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Development of a combined measurement system for torque and angular position

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Abstract

In this article a combined contactless measurement method is presented which is based on angle differences. The aim is the development of a combined, optical measurement system to determine the angular position of a shaft and the applied torque on it as well as an appropriate production technology to apply markings. Two independent modules are used which separately allow the measurement of angular position and rotational speed and if combined can measure torque. To ensure a simple integration of the system into any application, position markings are directly applied on the shaft using a laser. The selected technological approach is based on a contactless measurement method using angle differences. The concept as well as first research results are presented.

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Keywords: absolute angular position; angle difference; contactless combined measurement; sensor; torque

1. Introduction

For precisely controlling automated systems as well as monitoring their power, knowledge of current torque and rotational speed is an essential prerequisite. Furthermore storing these two measured values over the system's

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lifetime offers the possibility of long-term condition monitoring. This paper presents the concept of a novel non-contact measuring method to capture the absolute angular position twice and thus torque. Existing industrial applicable measuring systems that detect rotational speed and torque do not offer combined, non-contact and direct measuring methods. Non-contact implies that it is not necessary to apply strain gauges or incremental disks and that measured values are transmitted without any contact with the specimen. Most measuring methods detect absolute angular position and torque separately by means of rotary encoders and torque transducers. This separate detection, however, results in some disadvantages: often the measuring devices are incompatible to each other, inaccurate, require a lot of installation space and increase the weight and costs of the entire system. Furthermore, in most cases existing measuring systems require constructive changes and additional attachments to the measuring shaft which increases the weight as well as the installation effort.

Nomenclature

γ	shearing angle
e	number of markings/Increments
G	shear modulus
I_T	torsional moment of inertia
l	length (of torsion)
m	length of the code word
M	torque
n	rotational speed
φ	angle of twist
R	radius

1.1. Requirements to the system

The design requirements of the system shown in Table 1 were identified in collaboration with potential users of well-known companies. The measuring system to be developed should cover a wide measuring range with high resolution and accuracy at both low and high rotational speeds. For extensive practical use, the requirements were divided into minimum requirements and ideal requirements.

Table 1. Requirements to the measuring system.

Description	Minimum requirements	Ideal requirements
Type of shaft	solid shaft	solid and hollow shaft
Surrounding	low vibration and dust, lubricant-free	fuel/oil
Measurement method	non-contact	non-contact
Measuring range of torque [Nm]	- 50…+ 50	- 50…+ 50
Shaft diameter [mm]	10 - 20	> 10
Length of torsion [mm]	> 50	> 50
Range of rotational speed [rpm]	0 - 1000	0 - 12000
Resolution measurement of rotational angle [°]	< 0.01	< 0.01
Accuracy measurement of rotational angle [%]	< 0.1 FS	< 0.1 FS
Interface	digital	digital