Performance Evaluation and Analysis of Three Pin Constant Velocity Joint for Parallel and Angular Power Transmission

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***ABSTRACT*:-A coupling is a gadget used to interface two shafts together at their v . The basic role of couplings is to join two parts of rotating elements while permitting some degree of misalignment or end movement or both. by cautious selection, establishment and support of couplings, generous reserve funds can be made in decreased maintenance cost and downtime. Presently Oldham's coupling and Universal joints are used for parallel offset power transmission and angular offset transmission. These joints 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 upto 12 mm parallel offset and 15 degree angular offset ,at high speeds upto 2000 or 2500 rpm @ 90% efficiency. This design lowers cost of production, space requirement and simply technology of manufacture as compared to present CVJ in market.**

Keyword:- 3-pin constant velocity joint, Parallel offset, Angular offset, Power Transmission,Von-mises stress

I. INTRODUCTION

The essential capacity of a force transmission coupling is to transmit torque from an info shaft to a yield shaft at a given shaft speed and, where important ,to accomodate shaft misalignment. Misalignment is the after effect of numerous components including installation erors and tolerence variation. Shaft misalignment can expand the axial and radial forces applied on the coupling. In misaligned applications, undesirable side loads are usually introduced by the coupling. These side loads which are resulting from dynamic behavior of coupling, frictional loads and loads caused by flexing or compressing coupling components. The undesirable results include:

1. Torsional or angular velocity vibrations which diminish system accuracy.
2. Excessive forces and warmth on system bearings which diminish machine life.
3. Expanded system vibration and commotion which unfavorably influences equipment operation

II. LITERATURE REVIEW

Tae-Wan Ku, et.al [1] given that the external race of CV (steady speed) joints with six internal ball grooves has been con-ventionally created by the multi-arrange warm producing forms, which includes a few operations including forward expulsion, irritating, in reverse expulsions, estimating and necking, and also extra machining. There is still no decision yet to create the complex formed parts other than by this warm forging process. As an option, multi-stage cold forging process is exhibited to supplant these customary warm forging. It is demonstrated that the multi-stage chilly fashioning process in this study could be effectively connected to the large scale manufacturing of the external race of the CV joints with the considerably decreased processing time for the machining procedure on the inward ball groove.

Chul-Hee Lee, et.al [2] In this paper, a phenomenological CV joint friction model was created to display the contact conduct of tripod CV joints by utilizing an instrumented CV joint grinding mechanical assembly with tripod-sort joint gatherings. Examinations were directed under various working states of oscillatory speeds, CV joint articulation angles, oil, and torque. The trial information and physical parameters were utilized to build up a material science based phenomenological CV joint element grinding model. It was found that the proposed friction model catches the trial information well, and the model was utilized to anticipate the external produced axial force, which is the fundamental main source of power that causes vehicle vibration issues.

K.S. Park, et.al [3] In the present study on forged outrace CV joints, a ball groove estimation system that uses the mechanical linear displacement sensor and lab view programming has been created and executed in a modern production line. The ball groove estimation system was composed particularly to gauge the measurements of the six ball grooves in the external race. The recently created system provides high measurement accuracy with a simple operational sequence.

Katsumi Watanabe, et.al [4] shown the Rzeppa constant velocity joint is composed of several sets of the ball and two circular-arc grooves. Relative motions of the ball to two circular-arc grooves is analyzed and the output angle error in a practical use which contains sinusoidal fluctuations with periods 2π, $2\pi/3$, $2\pi/6$ is simulated by the circular-arc-bar constant velocity joint.

Nishant Ramesh Wasatkar [5] given that the function of power transmission coupling is transmitting torque from driving shaft to drive shaft along with shaft misalignment. Misalignment in shaft may results into undesirable strains on shaft orientation bringing. Couple of ordinary arrangements are available for misalignment issues like Oldham's coupling and widespread joint which have a few confinements. These limitations can be overcome with Thompson constant velocity (CV) coupling which offers highlights like minimizing side loads, higher misalignment capabilities, more operating speeds, improved efficiency of transmission and many more. This paper presents review on constant velocity joints/couplings configuration and advancement. In this paper the examination work of different researchers identified with transmission couplings and constant velocity joints is reviewed.

Jian Mao [6] gives A car drive shaft is utilized as a part of a front drive transmission vehicle for transmitting rotary movement from the gearbox output shaft to the wheels with a consistent speed. This paper shows the kinematic model of ball joint and tripod joint with thought of clearance and proposes a disentangled dynamic model of the drive shaft. The recreation of the dynamic model is given by the deliberate information. Also, the rough wear of the ball sort joint is tried on the experimental setup with thought of full stacking. The outcomes demonstrate that the progression of the movement will be influenced by the clearance when the stacking alters its course. The movement will be steady because of the damping. It can be found that the abrasive wear of ball joint to a great extent relies on upon the relative sliding speed from the experiments. This will most likely influence the dynamic performance and the impact power, which will likewise cause the other type of failures.

