PROPERTIES OF FORM FITTING SAFETY COUPLINGS

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ABSTRACT: Torque controlled safety couplings are used as safety elements in drive trains. Their function consists in separating input side and output side when the limit for the transferrable torque is exceeded. Main property of these couplings is the switching torque, the maximum transferrable torque before initiating the separation of the drive train. Target of the project is to examine the characteristics of the switching torque of form fitting safety couplings. Doing so three couplings of well known manufacturers are examined. Main result of the test is that the switching torque of form fitting safety couplings is underlying parameter dependencies and scatter. Safety and exploitation of the drive train are in cases considerably depended on the given point of operation and the coupling adjustment. In this respect it is of importance, to choose, to adjust and to operate the covered couplings systematically.

Target

Torque controlled safety couplings are used as safety elements in drive trains. Their function consists in separating input side and output side when the limit for the transferrable torque is exceeded. Hereby considerable damages in drive trains in case of overload may be prevented. Examples for such safety couplings are those in drive trains of powerful mining equipment or fast moving hoisting equipment of ship-to-shore container cranes (Picture 1).

Main property of these couplings is the switching torque, the maximum transferrable torque before initiating the spontaneous separation of the drive train.

Target of the project is to examine the characteristics of the switching torque of form fitting safety couplings. Doing so three couplings of well known manufacturers are examined at clockwise rotation / anti clockwise rotation and four different rotational speeds.

Tests

For the examination of the switching torque a drive train was built up. The drive train consists of a frequency inverter driven squirrel cage motor, the coupling to be examined as well as a magnetic powder brake (Picture 2). All components are situated on one axis. Close to the brake the speed of the drive train and the torque in the drive train can be measured. The setup facilitates the exchange of the couplings to be examined. The examination is executed for four speeds (n=5 min^{-1}, 50 min^{-1}, 400 min^{-1}, 700 min^{-1}) at clockwise rotation and anti clockwise rotation. In the beginning the drive train is running with closed coupling against the relative low friction torque. Then the braking torque is elevated dynamically in a manner, that the coupling is opened unavoidable. These tests were executed seven times for every measuring point and statistically evaluated under the assumption of a normal distribution of the switching torque.

Results

Regarding the mean values of the switching torques coupling 1 shows a relatively constant behaviour over speed. Maximum deviation of the switching torque from the adjusted switching torque is 3%. The prefix of the deviations depends on the direction of rotation, maybe caused by deviations in the symmetry of setup (Picture 3).

Coupling 2 shows a distinct dependence of the mean values of the switching torque on the rotational speed. At the lower speed of 5 min^{-1} the switching torque is deviating ±2% from the adjusted switching torque. With increasing speed the switching torque is decreasing 37-39% at 700min^{-1}. The directional variation of the switching torque is comparable to coupling 1 (Picture 3).

Coupling 3 shows, as well as coupling 2, a distinct dependence of the mean value of the switching torque of the speed. At the lower speed of 5 min^{-1} the switching torque is deviating +5-8% from the adjusted switching torque. With increasing speed the switching torque is decreasing -32-36% at 700min^{-1}. The distinct directional variation of the switching torque lies within a width of up to 34% (Picture 3).

Regarding the standard deviations of the switching torques shows coupling 1 a relative smaller scatter. The maximum standard deviation of the adjusted switching torque is 2% (Picture 4).

Coupling 2 shows a greater scatter of the switching torque. A standard deviation of the switching torque of up to 4% is occurring (Picture 4).

Coupling 3 shows a considerable scatter of the switching torque. A standard deviation of the switching torque of up to 19% is occurring. Apparently a dependence of the standard deviation of the rotational direction is given (Picture 4).

Following confidence intervals for 95% switching probability on basis of a normal distribution of switching torques are considered.

It is recognised, that for all coupling switching torques above the adjusted switching torque may occur, especially for lower speeds. The maximum switching torques for couplings 1 and 2 are 103%, for coupling 3 129% (Picture 5). Basing on this the realised safety function has to be evaluated.

