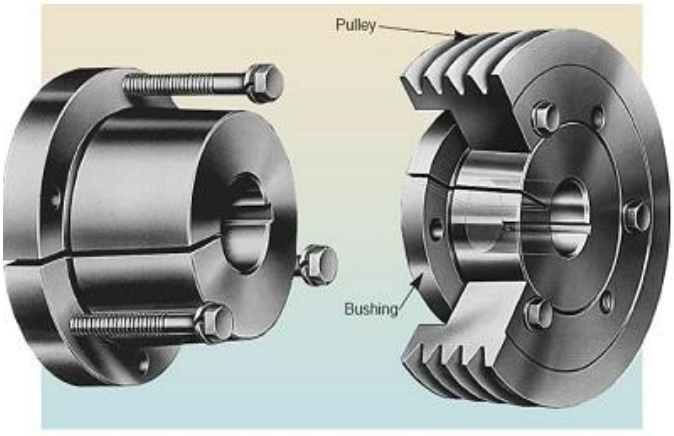

Fig 2.4 :- Keyed tapered bushings

III. COMPONENTS OF THE MODEL AND OPERATION

A. *Working*

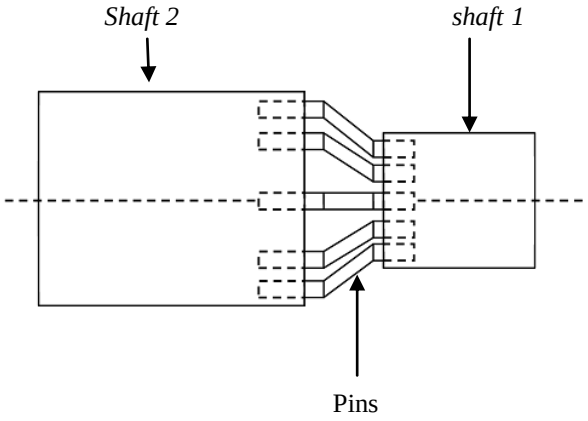

Fig 3.1 :- Front view of the arrangement for 8 pins.

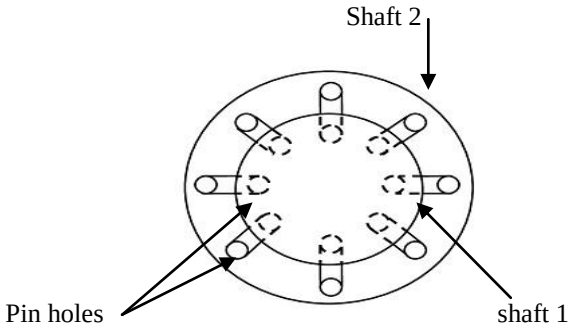

Fig 3.2 :- Side view of the arrangement for 8 pins.

Mechanism of this arrangement can be analysed very easily by using simple mechanics. According to the arrangement pins are held in the drilled holes provided at the driving shaft's end & driven shaft's end.

now in reference of fig 3.3., let at the starting instant T →0, Driving shaft starts rotating , as driving shaft rotates pins kept in holes also tends to rotate but other end of the pins which kept in the drilled holes of the driven shaft ,which is at this instant stationary and oppose the motion of pins with driving shaft , so a reaction force of magnitude F_1 developed at pin's surface which in contact with driving shaft's surface, which is transferred by pins to the its other end as F_2 & acts on the driven shaft's surface which in contact with the pins surface, as we mentioned earlier this arrangement shows for 2 pins(minimum no. of pins) at 180 degree to each other same action taken by the other pin and a force couple is formed, which is totally responsible for the rotation of driven shaft. Here we can use more no. of pins but no. of pins should be even so that more force couple formed and smoother rotation of shaft takes place. Also it is very easily understandable that the R.P.M. of the driven shaft is equal to the R.P.M. of the driving shaft. Driving shaft any one of the shaft either shaft 1 or shaft 2 and other shaft is driven shaft.

B. *Analysis of mechanism*

Force couple formed as shown in fig ,

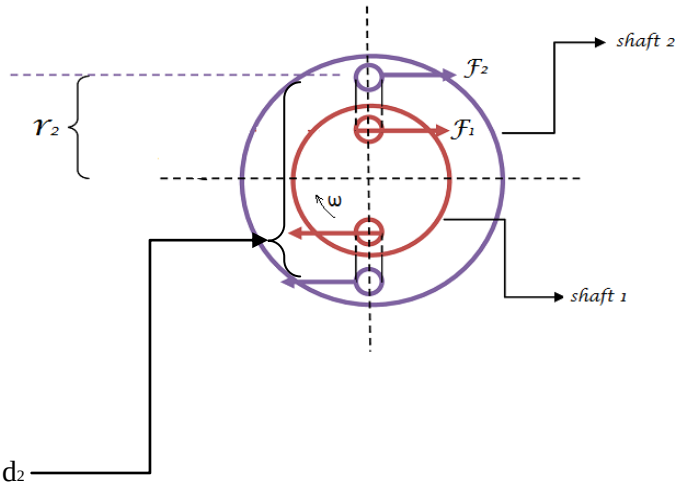

Fig 3.3: - Force distribution on arrangement{for 2 pin set}.

