Tribology for the Future: Biomimetism and Surface Engineering

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ABSTRACT

While Mechanics can be considered as the science permitting the solids to support forces by contacts, Triblogy is the science, which permit the motion of solids. Tribological processes are always dissipative; a friction force is opposed to the motion and then creating an energy loss. As a consequence, engineers are always trying to lower the friction force in order to decrease the energy losses. This objectives associated to a search of increasing the lifetime of mechanical systems are in fact a challenge for the future Tribologists. Considering some systems from the nature can help to find some interesting ideas for surface engineering.

1. Introduction

The word Tribology was defined in 1968 but the "tribology" fact is very old. As soon as men for their daily activities used the contact between solids and motion, the tribological problems were present: friction force and wear, with their negative consequences.

At first, Tribology was not considered as a problem but people optimize the tribological systems step by step by performing simple dedicated experiments. An example is shown Fig. 1.

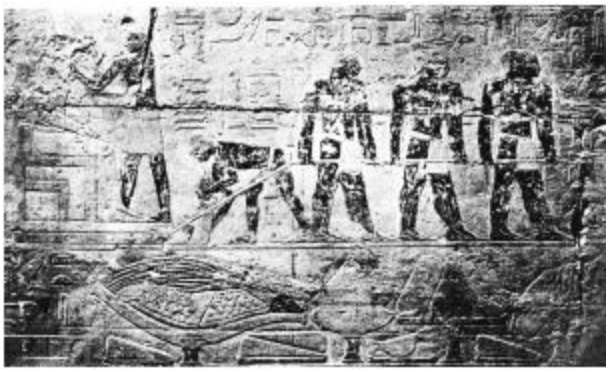

Fig. 1 Already at the Egyptian time lubrication was used to decrease the friction force. (transporting the statue of Ti – from a tomb at Saqqara – 2400 B.C.)

Then, people realize that contact between solids and friction exists and that friction and wear is a consequence of the interaction between the surfaces of matting solids. More sophisticated experiments where then developed in order to have information on friction and wear.

After that, the society was more and more developed for mechanical systems and tribological problems were more and more studied. It was then considered that material nature is important for the behavior and performances of tribological systems.

Surfaces appear after this period to be also a determinant factor… and then scientists were studying more and more the surfaces in order to find some way to improve their behavior (Fig. 2).

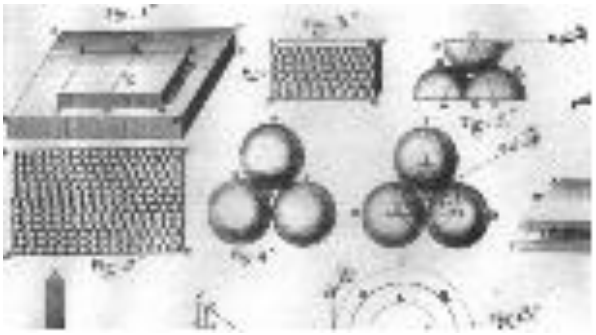

Fig. 2 In 1737 Tribologists begin to consider that the surface topography is an important parameter for friction processes. Belidor, a French scientist, represented the surface geometry using some ideal spheres.

The more simple was first to develop surface treatments in order to modify their mechanical properties; then various surface heat treatments were invented to form at the surface of metals some ompound with higher mechanical properties than the substrate. After, more complex strategies were developed to protect a solid surface by a coating with particular nature, structure and properties (see an example Fig. 3). Consequently, the tribological behavior is considered to be related to the behavior of coated surfaces. Of course, the adherence of the coatings appeared to be very important. In this period, very numerous coatings were investigated: hard coatings, soft coatings, multilayer coatings, composites coatings… always now, this strategy of protecting a sliding surface by a coating is under investigation in order to develop new and high-performence solutions.

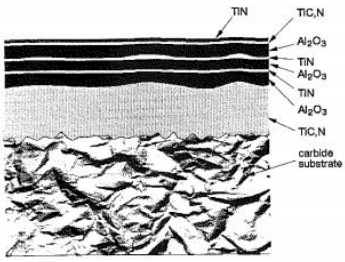

Fig. 3 An example of a multilayer coating for protecting cutting tools (cross section observed with a SEM).

More recently, surface topography was a parameter becoming of the first interest. Studies are trying to understand the relationships between surface topography and friction force and surface damage (Fig. 4). Machining surfaces with conventional machines was investigated: it becomes important to know what is the effect of machining parameters on the characteristics of the machined surface. Particular surface treatments such as sand blasting where used to modify the surfaces.

