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Effect of Shaft Penetration Factor and Interference Fit on Torsional Stiffness of a Coupling Hub-Shaft Assembly

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ABSTRACT

Introduction: Couplings are mechanical devices, which are widely used to connect two shafts, to enable a secure torque transmission while maintaining a good alignment between the connected shafts. To account for the stiffness for the shaft segment inside the coupling hub with a key, a shaft penetration factor (SPF) is used. SPF represents the ratio of the unrestrained versus restrained portions of the coupling hub-shaft interface. Alternatively, the shaft segment can be restrained inside the coupling hub through an interference fit. The objective of this study was to determine the relationship between the torsional stiffness determined from SPF versus interference fit so that the torsional natural frequency (TNF) of a shaft-hub assembly can be determined with confidence.

Methods: Finite element analyses were performed in ABAQUS. Two 20-mm-diameter, 545-mm-long shafts, were connected using a 90-mm-long hub with inner and outer diameters of 20 mm and 62 mm, respectively. Three SPF values, 0 (fully restrained), 1/3, and 2/3 were assumed by defining a frictionless contact to unrestrain the aforementioned portions of the shaft-hub interface, and a rigid contact for the remaining portion. For the interference fit, two values, *i.e.*, 0.02 and 0.054 mm, were selected as per industrial standard. An angle of twist was applied to the assembly to calculate the resultant torque and the torsional stiffness (K_t).

Results and Discussion: when SPF = 0, 1/3 and 2/3, the K_t and 1st TNF were, respectively, 1) 1156 Nm/rad, 1498.6 Hz; 2) 1124 Nm/rad, 1456.9 Hz; 3) 1093 Nm/rad, 1416.3 Hz. When Int. fit = 0.02 & 0.054 mm, the K_t and 1st TNF were, respectively, a) 1106 Nm/rad, 1498.5 Hz; b) 1129 Nm/rad, 1498.6 Hz. A change in torsional stiffness was observed using different SPF or interference fit values. However, consistent with the literature, the modal analysis could not predict the change in TNF measured in labs, which is still under investigation with different modelling approaches. The K_t difference was the smallest between SPF = 1/3 and 0.054-mm-int. fit cases. The length of the shafts may also affect the resultant torsional stiffness and TNF. The K_t results may justify the commonly used SPF = 1/3 in industrial applications. Appropriate finite element modelling may improve current understanding in the design of coupling hub-shaft assembly.