Japan Academy Prize to:

Yukio HORI
Professor, Vice President,
Kanazawa Institute of Technology
Professor Emeritus,
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and

Koji KATO
Professor, College of Engineering,
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for "Studies on Tribology"

Outline of the work:

The friction law between solid surfaces was studied by Leonardo da Vinci and later by Amonton and Coulomb, and its empirical law was established by the year 1800. Quantitatively, it was explained during the period 1920-50 by Bowden and Tabor, who used the adhesion theory of micro asperity junctions. The mechanism of hydrodynamic lubrication, which is necessary for reducing friction, was experimentally clarified by Tower in 1883 and was mathematically formulated by Reynolds in 1886. Many lubrication problems have been solved since then by using Reynolds' theory, including the lubrication analysis of reciprocating bearings by Yokobori in 1945.

On the other hand, rotating machinery, the speed of which increased rapidly in the first half of 20th century, incurred a problem of violent shaft vibrations (oil whip) at a shaft rotary speed of over twice critical speed caused by oil film action of the bearings. This prohibited further increases in shaft speed and length for many years. In the same period, a strong demand grew for higher reliability as machines became more complex to perform higher level functions. As a result, the 1950's saw a rapid increase in studies on the wear law of solids, which confirmed the macroscopic wear law and elucidated the microscopic mechanisms involved. The need to integrate science and technology related to friction, wear and lubrication into one discipline was strongly recognized, so a new term "tribology" was introduced as an interdisciplinary concept in Britain in 1966.

Amidst this trend, Dr. Hori's oil whip theory not only clarified for the first time the essence of the oil whip phenomenon but provided the criterion for stable shaft operation at speeds higher than twice critical speed. The shafts of today's large generators are operated at speeds of 5 to 6 times critical speed. He also pointed out for the first time that such a shaft is in danger of suddenly incurring oil whip caused by an earthquake or other large disturbance. To counteract this, he introduced a "dynamic" anti-earthquake design method. He also solved other important problems relative to a stable limit cycle of the shaft center in a linearly unstable domain and a stable rotating shaft supported by floating bush bearings. He also made large contributions to analyses of temperature rise and turbulence in lubricating films. He

published these results in a book titled *Ryutai Junkatsu* (Yokendo 2002), translated into English under the title *Hydrodynamic Lubrication* (Springer 2006).

Dr. Kato clearly showed the micro-mechanisms of slip initiation at the micro asperity junction by introducing a visualization method of interface slip, and he explained the generation mechanism of the static friction coefficient. He clarified the relationship between microscopic wear mode and wear particle morphology by making in-situ observations using a scanning electron microscope that he developed. The results of this work are widely used in monitoring the condition of large power plants in Japan. He also created wear maps by correlating microscopic wear modes and the friction coefficient, which made wear mode prediction possible for the first time. In addition, he introduced a new lubrication method, called *tribo-coating*, which is under practical development after having undergone an exposure test in space. His discovery of low friction phenomena of carbon nitride coatings in an N_2 atmosphere shows good promise as a new lubrication method. Much of his research has been applied to practical use, including water lubrication of ceramics for pumps and an ultrasonic friction drive for semiconductor testing devices.

The above-mentioned achievements by Dr. Hori and Dr. Kato have provided many of the fundamental theories undergirding the tribology discipline, and they advanced milestone research across a vast array of related fields, including power generation, manufacturing, information science, environment and space technology. Their work has been highly appraised by academic and industrial circles both inside and outside Japan. For these achievements, they have received many awards and prizes, including the Japan Society of Mechanical Engineers Awards (3 times), the Japanese Society of Lubrication Engineers Award, the Tokyo Metropolitan Merits (Science and Technology), the Medal with Purple Ribbon (Shijuhosho) and the Order of the Rising Sun, Gold Rays with Neck Ribbon (Kyokujitu Chujusho) to Dr. Hori, and Best Paper Award of American Society of Mechanical Engineers (ASME), the ASME Mayo D. Hersey Award, the International Award of Society of Tribologists and Lubrication Engineers, the Jacob Wallenberg Award of Royal Swedish Academy of Engineering Sciences (IVA) to Dr. Kato, who was also selected as a Foreign Member of IVA.