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Using tribological principles for a more sustainable grinding process

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The manufacturing process of microfibrillated cellulose (MFC) by means of grinding is robust and reliable. However, this process can reach a higher level of sustainability. This study, therefore, aims to use some tribological parameters -normal load, roughness, sliding distance, sliding velocity and different MFC dilutions- to obtain some recommendations for a more sustainable manufacturing process of MFC. The main objective is to satisfy high friction (which will enhance the breakage of the fibers) but keeping wear as low as possible.

Keywords: micro-fibrillated cellulose, grinding media, friction, and wear tracks.

1. Introduction

Using a stirred media mill, FiberLean Technologies Ltd disintegrate the fibers of cellulose into MFC thanks to a combination of impact, compression and attrition forces caused by the agitation and contact between media beads.[1] This bead-bead contact results in a consumption of grinding media in the process that can be reduced. Therefore, it is crucial to understand the motion of the grinding media to describe the collision of beads.

Different studies have investigated the grinding media motion in the grinding process, using tracking methods or describing the flow with some computational simulations.[2] In this study, tribological parameters will be considered at laboratory scale to study a single bead-bead contact where the main objective is to satisfy high friction, but keeping wear as low as possible.

2. Methods

Friction and wear have been evaluated carrying out sliding reciprocating motion between bead-substrate contact. The friction experiments were carried out using the ForceBoard™ (Industrial Dynamics AB, Sweden), a universal friction and force tester equipped with one horizontal and one tangential load cell. Then, the Coefficient of Friction (CoF) was extracted. Different parameters, shown in table 1, were studied using the friction tester.

Table 1: Parameters modified in the experiments.

Normal load, N	1-9
Roughness surface, R_a	1-3
Sliding distance, mm	50-1600
Sliding velocity, mm/s	1-20
MFC slurry dilutions, %fiber content	0.07-2.80

After the friction experiments, the obtained tracks in the substrates were quantified with the averaged penetration depth using a non-contact optical method, White Light Interferometry (MicroXAM2, OmniScan).

2.1. Results

The CoF values and the averaged penetration depth are evaluated to discuss the effect of every tribological parameter on the system. Figure 1 shows an example of one of the parameters studied. In figure 1, the results suggested that normal load has a significant effect on friction, but not necessarily the same effect on wear.

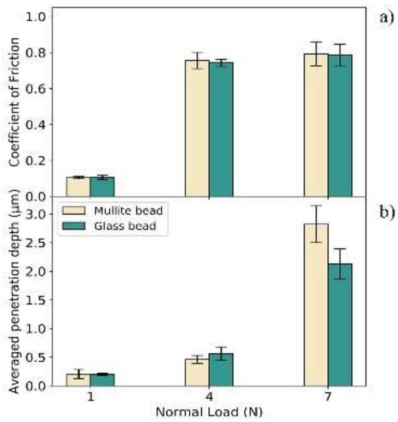

Figure 1: The effect of normal load on a) friction coefficients and on b) averaged penetration depth, for mullite and glass beads.

3. Discussion

From the results, we can learn that an increase in the normal load results in a significant increase on friction. The increase in friction is associated with a change in the surface morphology: high asperities may be fractured, surface may mate better, and wear occurs; producing wear tracks in the substrates. After analyzing the penetration depth of these scratches, we can observe that, as the normal load increases, there is an exponential growth in the penetration depths.

Other variables have been studied such as roughness, sliding distance, sliding velocity and different fiber content dilutions of MFC. The results for all the parameters studied helps us to understand the behavior of single bead-bead contact to set some initial conclusions which will be verified in the near future using a laboratory grinder.

4. References

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