Rahul N. Yerrawarl [7] gives Constant Velocity (CV) Joints are one of the most critical parts of front wheel drive axles. It is subjected to different stresses, for example, bending stress, shear stress and bearing stress. Aside from these stresses, it is additionally subjected to vibrations, because of out of equalization tire or haggle out of round tire or wheel, or a bent rim. The principle target of this work is to reduce the stiffness of the damper, so that the damper can withstand inside the required constaints (i.e. the constrained recurrence scope of 80 Hz to 150 Hz). The free vibrational and constrained vibrational impacts are examined to anticipate the resonance phenomenon of the damper. Finite Element Analysis in ANSYS-11 programming was performed to predict the dynamic behavior of the system under the required vibrational frequencies running from 80 Hz to 150 Hz at given loading conditions.

III. OBJECTIVE

1. Design & drawing of kinematic linkage to deliver parallel as well angular offset over a range
2. Development & manufacturing of drive
3. Testing of drive to derive the performance
4. Plot Performance Characteristic Curves

IV. METHODOLOGY

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;

1. Minimize or even eliminate side loads
2. Higher shaft misalignment capabilities
3. Greater drive accuracy.

Schematic showing the arrangement of test rig in three condition of testing namely :

a) Zero offset condition
b) Parallel offset condition
c) Angular offset condition

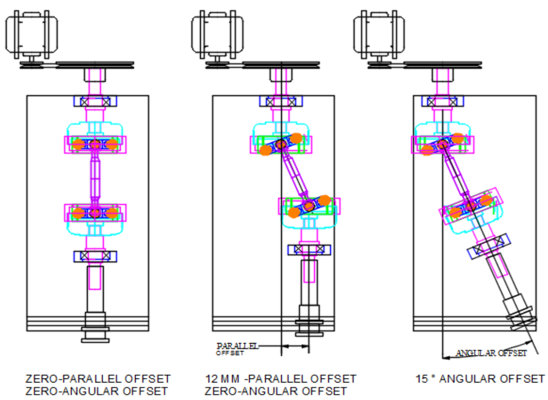


Fig. 1 Arrangement of Test Rig

Work will be carried out in the following steps.

Design Of Input Shaft:

1. Analytical Approach

By using torsional shear formula, torsional shear failure

Material: EN24

Ultimate Tensile Strengh: $800 N/mm^2$

Yield Strengh: $680 N/mm^2$

$fs_{max} = Uts/fos = 800/2 = 400\ N/mm^2$

Check for torsional shear failure of shaft

$$Te = \frac{\pi}{16} fs\, d^3$$

$fs_{\text{act}} = \frac{16\times0.25\times10^3}{\pi\times16^3}$

$fs_{\text{act}} = 0.310\ \text{N/mm}^2$

As; $fs_{\text{act}} < \ fs_{\text{all}}$

Input Shaft is safe under Torsional load.

2. Modeling of Gears

We generate 3D model of input shaft by using using CATIA V5R17 software.& then it is imported to Ansys Workbench

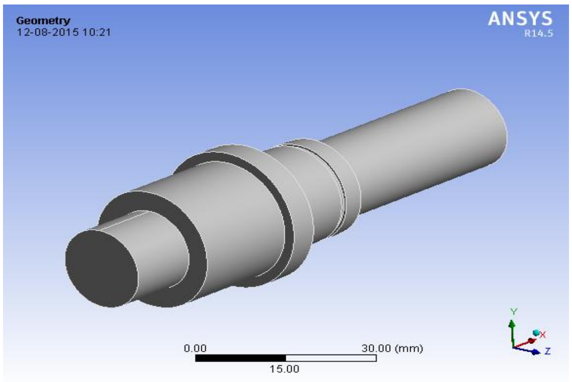


Fig. 2 Geometry of Input Shaft

3. Finite Element Analysis

Input shaft is meshed with triangular surface mesher with 3170 nodes and 1771 number of elements.

