Kinematic Couplings for Synchrotron Radiation Instrumentation

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Abstract

Kinematic couplings are often used in synchrotron radiation facilities to achieve high-precision positioning and relocation of opto-mechanical components. These devices are self-locating and free from backlash, allowing re-positioning repeatabilities in the sub-micrometric range to be attained. Moreover, since they are not overconstrained, kinematic couplings are deterministic and therefore their behavior can be represented in a closed form solution. The biggest shortcoming of kinematic couplings is that, with only six contact points generally accompanied by the absence of a lubrication layer, they present high contact stresses, which are difficult to calculate both analytically and numerically. In fact, the analysis of such devices implies the necessity to consider the mathematical theory of mechanical contacts between elastically deforming solids, known as the Hertz theory.

In literature various approaches can be traced to deal with such an analytical problem. The exact model based on the principles of mechanical elasticity is complex since it involves an iterative evaluation of elliptic integrals. Most of the other approaches are based on approximated methods that make use of diagrams or tabulated values for the calculation of the stress-strain behavior as a function of the mechanical characteristics of the couplings.

The aim of this work is to establish the limits of applicability of the various analytical approaches available in literature depending on the required degrees of accuracy. The validity of the theoretical models will be assessed experimentally via high-precision experimental measurements; these will allow the influence of the various mechanical parameters on the behavior of kinematic couplings to be established.

Keywords: kinematic couplings, Hertzian contact, high-precision, X-ray instrumentation

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