

COMPARATIVE INVESTIGATION OF STATIC FRICTION COEFFICIENT OF 6082 ALUMINIUM ALLOY WITH THE MATERIAL CONDITIONS T651 AND EQUAL-CHANNEL ANGULAR PRESSING (ECAP)

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1. Introduction

Knowledge of occurring friction is very important in mechanical engineering – both in order to ensure reliable friction-locked joints and to reduce energy loss. Friction coefficients are influenced by many factors, like hardness, material strength and structural conditions [1]. These materials properties can be improved through ultrafine graining of aluminium alloys by equal-channel angular pressing (ECAP) with subsequent aging treatment [2]. Therefore the influence of ECAP material conditions on the frictional behaviour of 6082 aluminium alloy is investigated in this paper.

2. Experimental Investigation

The test bench for determination of friction coefficients is shown in fig. 1.

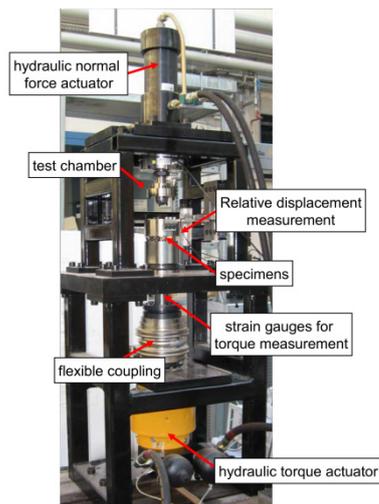


Fig. 1: Test bench.

After applying the normal load force F_V , two cylindrical specimens are twisted to each other till 5° angle is reached (fig. 2). During the torsional loading, the reaction frictional torque T_R is recorded over the twisting angle. The friction coefficient can be calculated according to eq. (1).

The friction diameter D_m arises from eq. (2) as a corresponding one.

$$\mu = \frac{2 \cdot T_R}{F_V \cdot D_m} \quad (1); \quad D_m = \frac{2}{3} \cdot \frac{d_a^3 - d_i^3}{d_a^2 - d_i^2} \quad (2)$$

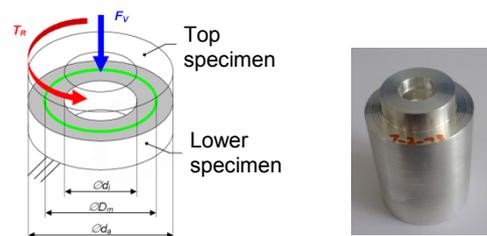


Fig. 2: Load principle and geometry.

Within the friction investigation specimens of 6082 aluminium alloy with temper designation T651 in comparison to those of ultrafine grained material condition by one ECAP pass with subsequent optimized aging treatment – called ECAP optimized – were used. Due to the material treatment an increase in the Brinell hardness of about 22 % and in the yield strength of approximately 8 % was reached. These results were achieved in collaboration with the Institute of Materials Science and Engineering (Chemnitz University of Technology) and are in accordance with earlier observations in [2].

Besides of the material properties the geometrical surface characteristic is important for the results synthesis. However usual parameters for surface roughness like average surface roughness R_z and mean roughness index R_a are not suitable, because of insufficient description regarding to the real surface profile shape [3]. Therefore S parameters are used, which refer to the surface instead of the profile (R parameters). The S_a parameter includes information about the surfaces roughness height and the S_{sk} parameter about the skewness of the amplitude distribution curve of the surface components. A negative S_{sk} value means the maximum of amplitude distribution is above the centre line (fig. 3). It mirrors the structural behaviour of the surface,

because there are only small peaks i. e. plateau shaped. A Ssk value of zero is reached by symmetric distributed surface components.

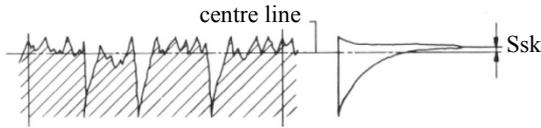


Fig. 3: Representation of a negative skewness (Ssk), according to [3].

3. Results and Discussion

The manufacturing process of all specimens was identical. The functional i. e. the frictional surface was made by conventional final cutting using constant process parameters. In spite of this specification differences in the surface geometry between both material conditions can be observed. The measured Ssk values are nearly zero. They tend mainly to be negative for specimens with temper designation T651 and positive for the ECAP optimized ones. Latter ones have a rougher surface, how the higher Sa values show in tab. 1.

Tab. 1: Surface conditions.

Test condition	T651	ECAP optimized
	before → afterward test	before → afterward test
degreased	Sa: 0.32µm → 1.48µm Ssk: -0.17 → 0.34	Sa: 0.81µm → 2.96µm Ssk: 0.10 → 0.96
lubricated	Sa: 0.36µm → 0.32µm Ssk: -0.01 → -0.29	Sa: 0.57µm → 0.51µm Ssk: 0.13 → -0.18

The surface modification in consequence of the frictional test was independent from the material condition. Following differences were observed between the lubrication conditions. The skewness value Ssk of degreased specimens became positive after the test and the Sa values increased. In contrary, lubricated specimens have reached a negative Ssk value and a slightly decreased Sa value. This means that the peaks are levelled. (tab. 1)

The recorded torque-twisting-angle-diagrams and so the determined friction coefficients do not

differ significantly between the two investigated material conditions, particularly in regard to small differences in surface conditions and test scatter. However there are large differences between the two lubrication conditions (fig 4).

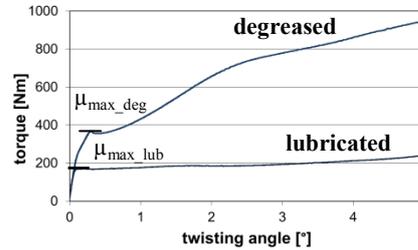


Fig. 4: Torque-twisting-angle-diagram (degreased and lubricated).

As a comparison value the maximum friction coefficient μ_{max} was used, which is defined as a local torque maximum within 0.4° twisting angle. This value decreases over 40 % for lubricated contact in comparison with the degreased. (tab. 2)

Tab. 2: Friction coefficient μ_{max} .

Test condition	T651	ECAP optimized
	μ_{max}	μ_{max}
degreased	0.273	0.257
lubricated	0.156	0.154

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