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Letter to the editor

Comment on Xu, Nannan, et al. "Modeling analysis and experimental study for the friction of a ball screw." Mechanism & Machine Theory 87 (2015):57–69

Three kinds of friction, friction on the ball–nut contact (F_A'), friction on the ball–screw contact (F_B') and friction between the balls (F_m'), are introduced in Ref. [1] to calculate the ball screw friction (F''), which is actually the sum of the three kind frictions. And the friction moment of the ball screw (M) is also calculated as the sum of the moments of the three kinds of friction. However, in a ball screw mechanism, it is the servo motor that drives the screw to rotate and produces the normal contact force between the screw–ball (Q_i) and ball–nut (Q_o) contacts in sequence, ultimately produces an axial force to balance the axial load. That means, the friction on the screw surface of the screw–ball contact is a passive force ($-F_B'$) while the friction on the nut surface of the ball–nut contact is a driving force ($+F_A'$). For a ball in the ball screw mechanism, the friction on the screw–ball contact is a driving force ($+F_B'$) while the friction on the ball–nut contact is a passive force ($-F_A'$), and the frictions between balls on the two ball–ball contacts are passive forces ($-F_m'$), which are small and usually can be ignored. The three kinds of friction are even not of the same type, thus it makes no sense to calculate the sum of the three kinds of friction or moments. And considering the normal contact forces between the screw–ball and ball–nut contacts (Q_i and Q_o), the ball's centrifugal force (F_c) and the drag force due to the lubrication (F_v), the force balance of a ball can be obtained in Ref. [2] ($\vec{F_B}' + \vec{F_A}' + \vec{F_m}' + \vec{Q_i} + \vec{Q_o} + \vec{F_c} + \vec{F_v} = 0$). For the low rotational speed used in Ref. [1], $\vec{F_c}$, $\vec{F_v}$ and $\vec{F_m}'$ can be regarded as zero, Q_i and Q_o are opposite to each other, so the relationship of the three kinds of friction actually is $F_B' + F_A' + F_m' = 0$. Besides, it is the friction on the ball–nut contact (F_A') that can be used to calculate the mechanical efficiency of the ball screws, not F'' or M introduced in Ref [1]. And this kind of study has already been done in Refs. [3,4].

In the experimental setup, the ball nut body is coupled to a load cell during the measurement of the friction moment, which is consistent with the test instructions of the no-load friction moment of ball screws in DIN ISO 3408-3 [5]. Thus, the obtained friction moment is just the moment applied by the friction force on the ball–nut contact at a distance from the screw axis, independent of the moment between the balls or the ball and the screw. The friction moment formula in Ref. [1] includes those of the above three kinds of moment, while the experiment verification is just the friction moment test of the preloaded ball screw under no load, which is the friction moment on the ball–nut contact. Thus the experiment verification is obviously not right.

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