Furthermore it can be seen, that for all couplings switching torques well below the adjusted switching torque occur, especially at higher speeds. Following minimal switching torques within the tested spectrum are registered: coupling 1: 97%, coupling 2: 59%, coupling 3: 44% (Picture 5). Basing on this the realised exploitation of the drive train may be evaluated. Is a drive train operated at a certain speed, the adjustment of the coupling according to this operating point may be regarded. Doing this, the outcome of lower operating speed has to be considered.

Conclusions

Main result of the test is that the switching torque of form fitting safety couplings is underlying parameter dependencies and scatter. Are the safety level and the exploitation of the drive train to reach a high level, are couplings with properties suitable for the given application to be used.

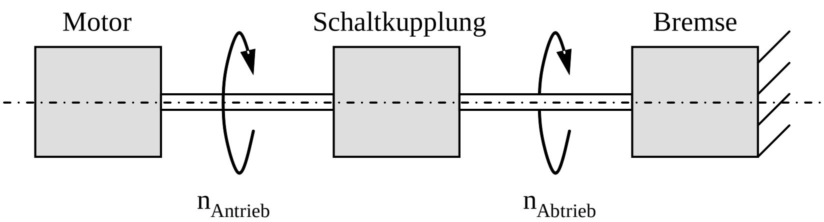
Safety and exploitation of the drive train are in cases considerably depended on the given point of operation and the coupling adjustment. In this respect it is of importance, to choose, to adjust and to operate the covered couplings systematically.

References

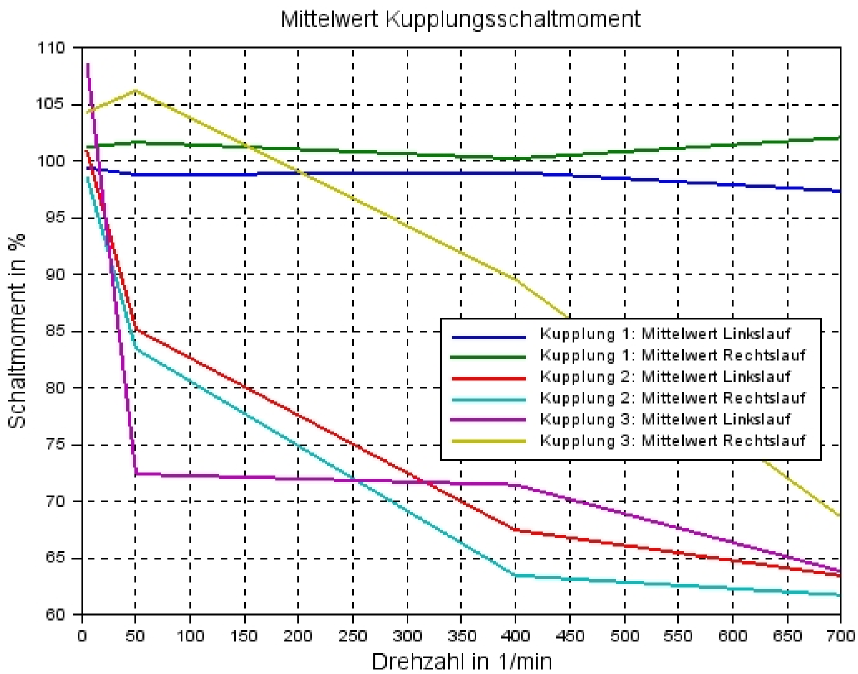
[1] Dennig: Entwicklung einer schnell schaltenden Bremse und Kupplung für Linearbewegungen zum Überlastschutz in Werkzeugmaschinen, Dissertation, Universität Stuttgart, 2009

[2] Vöth: Safety Concepts for Container Crane Hoists, ITI-Symposium, Dresden, 2014

