Three Pin Constant Velocity Joint for Parallel and Angular Power Transmission

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Abstract—Presently Oldham’s coupling and Universal joints are used for parallel offset power transmission and angular offset transmission. These joint have limitations on maximum offset distance/angle/speed and result in vibrations and low efficiency (below 70%). The three pin constant velocity joint is an alteration in design that offers up to 15 mm parallel offset and 12 degree angular offset, at high speeds up to 2000 to 2500 rpm @ 90% efficiency. This design lowers cost of production, space requirement and simply technology of manufacture as compared to present CVJ in market.

Key words: Parallel Power Transmission, Angular Power Transmission

I. INTRODUCTION

In any direct mechanical drive system, there exists a need to couple the variety of driven elements that may be included. The majority of drive elements, including gear reducers, lead screws, and a host of other components, are driven by shafting that is supported by multiple bearings. This allows for shafting to be held extremely straight and rigid while rotating, avoiding any possible balancing and support problems. Because of this rigid support, it is virtually impossible to avoid slight misalignments between a driving and driven shaft when they are connected. Restoring forces that occur as the two coupled shafts compete to maintain their original positions can put unwanted strain on shaft bearings, causing them to wear out prematurely. Additional axial loads are also placed on the bearings as thermal growth occurs in shafting during operation.

The basic function of a power transmission coupling is to transmit torque from an input shaft to an output shaft at a given shaft speed and, where necessary, to accommodate shaft misalignment. Misalignment is the result of many factors including installation errors and tolerance variations. Shaft misalignment can increase the axial and radial forces exerted on the coupling. In misaligned applications, undesirable side loads are usually introduced by the coupling. These side loads result from dynamic coupling behavior, frictional loads and loads caused by flexing or compressing coupling components. The undesirable results include:

− Torsional or angular velocity vibrations which reduce system accuracy.
− Excessive forces and heat on system bearings which reduce machine life.
− Increased system vibration and noise which adversely affects equipment operation.

II. PROBLEM DEFINITION

It is difficult to measure the articulated angle during operation because of the limited space available as well as the high-speed of the rotating driveshaft. Complicating the problem further is the movement of the wheel suspension that affects the driveshaft. The problem is to measure the vertical component, of the articulated driveshaft angle, correctly. When considering different solutions for the problem certain aspects need to be fulfilled. The solution to the above problem is an indigenous coupling that gives constant transmission of torque and angular velocity. The main features of the coupling being:

− Minimize or even eliminate side loads
− Higher shaft misalignment capabilities
− Greater drive accuracy.

Fig.1. Shows existing system in constant velocity joints.

III. PROPOSED WORK

Following activities will be carried out during this dissertation work. It includes literature survey, system design, mechanical design, fabrication, assembly, testing and experimental analysis, and comparative study etc.

A. Methodology:

1) Literature Review:
Study of various power transmission drives in machine tool systems using various drive-train handbooks, United State Patent documents, Technical papers,

2) Development of Theory:
− System Design: This part includes the design and development for the kinematic linkage as per the geometry to produce the desired output.
− Mechanical Design: This part includes the design and development of linkages, selection of suitable drive motor, strength analysis of various components under the given system of forces

3) Fabrication: Suitable manufacturing methods will be employed to fabricate the components and then assemble the test set –up. The fabrication will be carried out as per layout shown below.

4) Testing:
Testing of pump to derive performance characteristics namely:

− Testing of pump to derive performance characteristics namely:
IV. SYSTEM DESIGN

In system design we mainly concentrated on the following parameters:
- System Selection Based on Physical Constraints
- Arrangement of Various Components
- Components of System
- Man Machine Interaction
- Chances of Failure
- Servicing Facility
- Scope of Future Improvement
- Height of Machine from Ground
- Weight of Machine

A. Design of Drive Motor
- TYPE: SINGLE PHASE AC MOTOR.
- POWER: 1/15 HP (50 WATTS)
- VOLTAGE: 230 VOLTS, 50 Hz
- CURRENT: 0.5 AMPS
- SPEED: MIN = 0 rpm
  MAX = 9500 rpm

B. Design of Belt Drive
Power is transmitted from the motor shaft to the input shaft of drive by means of an open belt drive,
Motor pulley diameter = 20 mm
INPUT.shaft pulley diameter = 100 mm,
Reduction ratio = 5,
INPUT.shaft speed = 9500/5 = 1900 rpm,
T\text{motor} = 0.05 \text{N-m},
Torque at INPUT.shaft = 5 \times 0.05 = 0.25 \text{Nm}
Tension in tight side of belt (T_1) = 196 N
Tension in slack side of belt (T_2) = 49 N

