A Review on Multi Link (5-Dimensional) Coupling: Novel Approach

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Abstract— Most couplings are designed to accommodate axial, angular or parallel shaft displacements only. For some applications, operational conditions require all possible shaft misalignments. If these shaft misalignments exceed the limit of the selected coupling capacity, excess side loads are introduced into the equipment which can cause vibrations, life reduction or failure of vital machine components such as bearings, motors, etc. In this present work sheds light on various couplings, methodology and experimental analysis of coupling. In additions novel approach not on highlights.

Key words: 5-Dimensional Coupling

I. Introduction

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 [1].

The Five Dimensional Couplings are designed to accommodate 5 degrees of shaft misalignment. Five Dimensional Couplings offer two parallel misalignments and three angular misalignments capabilities. The acting forces within the coupling can be precisely calculated, assuring a sound coupling design which is especially important for heavy-duty applications. If these shaft misalignments exceed the limit of the selected coupling capacity, excess side loads are introduced into the equipment which can cause vibrations, life reduction or failure of vital machine components such as bearings, motors, etc.

Coupling is a power transmitting device used to connect mechanical driven elements. The majority of driven elements include 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 [11]. Misalignment is a condition where the centerlines of coupled shafts do not coincide. If the misaligned shaft centerlines are parallel but not coincident, then the misalignment is said to be parallel misalignment. If the misaligned shafts meet at a point but are not parallel, then the misalignment is called angular misalignment [2].

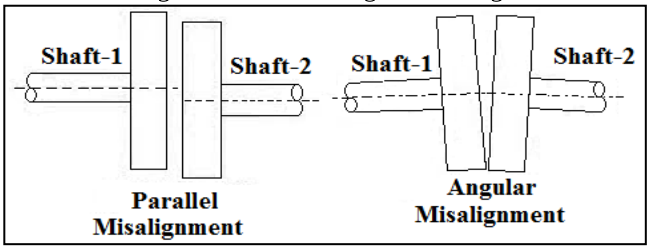

Fig. 1: Types of Misalignments [11]

The primary role of a power transmission coupling is to transmit torque from an input shaft to an output shaft at a given shaft speed 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 [11].

II. Mechanism

Farzad Vesali [2] explained dynamics of universal joints and its failures. It consists of a pair of hinges located close together, oriented at 90o to each other, connected by a cross shaft. The universal joint suffers from one major problem that when the input drive shaft rotates at a constant speed, the output drive shaft rotates at a variable speed, thus causing vibration and wear. The task was performed by initially deriving the motion equations associated to the universal joints. The forces in the joint bearings are calculated by using an analytical method that was also supported by the numerical modeling. The defected bearings with deformed sections were selected for the laboratory examinations. By analyzing the loading behavior and the surface conditions of the defected bearings and by comparison with the known fatigue theories attempts were made in order to dig into the causes for the failures in these joints and their bearing surfaces. Siraj Sheikh [4] analyzed the universal coupling under different torque condition. A universal joint (U-joint) is a joint in a rigid rod that permits the rod to move up and down while spinning in order to transmit power by changing the angle between the transmission output shaft and the driveshaft. Lung Wen Tsai [5] have described a mechanical balancer, based on the Oldham-type shaft coupling, for reducing or eliminating second-harmonic out-of-balance in mechanical systems. It is shown that by proper arrangement of two Oldham couplings, a balancer can be obtained for the elimination of second-harmonic shaking forces or second-harmonic shaking moments or a combination of both shaking forces and moments. Ian Watson [5] explained the double Cardan linkage and consequently constrains of this shaft to bisect the axis of input and output. Closed-form expressions for its motion and the rotation of the double Cardan joint were derived by consideration of spherical linkage kinematics. I. Redmond [7] the model is setup to account for both angular and parallel misalignment in the presence of mass unbalance and incorporates a coupling having angular, torsional and axial flexibility. Among the important features is the ability to simulate both nonlinear bearing stiffness and coupling angular-stiffness anisotropy. The equations of motion are derived for the linear system, extended to include nonlinear bearing effects and subsequently transformed into non-dimensional form for general application. Joe Corcoran [14]. have compared the characteristics of the various types of gas turbine couplings. The analysis of different types of couplings shows that they do not react in the same way when they experience the same torque and same misalignment. Discussion is the reliability of the various types, kinds of safety margins required, and experience factors should be considered for various applications. In addition, the level of unbalance that can be achieved, the reactive forces that each type can produce on the equipment, and advances in manufacturing materials, and design tools are covered.