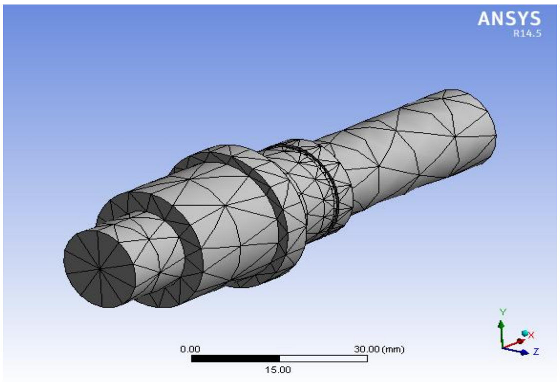


Fig. 3 Meshing of Input Shaft

After meshing one fix support and moment 250 N-mm is given to Input Shaft

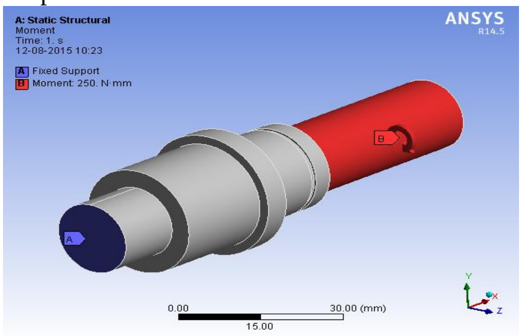


Fig. 4 Static Strucure of Input Shaft with Fixed Support & Moment

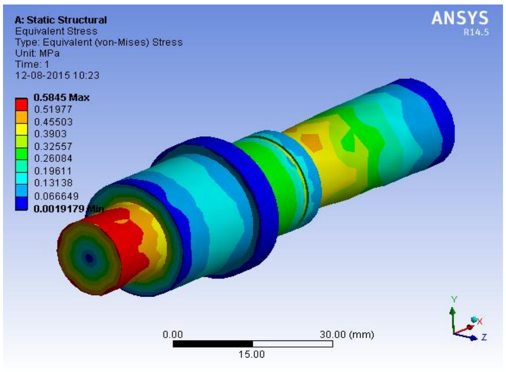


Fig. 5 Von-Mises stress of Input Shaft

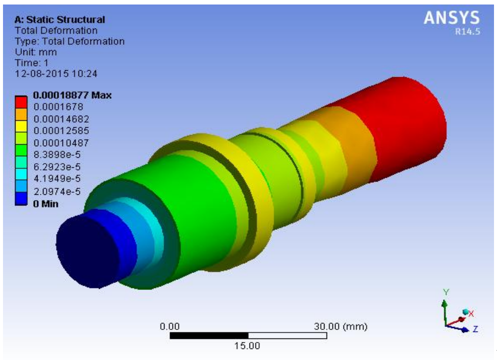


Fig. 6

Total Deformation of Input shaft

The maximum Von Mises stress for input shaft is 0.5845 Mpa and total deformation is 0.00018877 mm.

The Finite element analysis results of all other parts are given below

Table I. Von Mises Stress and Total Deformationof all Design Parts

Part name	Max. shear stress N/mm^2	Actual Theoretical stress N/mm^2	Von-mises stress N/mm^2	Total deforma-tion mm
Input Shaft	400	0.310	0.5845	0.0001887
Input Coupler Body	200	0.15	0.098	9.06E-6
Input Coupler Ring	400	0.0035	0.013	1.045E-6
Input Coupler Female Liner	400	0.0113	0.40	1.045E-6
Coupler Pin	400	2.486	5.02	0.0011
Trunion Holder	200	0.2	0.9	0.00023

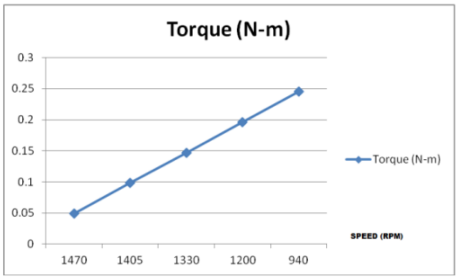
Theoretical Actual stress and Von-mises stress of all parts are well below the allowable limit, hence all the parts are safe. Also the value of Total deformation of all parts is very small so the deformation is neglected.

VI. RESULT AND DISCUSSION

1. Parallel Offset : 12MM

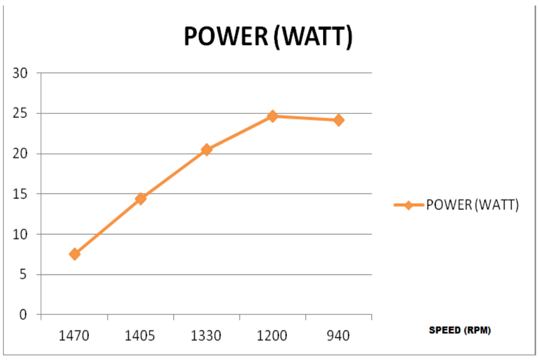
Table II. Power and Efficiency of 12mm Parallel Offset

Sr. No.	Load (kg)	Speed (rpm)	Torque (N.m)	Power (Watt)	Efficiency
1	0.2	1470	0.04905	7.55164	25.5123
2	0.4	1405	0.0981	14.4354	48.7684
3	0.6	1330	0.14715	20.4973	69.2476
4	0.8	1200	0.1962	24.6584	83.3054
5	1.0	940	0.24525	24.1447	81.5699