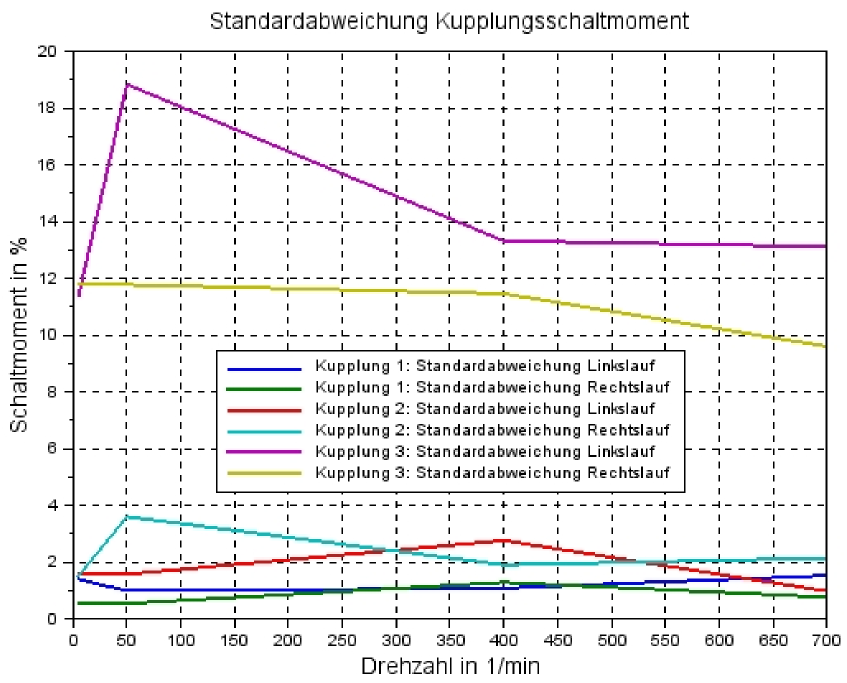
Picture 1: Ship-to-shore cranes



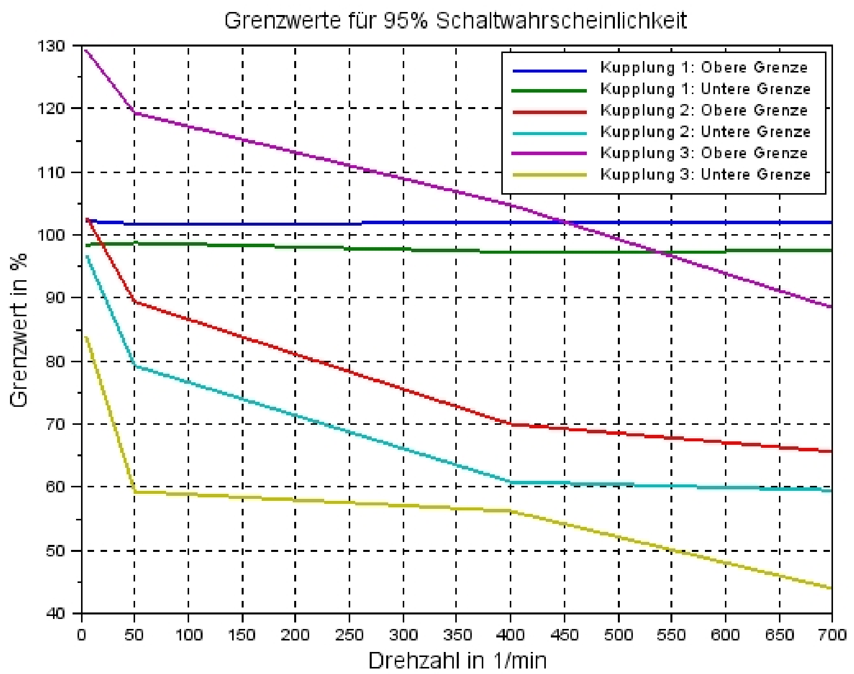
Picture 2: Schematic testing arrangement



Picture 3: Normed switching torques (Mean value)



Picture 4: Normed switching torques (Standard deviation)



Picture 5: Confidence intervals for 95% switching probability