III. EXPERIMENTATION AND ANALYSIS

Siraj Sheikh [4] conducted metallographic analyses and hardness measurements on each part. For the determination of stress conditions at the failed section, stress analysis was performed by the finite element method. The results illustrate that an increase in the drivable joint angle requires a corresponding increase in manufacturing cost. However, for both the flange and weld yoke, a substantial reduction in manufacturing cost may be realized by restricting the joint angle to less than 30°. The manufacturing cost of the flange and weld yokes may be decreased by 4.5% and 4.0%, respectively, while simultaneously increasing the joint angle by 34° and 38°. Ian Watson [5] A simple spherical geometry model of the Thompson coupling has been discussed. This model has been used for an initial parameter study of the basic flexible design variables in the Thompson coupling. Whilst more advanced consideration of the rigid body dynamics is possible using established quaternion representations, this model is valuable for its simplicity and thus flexibility. A great many operating scenarios can eventually be addressed in a relatively straightforward manner, including run-up and run-down scenarios, even under a variable angle of articulation. I. Redmond [7] A series of numerical analyses are performed and the influence of important system parameters assessed thereby providing insight to the resulting static and dynamic forces and motions. Angular and parallel misalignments are shown to produce fundamentally different system response. It is found that the static preload induced by both types of misalignment can play a key role in producing complex vibration resulting from its interaction with rotating-element anisotropy and bearing nonlinear properties. Bearing static forces are altered and rotating elements are subjected to alternating forces which could affect fatigue life. Bearing forces can be further modified by the application of transmitted torque. The potential for great variability in system response is shown to exist due to the participation of numerous influential variables. K. M. AL-Hussain [8] reported the effect of parallel misalignment on the lateral and torsional responses of two rotating shafts is examined with theoretical and numerical analysis. The general equations of motion are derived and given in dimensionless form to represent the general case. The equations of motion revealed that parallel misalignment couples the translation and angular defections through the stifness matrix and the force vector. The numerical results show that the system natural frequencies are excited at transient condition due to the presence of pure parallel misalignment. Naik [9] reported the power transmission system of vehicles consists of several components which encounter unfortunate failures. These failures may be attributed to material faults, material processing faults, manufacturing and design faults, etc. Analysis was being performed on the universal joint yoke and the propeller shaft. In the universal joint yoke, certain modifications were made in the existing geometry and analyzed for the identical loading and boundary conditions. In case of propeller shaft a comparative study had been made between two shafts differing in their material, keeping in view the possible weight reduction that can be obtained without affecting the functionality of the shaft. Both the components were analyzed in ANSYS and the results were compared. Tanodi [10] studied the gearless transmission for intersecting shafts is a device for transmitting motions between the intersecting shafts with angular misalignment. These L-pins rotate as well as slide inside hollow cylinders thus formatting a rotary and sliding pair. The L-pins (or L links) are free to rotate and slide in the holes, which are drilled parallel to the axis of shafts. The angle for which the L-pins are bent to must be precisely the same for each one, and the holes in the shafts must be accurately drilled, both radially and axially. All parts of this coupler move when the shafts rotate. This is a very smooth-acting device, and the minimal power loss. It can be run at nearly any speed, even at high speed, and is very quiet. It is fascinating to watch in action, with the L- pins rotating and sliding in holes as it rotates. Unlike Bevel and Worm gear there is no unequal distribution of forces. Brahmbhatt [12] explained that couplings are necessary to connect one shaft to another or to couple a drive shaft to drive shaft. For better working of coupling or any other mechanical component designing and manufacturing is very important term. The interface of commercially available software like Pro-Engineering wildfire 5.0 and Microsoft office excel spreadsheet was done for 3D parametric modeling purpose. By parametric designing concept different products variants of the mechanical component have been executed in Pro/Engineer Wildfire.

