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Micro plasma cosmos for tuned cast friction

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Lightweight metals become progressively important in different industries such as automotive or machinery, since their application leads to a fuel consumption reduction and, thus, an environmental shielding. To unveil the whole potential of Al alloys in high-loaded applications, the existing surface treatments can be modified by innovative surface technologies. In this study the plasma electrolytical oxidation process (PEO) was optimized to form homogeneous hard, dense and ductile surfaces on eutectic Al casting alloys, which show low coefficient of friction especially in combination with novel low-viscosity oil, accompanied by a long-last wear protection. An additional optimization could be achieved by laser texturing adopting the DLIP (Direct Laser technology Interference Patterning) technology.

Keywords (from 3 to 5 max): friction reduction, PEO, lubrication, motor applications, novel structures

1. Introduction

A special attention should be paid on the optimization of the tribological behavior in the combustion engine system by decreasing the friction and wear losses to achieve an environmental shielding, since 60 % of all automobiles will be still equipped with a combustion engine in 2040, whereas enhanced motor fuels and a mixture of the power train will play an important role [1]. This study deals with nanocrystalline, hard and dense PEO surfaces (plasma electrolytical oxidation) on casting Aluminum alloys with high Si content [2], which results in very wear-resistant surfaces. By adjustable topography and morphology of these surfaces using the Ultraceramic® process [3], positive frictional conditions in the tribological contact can be achieved and especially the wear of the tribological partner can be reduced. Special improvement was achieved by structuring the PEO surfaces using the DLIP method [4]. The impact of different oils and their influence on friction and wear are elucidated by testing with different parameters in a pin-on-disc setup, whereas the findings are correlated with wear mechanisms by using SEM and EDX analysis. Promising results are achieved by testing with novel low viscosity oil, which is developed for innovative engine applications: Here, a significant reduction of the wear on coating and on counter body side could be shown under different testing conditions.

2. Methods

2.1. Materials

In this study two different Al casting alloys were taken into account by performing the Ultraceramic® PEO process on them, which is a ‘green’ technology due to its environmentally friendly electrolyte. Different surface states like native, grinded and polished were examined.

2.2. DLIP

The DLIP technique is based on interference pattern of a spitted laser beam into two or more beams. Therefore, only by one spot a structure can be achieved on the sample surface.

2.3. Friction and wear behavior

The resulting surfaces were tested by a Pin-on-Disc tribometer operating in a linear reciprocal mode by applying different loads, while testing under different motor oils – from high to low viscosity.

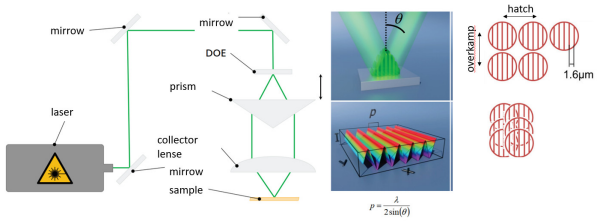

Figure 1: Scheme of the DLIP technique to perform structures on the surface

As an advanced method a ball-on-three-plates combination was used to observe the friction conditions along the Stribeck curves under different temperatures. Furthermore, the resulting wear scares as well as the wear traces on the counter body part were analyzed in terms of the wear coefficient and the ruling wear mechanisms using SEM and EDX techniques.

3. Discussion

In nowadays motor oil (5W30) the PEO surfaces do not show any advantages in comparison with the native eutectic Al surfaces regarding friction or wear on the counter body. Here, a structuring by DLIP of the PEO surfaces leads to an enhancement. On the other hand, the PEO surfaces unveil their full potential in a low-viscosity oil (0W8): Here, the friction and the wear on both, Al sample and steel counter body, can be reduced, which makes the PEO surface on Al casting alloys a perspective technology to be adopted in novel motor applications. A long-term wear test over 500h certifies the Ultraceramic® PEO surface to be long-term wear-resistant by being gentle to the counter body as well.

4. References

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