Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 213 (2018) 477–487

Procedia Engineering

www.elsevier.com/locate/procedia

7th International Conference on Fatigue Design, Fatigue Design 2017, 29-30 November 2017, Senlis, France

Strength of a pinion-motor shaft connection : computational and experimental assessment

Samuel Kœchlin*, Helmi Dehmani, György Kulcsár

Leroy Somer, boulevard Marcellin Leroy, 16915 Angoulême Cedex 9, France

Abstract

Load capacity of keyway couplings is usually calculated according to standards (e.g. DIN6892, DIN743) based on nominal stress and simplifying assumptions dating back to several decades. Detailed modeling of keyway couplings is still a research topic, because of the complex mechanical behaviour involved. Moreover, the current standards apply only to usual geometries the designer sometimes needs to depart from, especially for the sake of compacity.

This is the case in gearmotors, where the input pinion is directly fixed on the electric motor shaft. This requires, for small diameter pinions, that the pinion shaft be inserted in the hollow motor shaft end.

In the design investigated hereunder, a special key is built in an opening in the hollow shaft wall. This design is substantially different from usual shaft-hub connections; it combines a geometrical notch with an interference fit, and is submitted to a peculiar stress distribution.

This article explains the detailed investigations made on such a connection. After summarizing the different possible failure modes on classical keyway connections, it explains how a simple interference fit behaves under an external load. Despite its inherent limitations, a FE model gives valuable insight into the connection behaviour : especially the influence of the interference fit, the load combination and the progressive stress stabilization after a few revolutions, due to the combination of friction and relative deformations.

Static test results are then presented, and the challenges of a realistic fatigue tests are analyzed.

A simplified dimensioning strategy is finally set out, which is more suited to practical application in the design office.

Peer-review under responsibility of the scientific committee of the 7th International Conference on Fatigue Design.

Keywords: shaft-hub connections, coupling, pinion, keyway, interference fit, gearmotor

* Corresponding author. Tel.: +33 5 45 64 54 87;
E-mail address: samuel.koechlin@mail.nidec.com

1877-7058
Peer-review under responsibility of the scientific committee of the 7th International Conference on Fatigue Design.
10.1016/j.proeng.2018.02.047

1. Introduction

1.1. Industrial application : gearbox-motor connection

In order to connect the electric motor to the gearbox without intermediate coupling device, Leroy Somer has developed the so-called "Montage Intégré" (MI, i.e. compact mount), where the input pinion is directly fixed on the motor shaft.

This design requires a special shaft end. In the case of small pinions, the pinion shaft must be inserted in a hollow motor shaft end, with an additional feature for transmitting the torque: either a transverse pin, or a special key, as shown in Fig. 1.

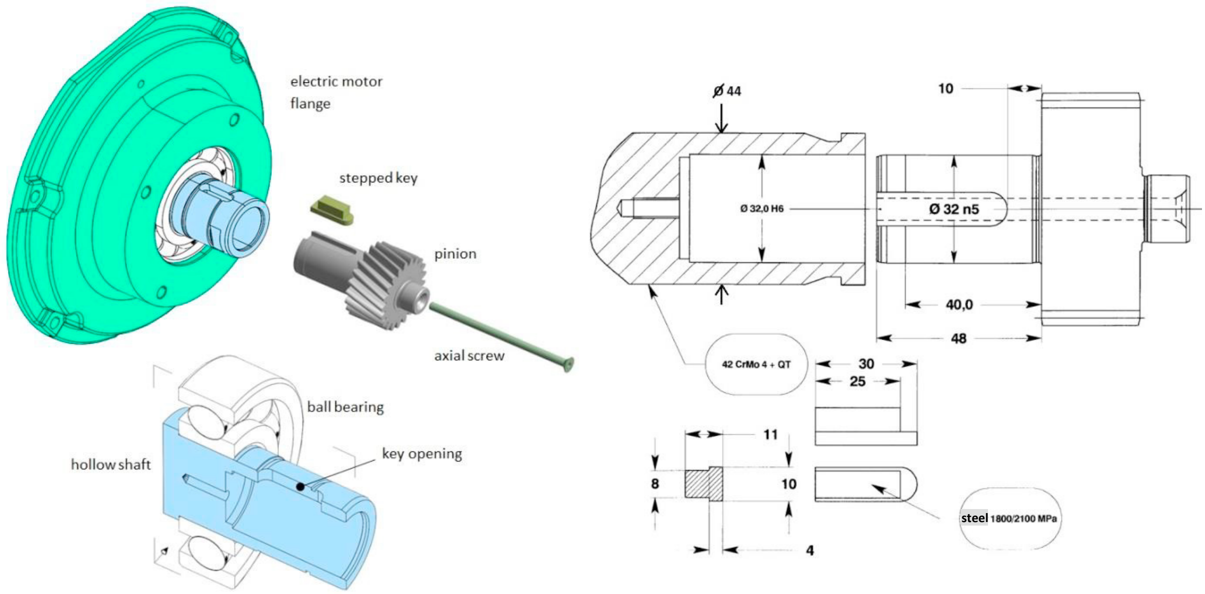

Figure 1 : hollow shaft and pinion assembly – main dimensions

With the evolution of electric motors over the years, and specifically with the introduction of the IE2 efficiency compliant motor range, the torque characteristics of the motors have changed. For the most heavily loaded connections, it is therefore necessary to assess their mechanical strength.

1.2. Aims of the study

The objective of this work is threefold :

1. Detailed strength assessment :
   - What are the failure modes and where are the critical areas?
   - What is the allowable torque? This is not quite the same as getting a safety margin for a given load, it is actually the inverse problem. Since no simple relationship can be given a priori between load and safety margin, solving the strength problem this way turn out to be significantly more complicated.

     The estimated torque limit will depend on :
     - the different load sequences (starting, nominal running conditions, stop, torque inversion)
     - the unavoidable parameter variations (fit of the pinion in the hollow shaft, scatter of friction coefficient)
     - the different pinion sizes (for different gearbox reduction ratios)