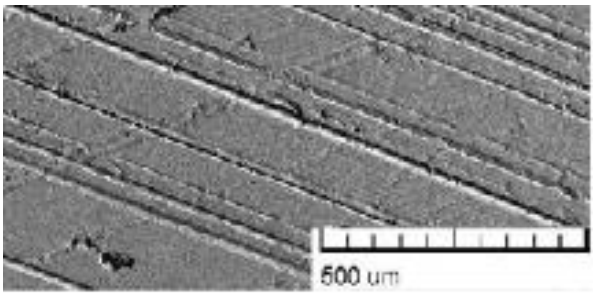

Fig. 4 Surface topography used for the sliding internal surface of diesel engine liners. Scratches with various sizes, which can act as lubricant reservoir and wear particles retainer, compose the particular roughness, manufactured by Honing.

With the development of machining technologies, scientists try to manufacture textured surfaces at a scale being smaller and smaller. Currently, the femto second laser can be considered as one of the most sophisticated machine tool for modifying surfaces; it can be used to create networks of very small holes in order to improve the behavior of surfaces in lubricated conditions (Fig. 5).

In a parallel way, the nature was in fact also optimizing the things in order to adapt them to a function. The structure, the materials and the surfaces are naturally designed in order to present the desired function: adherence, friction noise, mechanical resistance, wettability, colors, … many examples can be considered for this (Fig. 6).

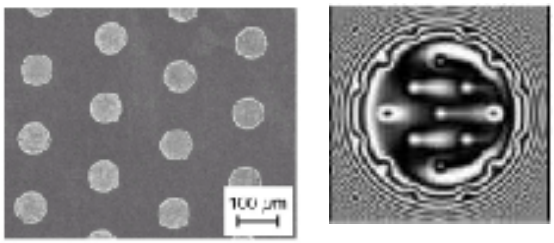

Fig. 5 Laser texturing can be used for tribology: creation of small dimple on a surface (left). This particular topography modifies the lubricant film formation in the case of elastohydrodynamic lubrication (right: result of modeling the film thickness).

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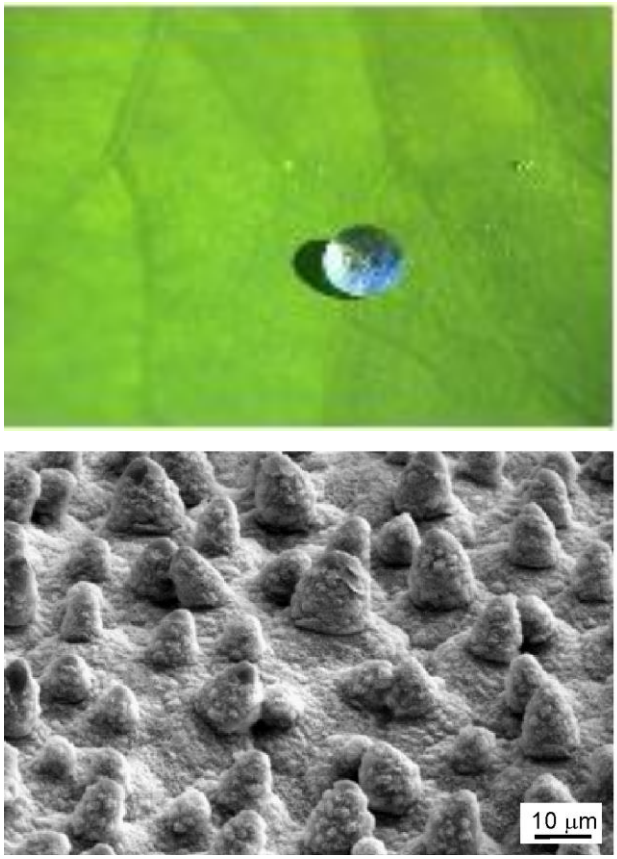

Fig. 6 Observation of a water drop on a Lotus leave (top) showing the super hydrophobicity created by the roughness and nature of surface (SEM picture, bottom).

Then, scientists and tribologists considered the idea of biomimetism. They try in fact to imitate the nature to have some particular function. But now, it is very important to think about the real challenges in the field of Tribology.

2. Future Trends in Tribology

Nowadays, Tribologists have developed a lot of effort to understand tribological processes with the use of high-performent equipements and complex modeling. Predictions are then more and more present but it is always necessary to continue theses efforts.

The present challenges are to develop mechanical systems with high output (low friction losses) and long lifetime. In the field of automotive industry, this challenge has also to be completed by considerations on production costs, recyclability and ecology.

With these aims, surface modifications represent a very attractive strategy. The development of new surface coatings and new surface topography is always a key problem for the future. We have for this to consider not only scientific progress in the field of surface science but may be interesting ides can be found in the nature to optimize a surface for a given purpose.