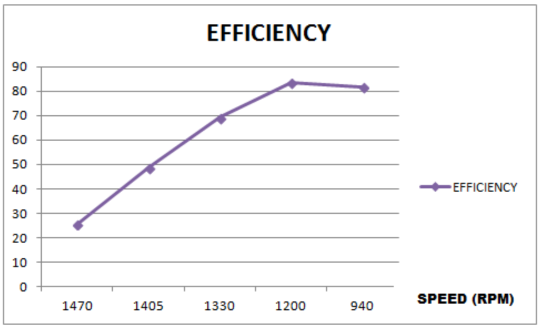
Graph 1. Torque vs Speed Characteristics of Parallel offset

Graph demonstrates that torque increases with reduction in output speed of coupling



Graph 2. Power Vs Speed Characteristics of Parallel offet

Graph demonstrates that maximum power is conveyed by the coupling at close to 1200 rpm .So this is suggested speed at maximum parallel offset condition.



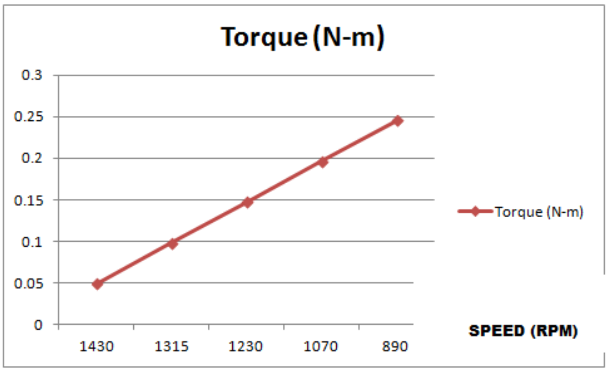
Graph 3. Efficiency Vs Speed Characteristics of Parallel offset

Graph demonstrates that max. efficiency is achieved by the coupling at near 1200 rpm .In this way this is suggested speed at greatest parallel offset condition for mximum efficiency.

2. Angular Offset : 14 DEGREE MAXIMUM

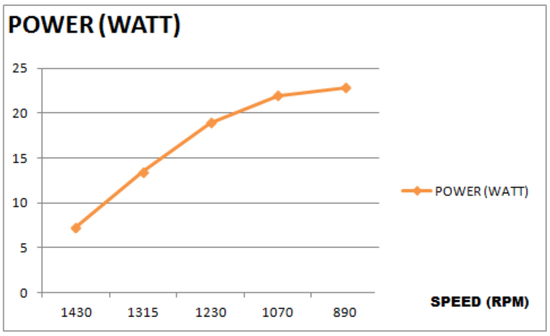
Table III. Power and Efficiency of 12mm Angular Offset

Sr. No.	Load (kg)	Speed (rpm)	Torque (N.m)	Power (Watt)	Efficiency
1	0.2	1430	0.04905	7.3462	24.8181
2	0.4	1315	0.0981	13.5108	45.6445
3	0.6	1230	0.14715	18.9562	64.0411
4	0.8	1070	0.1962	21.9871	74.2807
5	1.0	890	0.24525	22.8604	77.2311



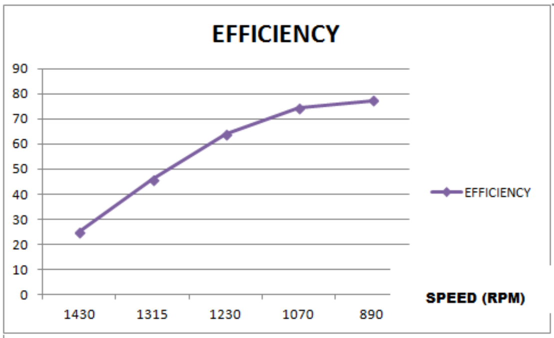
Graph 4. Torque vs Speed Characteristics of Angular offset

Graph demonstrates that torque increases with decrease in output speed of coupling



Graph 5. Power Vs Speed Characteristics of Angular offet

Graph demonstrates that most extreme force is conveyed by the coupling at close to 900 rpm .subsequently this is suggested speed at maximum parallel offset condition.



Graph 6. Efficiency Vs Speed Characteristics of Parallel offset

Graph demonstrates that maximum efficiency is achieved by the coupling at near 900 rpm .so this is recommended speed at maximum angular offset condition for mximum efficiency.

VII. CONCLUSION

- Torque of the coupling increases with reduction in output speed
- Also it can efficiently transmit power for inline shaft, parallel offset shaft and angular displaced shafts
- Recommended speed for maximum Efficiency and maximum power transmission for parallel offset condition is 1200rpm & for angular offset condition is 900rpm

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