Torsional Dynamic Stiffness of Flexible Coupling by Analytical and Simulation method

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ABSTRACT

Aiming at the smooth running of Engine- Flexible Coupling- Hydraulic Pump system, Torsional vibration Analysis should be performed for the system to avoid damage of the components and unpredictable accidents. Torsional Stiffness of the coupling is key parameters for Torsional Vibration Analysis, since the material properties of the elastic element of the coupling might change after a long time operation due to the severe working environment and the variation of such properties will change dynamic feature of the coupling. So in this paper Dynamic torsional stiffness of coupling evaluated by analytical method and simulation methods are compared. The results obtained shows that both the results are match with deviation of 2 percentage approximately.

Keywords:- Torsional Vibration Analysis, Flexible coupling, Dynamic Torsional Stiffness.

ARTICLE INFO

Article History
Received: 25th March 2017
Received in revised form: 25th March 2017
Accepted: 25th March 2017
Published online: 4th May 2017

I. INTRODUCTION

Torsional Vibrations are angular vibrations of an object. As the torque is created, the object starts rotating with a velocity and the centrifugal force starts acting on the surface which leads to the object center of mass to disturbed and starts vibrating along direction of axis of shaft. To perform Torsional Vibration Analysis for and system, the mass moment of inertia of driver and driven components and torsional stiffness of connectors are key parameters. Driver and driven components have fixed dimensions and specifications as per the application so their parameters cannot be modify. Coupling as connectors is the only component in the system which torsional stiffness can modify by changing material and dimensions. Torsional stiffness is classified as torsional static stiffness and Torsional dynamic stiffness. Rathi Transpower Pvt. Ltd is the leading Flexible coupling manufacturer and has variety solutions ranges from 30Nm to 200 KNm. Rathi-Lovejoy Couplings are classified as metallic or non-metallic depending on flexible elements present and are customized as per customers and application requirements. For metallic coupling, static and dynamic stiffness have same value as its material properties remain same during operation. Non-metallic couplings have different values for static and dynamic torsional stiffness as the characteristics of elastomers parts of the coupling is changed due to high temperature under operation, alternating torque and aging. Elastomer couplings are widely used for modification of stiffness and damping in power transmission system both in torsion and in other directions (misalignments compensation). In Engine – Hydraulic Pump application the elastomer coupling is installed on the flywheel of the Engine, which produced microcracks on the surface of the non-metallic coupling components of an elastomer coupling. Microcracks on the non-metallic coupling components cause the coupling torsional stiffness to change inevitably, which may lead to increase amplitude of torsional vibrations. When these vibrations are of extremely high amplitudes or resonance occurs then there will be chances of damage of Engine or hydraulic pump which is having very high cost compare with the coupling. So to avoid such
unpredictable accidents or loss, it is quite necessary to calculate the dynamic stiffness of elastomer coupling to check that the elastomer coupling used for the engine-hydraulic pump application is suitable or not. If it is not suitable then dynamic stiffness can be adjusted by changing the materials and dimensions of coupling.

Analytical method

System involving torsional vibrations can be represented as combination of rigid discs or rotor with fixed mass moment of inertia and connectors with torsional stiffness. Weights, mass moment of inertia are calculated by breaking component into simple shapes and then add calculated values for individual parts. If the shafts are of small length and diameter their masses can be neglected. Torsional Dynamic stiffness of coupling is difficult to determined, and it is an inappropriate to measure this parameter by disassembling the power unit while it is under normal operation. Due to which torsional dynamic stiffness is not calculated directly. First it is necessary to calculate torsional static stiffness by considering coupling shape, dimensions, material properties. The material properties like modulus if elasticity and Poisson ratio of each materials and parameters like polar moment of inertia and length of individual part of coupling is used to calculate torsional stiffness of coupling. Shaft penetration effect is also considered as per Agma standards [3].

Coupling Specification:
Rated torque: 800Nm
Coupling rating: 218KW at 2600rpm.
Working temperature: 60°

The calculated Torsional Static Stiffness of Flexible Coupling is 250 KNm/rad.

Torsional dynamic stiffness is determined by multiplying magnification factor to the torsional stiffness, where magnification factor is measure of resiliency of the material. Magnification factor for completely resilient material is 1 and has maximum value 1.4 [2]. Generally the magnification factor for elastomer coupling is taken as 1.2 [1].

The calculated Torsional Dynamic Stiffness of the Flexible Coupling is 300 KNm/rad.

Simulation method:

Simulation method is used to perform any analysis before performing with the actual components to avoid risks and damage of the components along with wastage of material, cost and time. Dynamic stiffness of the coupling is calculated by using Ansys software.

The steps to calculate dynamic stiffness are as follows:
1) Individual components of coupling are modeled and assembled in CAD software (Solidwork 2013). The iges file of 3D model is imported in ansys for analysis.
2) FEA model is generated by meshing the 3D geometry using tetrahedral elements with minimum element size 1mm. is shown in figure 1.

![Figure 1: FEA Meshed model](image)

3) Transient analysis is performed by considering the coupling Specifications and practical boundary conditions. Specified frequency of given coupling is 10 Hz. The deformation of the coupling due to torque is plotted as shown in figure 2.

![Figure 2: Deformation of Coupling.](image)

4) From the deformation value the twist angle is calculated and dynamic stiffness is calculated by dividing value of the torque by twist angle. The Torsional Dynamic Stiffness of flexible coupling by simulation method is 317.19 KNm/rad

II. RESULTS AND VALIDATION

The results by analytical method are evaluated and Simulation method validates the results as the deviation between results is accepted as shown in Table 1.

<table>
<thead>
<tr>
<th>Sr. no</th>
<th>Parameter</th>
<th>Analytical method</th>
<th>Simulation method</th>
<th>Error (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Torsional Dynamic Stiffness of Coupling (KNm/rad)</td>
<td>300</td>
<td>317.19</td>
<td>2.39</td>
</tr>
</tbody>
</table>

Table 1: Comparisons of result values
III. CONCLUSION

The value of Torsional dynamic stiffness of coupling by analytical method and simulation method validates the results as the deviation between results is acceptable.

IV. ACKNOWLEDGEMENT

This work is supported by Rathi Transpower Pvt Ltd, Pune. Rathi group is pioneer in development of “Lovejoy” brand couplings in India and is supplying Rathi brand couplings globally to more than 40 countries. The other brands of Rathi group are Polybond and polysure. Polybond is manufacturer of automotive and other rubber products, anti-vibration mounts, rubber and silicon hoses etc. Under Polysure brand, they are manufacturing high end disposable medical products. Authors are thankful to Mr. Adit Rathi (MD, Rathi Group), HR team, RTPL Engineering team, and all Rathi members for their continuous help and encouragement.

REFERENCES