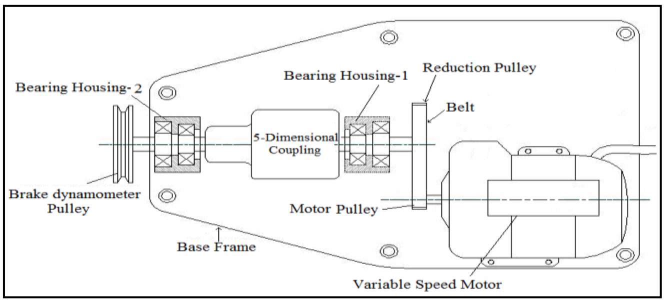

Fig. 2: Experimental Setup for Five Dimensional Coupling

IV. NOVEL APPROCH

Tushar Shinde [1] explained merits of multi-link coupling that size of the gear less variable speed reducer is very compact; which makes it low weight and occupies less space in any drive. The changing of parallel and angular offset is gradual one hence no calculations of speed ratio required for change gearing. Merely by rotating hand wheel speed can be changed. Entire range of offset is covered by a single hand wheel control.

The multi links (5-D) Couplings are a modification of the inline Coupling designed to accommodate 25 degrees of angular shaft misalignment. This coupling allows easy adjustment to any possible misaligned shaft position without imposing heavy side loads on shafts, bearings or other machine equipment. 5-D Couplings offer large shaft misalignment capabilities and constant angular velocity. The acting forces within the coupling can be precisely calculated, assuring a sound coupling design which is especially important for heavy-duty applications.

Archana Chandak [3] studied and investigated parallel and angular offset Couplings. These were developed to fill a gap in the family of torque- rigid couplings. Most couplings are designed to accommodate axial, angular, or parallel shaft displacements only.

Some applications operational conditions require all possible shaft misalignments. If these shaft misalignments exceed the limit of the selected coupling capacity, excess side loads are introduced into the equipment which can cause vibrations, life reduction or failure of vital machine components such as bearings, motors, etc.

Ian Watson [5] observed that, “The Thompson Coupling” is a novel constant velocity joint that operates using the robust double Cardan mechanism. Constant velocity and determinate linkage kinematics are maintained by a spherical pantograph. Zero-Max, Schmidt coupling [13] Schmidt Inline Couplings are a torque-rigid type, designed with two pairs of parallel links installed 90 degrees out of phase with each other. This linkage arrangement allows for the precise transmission of torque and constant angular velocity between shafts with small to moderate parallel misalignments. The coupling utilizes needle bearings which can be preloaded for Low and Ultra Low backlash conditions. Where backlash is not as critical, non-lubricated filament wound Teflon bearings are available for higher torque capacity and where re-lubrication of the coupling is difficult. Typical applications which benefit from the high accuracy provided by Schmidt Inline Couplings are feeders, embossers, compactors, printing presses and many others.

V. CONCLUSION

– Different joints are available according to parallel, angular misalignment or both, each having some advantage and disadvantage. Lot of work is seen already done on design and analysis of Carden joint, Oldham’s coupling etc. A little work was found on design and analysis of couplings with combined axial and angular misalignment. A couple of catalogues from manufacturers are viewed, however, giving very little information on design and analysis.
– The primary purpose of couplings is to join two pieces of rotating equipment while permitting some degree of misalignment or end movement or both. By careful selection, installation and maintenance of couplings, substantial savings can be made in reduced maintenance costs and downtime.
– The Five Dimensional Couplings are designed to accommodate 5 degrees of shaft misalignment. This coupling allows easy adjustment to any possible misaligned shaft position without imposing heavy side loads on shafts, bearings or other machine equipment.
– Five Dimensional Couplings offer two parallel misalignments and three angular misalignments capabilities. The acting forces within the coupling can be precisely calculated, assuring a sound coupling design which is especially important for heavy-duty applications. If these shaft misalignments exceed the limit of the selected coupling capacity, excess side loads are introduced into the equipment which can cause vibrations, life reduction or failure of vital machine components such as bearings, motors, etc.
– Five dimensional Couplings are designed to accommodate five degrees of shaft misalignment. This coupling allows easy adjustment to any possible misaligned shaft position without imposing heavy side loads on shafts, bearings or other machine equipment. Five dimensional Couplings offer large shaft misalignment capabilities. The coupling provides a smooth flow of power for maximum product quality.

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