Friction and Wear of Additive Manufactured Polymers in Dry Contact Application

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1. INTRODUCTION

The working principles and functionality of an additive manufacturing (AM) system which define material properties plays a pivotal role in surface texture definition, accuracy and refinement. As supposed to most polymer processing techniques such as injection molding, extrusion etc., 3d printing affords the flexibility in polymer manufacturing and provides geometrically stable polymer based materials (PBM) for varied engineering applications.
Polyjet additive 3d printing technique as amongst many AM techniques uses a multi piezo-inject printing technology combined with UV-curable materials to accurately and economically produce detailed layer-by-layer PBM with varied chemical, mechanical and physical properties[1].
Their relatively reduced mechanical and structural properties compared with most metallic and ceramic composites, have provided them with an added advantage in tribo pair applications such as lip seals, rollers, ball bearings and artificial joints due to their excellent tribological performance under such conditions [2]. However, depending on the type of AM technique employed in the manufacturing process, material properties such as surface roughness, hardness, and elastic modulus etc., which serves to provide the bulk of the material properties are altered in the process. In theory, a high cross-linked density PBM is crucial in preventing material loss and fragmentation during surface contact in tribological application [3]. However, the effect of print orientation and degree of surface roughness introduces new sets of challenges when characterizing both friction and wear regimes of these PBM, hence providing a good justification to further study the tribological behavior and mechanisms in dry reciprocating sliding contacts.

2. Experimental Method

2.1 Sample Preparation

The ball and plate PBM samples were both prepared to examine the tribological properties of three PBM. A 6.5mm AISI52100 steel ball bearing was used in a multi-functional UMT TriboLab equipment as the counterface body in a reciprocating dry sliding experiment. Two out of the three PBM (3D printed ABS and VeroGrey) studied were produced using the Polyjet®1000 AM machine with dimensions 20mmX15mmX2mm. Moulded ABS polymer of similar dimensions was used as a reference PBM in this experiment.
In this test, the anisotropy of surface finishing giving rise to varied surface roughness properties along (parallel) and across (perpendicular) the print direction. A normal applied load of 1, 5 and 10N and a Stroke length 2mm and a sliding speed of 8mm/s are studied in a 60minute test

3. RESULTS AND DISCUSSION

Results from this study reveal a strong correlation between surface anisotropy effect as a function of time and applied load (Fig.2).Under lower load conditions, the coefficient of friction (COF) along and across the print direction showed varying and distinct friction and wear properties. The COF perpendicular to the print orientation generally showed increased friction values compared with the friction parallel to the print orientation. This is as a result of the increased real contact area resulting in strong adhesion between the surface asperities and the counter surface. Israelachvili *et al*. (2000) noted that, the adhesion-controlled input to the overall friction force is proportional to the real contact surface.

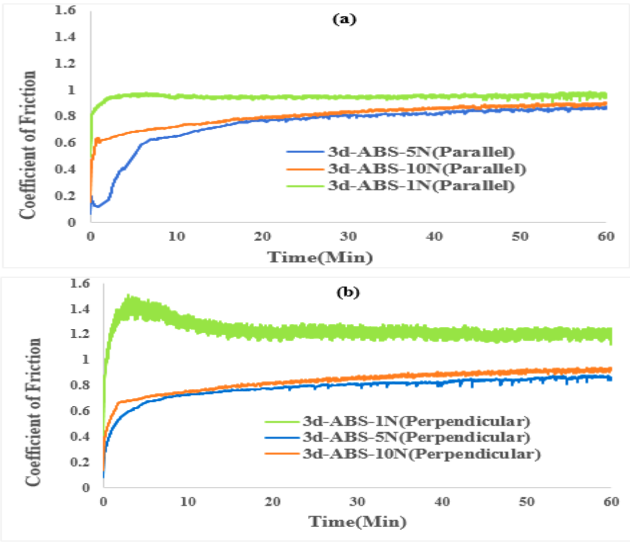

Fig.1 Coefficient of friction results of 3d-ABS under 1-N, 5-Nand 10N of (a) parallel and (b) perpendicular print orientations.

Full report on the tribological test are discussed in the full page paper.

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