F1= *magnitude of reaction force developed at pin's surface which in contact with driving shaft's surface.*

F2= *transferred force acts on the driven shaft's surface which in contact with the pins surface*

r2, d_2= radius and diameter of the circle on which centres of holes of *driven shaft's lies respectively.*

ω 1,2= *angular velocity of driving shaft and driven shaft respectively.*

Shaft 1= *driving shaft.*

Shaft 2= *driven shaft.*

Moment due to force couple= $F_2 * d_2$ { *used when even no. pins used & angle between set of two pins is 180 degree*.*}
*angle between pins 180 degree means that the holes in the are on the line which is the represent the diameter of the shaft.
Also, for this arrangement we can use the any no. of pins. Let for the 3 pins,

Total Moment about axis= $F_{21} * r_2 + F_{22} * r_2 + F_{23} * r_3$
here suffix over F_2 is used for pin 1, 2 & 3.

- direction of forces not discussed here because moment provided here either in clockwise or anticlockwise direction.

⇨ The value of r_2 is taken as much as possible within the shaft so that the value of force couple is maximum, which is primary necessity for rotation of driven shaft.

- Minimum shift between the shaft is slight greater then the diameter of connector of pins end, not equal to diameter of connector of pins end otherwise end surfaces of shafts are in touch with the connector surface and friction loss takes place in large amount.

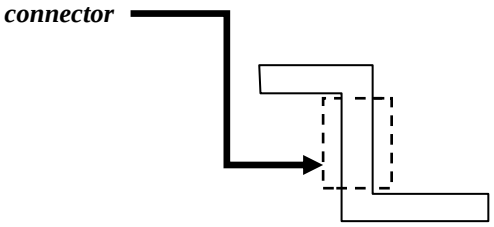

Fig 3.4–connector zone.

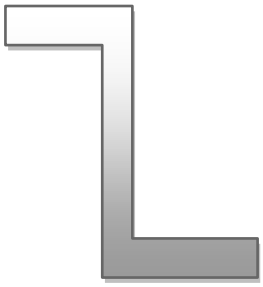

Fig 3.5– Elbow pin.

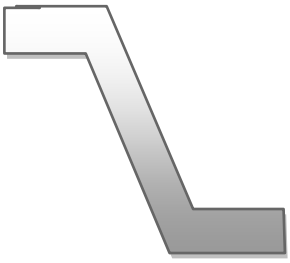

Fig 3.6 – Z -type pin.

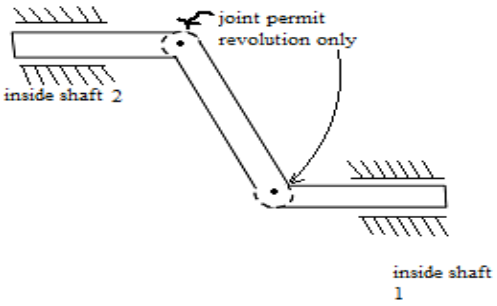

Fig 3.7- link .

- Use of Link shown in figure 3.7 cover the wide range of shafts diameter and no need of separate pins used for different shafts .
- Offset between the axis of conjugate holes of driving and driven shaft is not much because it effect the strength of connector of both elbow pin and Z-type pin .
- Shift between the shafts not much otherwise bending of pins takes place.
- Both shafts must be co-axial for smooth transmission.

IV. ADVANTAGES

1. This arrangement can be used for any set of shafts of different diameters which may be standard or non-standard. In short cover wide range of set of diameters.
2. Since this arrangement is for co-axial shaft , so large space saving should be done which is not possible in case of gear and belt-pulley arrangement because for these system there must be some offset between the shafts which required large space.
3. Very low setup cost. Cost includes only the cost of drilled holes & pins cost. Where as in belt-pulley & gears arrangement having higher cost such as manufacturing & process of manufacturing is quite complex.
4. Very easy & time saving installation .
5. Very minimum amount of power loss unlike of belt pulley's & gear friction losses.
6. Constant velocity ratio maintained because no chance of slipping or backlash as in case of belt pulley & gears arrangement respectively
7. No possibility of radial vibrations.

V. APPLICATIONS

Applications in the areas or machines where the shafts with different diameters are not very easily connected because of very less availability of transmission arrangement or space restrictions, the introduced arrangement in this paper is opened up new possibilities in transmission design . also where the space availability is less and belt-pulley or gears or any other appliance cannot be used, this arrangement can employed very easily and effectively. During modeling observation and in the light of references[1] We have designed this arrangement for parallel shaft displacement up to 500 mm and torque capacities from 5.4 to 80000 Nm.

VI. CONCLUSIONS

During analysis on experimental setup and after a long discussion it is observed that proposed arrangement 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.

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