Study of Sliding Contact of Layered Surfaces

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Abstract

Tribology, one of the applied sciences in mechanical engineering which studies friction, wear and lubrication, contributes in the effort of minimizing wear and loses due to contact between two surfaces. Tribology is an essential technology for most of industries due to the impacts on energy efficiency, machine life, engine design, maintenance schedules and machine downtime. In the medical area, tribology is also critical to the long term mobility, healthy and the quality of life of patients with for instance replacement joints. An energy efficiency which is related to green technology is an important issue nowadays. However, it appears that possibilities to save energy by reducing the losses due to wear and friction have not sufficiently been taken into account in a large number of countries, especially in the developed-countries. It can be said that through tribology strategies for energy conservation can be reached. Industry could savings 1.5 % of GNP for the UK from better tribology application, based on the report made by Jost in 1966. It was a surprising value at that time. The number can be larger at this moment after considering the increasing of the use of the components in mechanical systems. A value at the same level is expected for Indonesia if the better tribology technology is applied.

Running-in, as a part of the tribology science, has a significant role in the reliability of mechanical components. Running-in occurs in the first period in the life-time of a rolling or sliding contact of a lubricated system. The running-in phase cannot be avoided in any mechanical system in which moving parts are present. For this, the running-in behaviour of surfaces has to be understood to be able to give guidelines to industry how to produce in a simple way their surfaces.

The long term project in the Laboratory for Engineering Design and Tribology, Department of Mechanical Engineering UNDIP focuses on the research of running-in of rolling-sliding contact system. Study of the layered surface becomes important related to the running-in because the layered surface contributes specific surface roughness. The specific surface roughness controls the running-in process.

One of the effective ways to improve the tribological properties of the contacting surface during running-in is by laminating or coating the surface with thin layers. The layers which can be deposited from several nano to a few microns are designed to control the surface roughness. The appropriate initial surface roughness, produced by good design of the thin layers, can contribute in reducing the friction and the wear rate in the running-in process and, as a result, prolong the component life.

It is important to realize that the mechanical contact between solids is localized to micro-scale contact spots that together form the real contact area. The contact pressure in these tiny areas is of the order of their hardness irrespective of the nominal contact pressure. Bearing this in mind, it is not surprising that damage can occur even in apparently very mildly loaded tribological contacts. One such example is the damage occurring on ceramic seals in sliding contact despite the nominal contact pressure being a hundred thousand times lower than their hardness. A layered surface can fail

prematurely due to the detachment, delamination, cracking and/or spalling of the coating material. The present research will obtain the situation where the coating/layer, the substrate and the interface show a good performance during the sliding contact.
The conventional way to determine the layered surface behaviour is by performing experiments. The different material pair of the thin layer/film, coefficient of friction and load will show a different state of the stress distribution, the contact pressure, and the wear. The experimental research on layered surface requires a large number of experiments and the costs are enormous. Due to the difficulty in making precise measurements and the lack of the measurement setup in Indonesia, numerical method is the best approach to study the behaviour of the layered surface contact system. Therefore, in this project, finite element analysis (FEA), as one of the useful numerical tools, will be used to solve the problem in the present study.
Different arrangement of the thin film, i.e. layer/film thickness and the structure of the layer, will be used as the variable in the sliding contact simulation. The commercial finite element software package ANSYS is used for the simulation. Several geometrical models will be used for the simulation based on the previous results from the research conducted in the Laboratory for Engineering Design and Tribology UNDIP. Variations of load, below and beyond the critical load, are applied to the contacting layered bodies. The critical stress distribution, strain, contact pressure, and deformation due to sliding contact on the layer, the substrate and the interface will be reported. Finally, the optimum model for the layered surface is presented where stresses, pressure and strain is satisfactory in preventing damage of the layer due to sliding action.

Key words: layer, coating, elastic-plastic, contact mechanics, sliding.