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TITLE

Tribological operant coating systems for cold forming of steel, stainless steel and aluminium – state-of-the-art and future prospects

In order to enable (cold and warm) forming processes of metals a coverage of the metal surface with a tribological operant coating is necessary. Only by reducing the friction and by avoiding any direct contact between workpiece and tool a cost-effective mass production at high quality can be realized.

Cold forging of carbon steel

The process development of cold forming of steel especially in the automotive industry (emerging in the 1960's) is closely related to the development of high performance tribological systems. The combination of a conversion coating of zinc phosphate which is chemically bound to the surface of the work piece with a suitable lubricant is still the most common way of working since its capability even for high-demanding cold forging processes has been well approved in the industrial application for decades. Soap is well-suited for lower degrees of forming as well as for ironing and drawing operations, whereas molybdenum disulfide is the lubricant of choice for severe forgings with high pressure load, high degree of forming, high surface extension and high demands in dimensional accuracy. Special aqueous dispersions with superior adhesion and thus improved forging performance have replaced the traditional powder application widely. This advanced lubrication

technology allows to obtain higher degrees of forming in less forming steps and thus reduces the number of chemical treatment steps.

For further shortening of the chemical treatment ZWEZ-SLS (Short-Lubrication-System) is a new approach for zinc phosphate free cold forming of steel. Shot blasting replaces the chemical cleaning to remove scales and rust and provides lubrication pockets to the surface. A special conditioner (ZWEZ-Cond MPS 4.0) in combination with adjusted lubricants basing on molybdenum disulfide or polymers enable forging operations quite near to the standard process with zinc phosphate.

Growing market demand for aluminium and stainless steel

Because of its high ductility of **stainless steel** causes very high tribological loads in cold forging. So usually molybdenum disulfide dispersion is the lubricant of choice. The chemical coating process is very similar to the process prior to cold forming of steel. Only zinc phosphate is replaced by an oxalate coating.

The task to reduce the carbon footprint of transportation calls among others for light weight construction, and **aluminium** plays an important role. The demands for mechanical strength and dynamic load capacity require aluminium alloys like EN AW 5083, 6082 and 7022. Alloys of the range EN AW 8xxx with alloying elements iron or lithium will most probably cause new demands to the tribo system.

In case of high degrees of forming these highly alloyed aluminium grades usually cannot be forged with zinc stearate (applied by tumbling) but require a conversion coating (“aluminate”) and lubricants basing on sodium stearate or polymer. Since this analagon to the zinc phosphating process is so far not widely available there is a good opportunity for novel polymer lubricants specially adapted to aluminium which work without a conversion coating.

	Carbon Steel		Stainless Steel incl. Inconel, Monel & similar super alloys		Aluminium		
	Standard	Short Lube System	Standard	Short Lube System	EN AW 1xxx	EN AW 2xxx, 5xxx, 6xxx, 7xxx, 8xxx	Short Lube System
Tribo System	Standard	Short Lube System	Standard	Short Lube System	Standard	Standard	Short Lube System

Pre-treatment							
shot blasting	◆	■	◆	■	◆	◆	◆
cleaning + WR	■		■		◆	◆	◆
pickling + WR	◆		◆				
conditioning	■	◆		◆			◆
Coating							
zinc phosphate	■					(□ ¹)	
oxalate			■				
aluminate						■	
water rinse	■	◆	■	◆		■	◆
neutralizing	■		■				
drying		■		■			■
Lubrication							
oil					■		
zinc stearate					□	□	
sodium stearate	■		□			■	
polymer	□	□	□	□	□	□	■
MoS ₂ -dispersion ("liquid moly")	■	■	■	■		(□ ²)	(□ ²)

Nos. of tanks *	15	1-2	15	1-2	0-1	9	1-2
process time	1 h	10 min	1 h	10 min	10 min	½ h	10 min

Table: Survey on commercially available high-performing tribo systems for cold forming of steel, stainless steel and aluminium (incl. cold heading wire CHQ)

■ = standard □ = alternatively ◆ = if required

WR = water rinse

(□¹): usually not applied due to short service life of medium (1 day up to 1 week)

(□²): superior forging properties, but requires advanced cleaning

* in case of three-fold water rinsing cascades