

LUBRICANT SELECTION FOR COLD SHEET METAL FORMING OF STAINLESS STEEL

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EXTENDED ABSTRACT

The TNO slider-on-sheet tribo meter is used to investigate the influence of forming lubricants on galling, specifically for stainless steel sheet material AISI 304. One of the aims is to find a lubrico system that performs well in terms of galling prevention, not using traditional (chlorinated) lubricants.

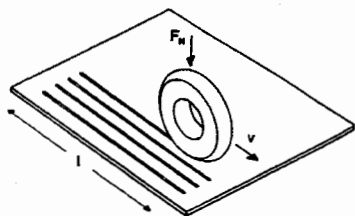


Figure 1 TNO slider-on-sheet tribo meter

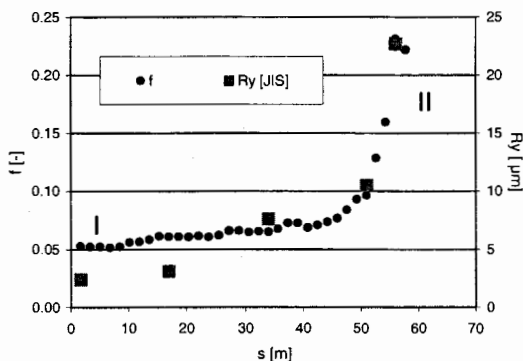


Figure 2 Typical development of the coefficient of friction (f) and the depth of the tracks on the sheet (R_y) as a function of the sliding distance (s).

In figure 1 the measurement principle is schematically shown. A slider is pushed against sheet material with a normal force F_N . Then the slider moves in the x -direction, with a sliding speed v . At the end of the track (track length l) the slider is lifted from the sheet and moved over a distance of 1 mm in the y -direction. The slider, still lifted from the sheet, returns to the starting point. The normal force is re-applied and the next track is made assuring virgin sheet material in the contact. All the experiments are conducted at room temperature and with $v = 0.5$ m/s, $F_N = 100$ N and $l = 1700$ mm. The maximum sliding distance is set to 500 m.

Figure 2 shows typical test data gained with this method. It is not hard to construct a relation between the development of the scratch depth and the development of the coefficient of friction. Part I of this graph is a region in which the system performs adequate in terms of friction and wear. Part II is characterised by severe material transfer from the sheet to the slider. The lifetime of this system is reached within 60 m sliding contact.

A set of nine lubricants, varying from a mixture of esters without any EP additives to a lubricant containing up to 35 weight % Cl (lubricant A), is tested on 0.8 mm cold rolled austenitic stainless steel sheets AISI 304, with sliders made out of high-speed steel ASP 23 (WN 1.3344). The results show that with this test method, it is possible to select sheet metal forming lubricants on their ability to avoid galling. It is clear that the coefficient of friction at the start of

the experiment can not be used to predict the occurrence of severe material transfer after a substantial sliding distance (see table 1).

Table 1 Ranking of nine forming lubricants based upon $L_{f>0.15}$: the sliding distance at which the coefficient of friction becomes larger than 0.15. The maximum sliding distance was 500 m. f_{start} = average coefficient of friction over the first track of the experiment.

Lubricant	$L_{f>0.15}$ [m]					average $L_{f>0.15}$ [m]	average f_{start} [-]
	exp. 1	exp. 2	exp. 3	exp. 4	exp. 5		
A	> 500					>500	0.050
F	> 500					>500	0.040
G	373	422				398	0.058
I	319	91	208			206	0.050
E	98	139				119	0.049
C	120	39	54	60	55	66	0.052
B	32	31				32	0.051
H	9	18				14	0.087
D	11	11				11	0.072

Two experiments were performed with a PVD TiN (Balinit A, Balzers) coated WN 1.3344 slider, one with lubricant B and one with lubricant H. Both lubricants performed poorly in combination with uncoated WN 1.3344. From figure 3 it can be seen that the development of friction as a function of the sliding distance changes due to the use of PVD TiN. The maximum measured coefficient of friction in these two experiments is 0.11 over 3000 meters sliding distance. The coefficient of friction at the start of the experiment becomes almost equal for both lubricants.

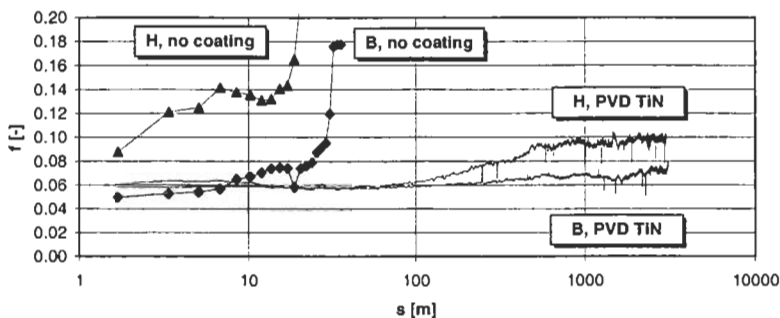


Figure 3 The effect of a PVD TiN coated slider, on lubricant selection.

Concluding remarks

The experimental results show that it is possible to rank sheet metal forming lubricants with respect to galling (prevention) by using the TNO slider-on-sheet tribo meter. Essential part of this method is the link between the development of material transfer or scratch depth on the sheet and the development of the coefficient of friction. Comparing the initial coefficient of friction with the sensitivity to avoid galling indicates that selection of lubricants for sheet metal forming operations should be done based on long term tribo tests instead of on short term tribo

tests.

The results show that there are differences between lubricants with respect to their ability to form adequate protective layers in the sliding contact between sheet and tool. The conventional Cl-containing lubricant A performs well, as known from industrial practise. A promising alternative for the Cl containing lubricant A, could be lubricant F. Another option is to use a PVD TiN coated tool. The experiments show that this coating enables the use of 'less active' lubricants like lubricant B which is an undoped mixture of esters.