C. Design of Components of 3 Pin Constant Joints

<table>
<thead>
<tr>
<th>Part Name</th>
<th>Maximum theoretical stress N/mm²</th>
<th>Von-mises stress N/mm²</th>
<th>Total deformation mm</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input &amp; Output Shaft</td>
<td>0.310</td>
<td>0.5845</td>
<td>0.0001887</td>
<td>safe</td>
</tr>
<tr>
<td>Input &amp; Output Coupler Body</td>
<td>0.15</td>
<td>0.098</td>
<td>9.06E-6</td>
<td>safe</td>
</tr>
<tr>
<td>Input &amp; Output Coupler Ring</td>
<td>0.0035</td>
<td>0.013</td>
<td>1.045E-6</td>
<td>safe</td>
</tr>
<tr>
<td>Input &amp; Output Coupler Female Liner</td>
<td>0.0113</td>
<td>0.40</td>
<td>1.045E-6</td>
<td>safe</td>
</tr>
<tr>
<td>Input &amp; Output Coupler Pin</td>
<td>2.486</td>
<td>5.02</td>
<td>0.0011</td>
<td>safe</td>
</tr>
</tbody>
</table>

Table 1: Components of 3 Pin Constant Joints

<table>
<thead>
<tr>
<th>ISI No</th>
<th>Bearing of basic design No (SKF)</th>
<th>d</th>
<th>D1</th>
<th>D2</th>
<th>B</th>
<th>Basic capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2AC04</td>
<td>6004</td>
<td>20</td>
<td>23</td>
<td>42</td>
<td>36</td>
<td>12</td>
</tr>
</tbody>
</table>

Table 2: Selection of Ball Bearing for Input Shaft

D. Design of Trunion Holder

<table>
<thead>
<tr>
<th>Designation</th>
<th>Ultimate Tensile strength N/mm²</th>
<th>Yield strength N/mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALUMINIUM</td>
<td>400</td>
<td>280</td>
</tr>
</tbody>
</table>

Table 3: Trunion Holder Material Specification

1) \( f_{\text{max}} = \frac{UTS}{FOS} = \frac{400}{2} = 200 \text{N/mm}^2 \)
Check for torsional shear failure:

2) \( \frac{T_{\text{act}}}{16} \leq f_{\text{act}} \times \left[ \frac{D_{\text{ax}}-D_{\text{bx}}}{D_{\text{ax}}} \right] \)

3) \( \frac{0.25 \times 10^{-6} \times 16.4 \times f_{\text{act}}}{16.4^{4} - 23^{4} + 36.4} \)

4) \( f_{\text{act}} = 0.2 \text{N/mm}^2 \)
As; \( f_{\text{act}} < f_{\text{all}} \)
Trunion holder is safe under torsional load.

<table>
<thead>
<tr>
<th>Part Name</th>
<th>Maximum theoretical stress N/mm²</th>
<th>Von-mises stress N/mm²</th>
<th>Total deformation mm</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trunion Holder</td>
<td>0.2</td>
<td>0.9</td>
<td>0.00023</td>
<td>safe</td>
</tr>
</tbody>
</table>

Table 4: Trunion Holder Conclusion

Fig.2. Shows the 3 Pin constant join. This joint is an alteration in design that offers up to 12mm parallel offset and 15 degree angular offset to increase efficiency up to 80-85%.

V. OBSERVATION

Table V observation table contains of 3 pin joint loading readings and unloading readings.

<table>
<thead>
<tr>
<th>Sr No</th>
<th>Loading</th>
<th>Unloading</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weight (KG)</td>
<td>Speed (rpm)</td>
</tr>
</tbody>
</table>
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### Table 5: Observation Table

<table>
<thead>
<tr>
<th>Sr No</th>
<th>Load (kg)</th>
<th>Speed (rpm)</th>
<th>Torque (N.M)</th>
<th>Power (watt)</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>1470</td>
<td>0.04905</td>
<td>7.55164</td>
<td>25.5123</td>
<td></td>
</tr>
<tr>
<td>0.4</td>
<td>1405</td>
<td>0.0981</td>
<td>14.43545</td>
<td>48.7684</td>
<td></td>
</tr>
<tr>
<td>0.6</td>
<td>1330</td>
<td>0.14715</td>
<td>20.49731</td>
<td>69.24766</td>
<td></td>
</tr>
<tr>
<td>0.8</td>
<td>1200</td>
<td>0.1962</td>
<td>24.65842</td>
<td>83.30546</td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td>940</td>
<td>0.24525</td>
<td>24.1447</td>
<td>81.56993</td>
<td></td>
</tr>
</tbody>
</table>

### Table 6: Result Table

Graph shows that maximum power is delivered by the coupling at close to 1200 rpm. Thus this is recommended speed at maximum parallel offset condition.

![Fig. 5: Speed Vs. Efficiency](image)

Graph shows that maximum efficiency is attained by the coupling at close to 1200 rpm. Thus this is recommended speed at maximum parallel offset condition for maximum efficiency.

### VI. CONCLUSION

Maximum stress by theoretical method and Von-mises stress are well below the allowable limit; hence the output trunion holder is safe. Trunion holder shows negligible deformation.

The Three Pin Constant velocity joint is an ideal solution to the power transmission between shafts at angle of 20 degree to 25 degrees, the only wearing parts being the trunion joints. The Three Pin Constant velocity joint ensures that no fluctuating loads are transmitted across to the output shaft.

### REFERENCES

