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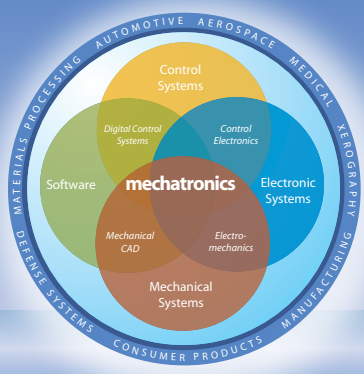
MECHATRONICS IN DESIGN

FRESH IDEAS ON INTEGRATING MECHANICAL SYSTEMS, ELECTRONICS, CONTROL SYSTEMS AND SOFTWARE IN DESIGN

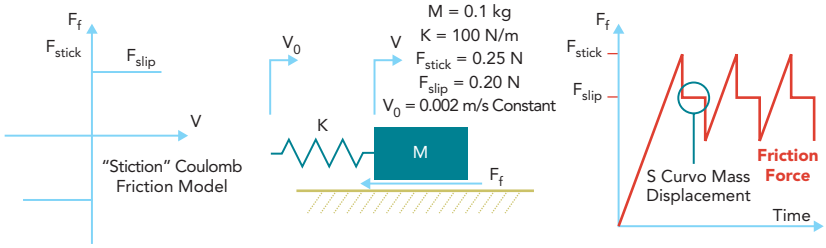


Friction Fundamentals and Accelerating Cars

In elections it's always the economy; in engineering it's always the fundamentals

Friction may well be nature's most useful phenomenon. Without friction, walking would be impossible and there would be no belt drives, no clutches, no wheels and no brakes. However, in machinery in which it is not the driving force, friction is an undesirable parasitic effect, generating heat, causing wear and wasting energy. So whether the goal is to reduce friction or enhance friction, the proper combination of geometry, materials and lubrication must be employed in a design, i.e., a proper tribological approach. Tribology is the study of friction and wear and it has been estimated that the correct application of tribology throughout U.S. industry could save the country $500 billion annually.

We have all read about the problems with uncontrolled acceleration of automobiles due to faulty accelerator pedals. Friction has been identified as the likely culprit and the proper combination of geometry, materials and lubrication will lead to a solution. Why did this happen? It is certainly too early to answer that question with any certainty, but I do know that most engineers, including mechanical engineers, do not fully understand the friction phenomenon. Failure to understand the fundamentals of such a pervasive physical effect is bound to lead design failures, some of which might be catastrophic.



Stick-slip motion is a common behavior associated with friction. A typical stick-slip experiment is to attach one end of a spring to a block sitting on an unlubricated horizontal surface. The other end of the spring is moved horizontally with a constant velocity. How will the block move? Of course it is highly dependent on the physical system parameters, but one possible outcome is stick-slip motion, as shown in the figure above. When the spring force exceeds Fstick, the mass accelerates, the spring elongates and the mass comes to rest. The process then repeats, creating the stick-slip behavior. A model used to describe the friction phenomenon must be able to show this behavior. The automobile accelerator pedal relies on a balance between the return-spring force and sliding friction, which could vary over time due to wear and contamination, to perform effectively and safely.

In the automobile electronic accelerator pedal assembly — electronic because when the gas pedal is depressed, a sensor tells the car to accelerate — it is essential to have a certain amount of friction to make it easier for the driver to maintain a steady throttle setting and also to reduce fatigue from pushing against the pedal return spring continuously. The designed-in friction is meant to simulate the intrinsic friction that is present in a traditional throttle cable as it passes through the cable housing. If the friction is excessive, the pedal return spring cannot return the pedal when the driver's foot is removed — the pedal sticks in the partially open position. Changing the friction characteristics will of course change the accelerator feel for the driver. In addition, if wear or contamination is allowed to occur and change the friction characteristics, not only will the pedal feel change, but the safe operation may change as well. The original problem and proposed solution for a major manufacturer, Toyota, can be viewed online at http://designnews.hotims.com/27742-XXX.

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The Toyota pedal assembly includes a shoe that rubs against an adjoining surface during normal pedal operation. As discussed above, due to the materials used, wear, and environmental conditions, these surfaces may, over time, begin to stick and slip instead of operating smoothly. In some cases, friction could increase to a point that the pedal is slow to return to the idle position or stick, leaving the throttle partially open. A solution is to insert a spacer that will reduce the friction between the friction shoe and the adjoining surface, thus eliminating the excess friction that can cause the pedal to stick.

In a mechanical design, a proper tribological approach, i.e., geometry, materials and lubrication, must be taken to ensure safety, performance, and energy-efficient operation.

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