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Friction is the way of nature

When we get real close, all surfaces are rough and pointy and raging with hell-fires of electrical fields, says S.Ananthanarayanan.

Smooth surfaces are smooth only up to the point of the irregularities that we can detect and measure. But the actual surface cannot be smoother than the shape of atoms, of which all things are made.

Atoms in ranks and files

Atoms are mostly empty space – a blob of positive charge at the center and a collection of tiny, negatively charged electrons whizzing around, some near, some far. The distances are all thousands of times the sizes of the particles, with empty space in between. But, for all that, the distances themselves are so small that in the vicinity of the charged particles, the electrical fields dwarf those in a bolt of lightening!

Atoms, which are these fuzz-balls of charge, can neither get too close to each other nor too far. When seen from a distance, the whole atom is neutral, but at close quarters, the negative charges in the electron cloud of one atom start repelling the like charge of the electron cloud of the other atom. And in metallic things, usually, the cloud borders get fuzzy and some electrons are shared. This makes for ‘marriages’ and the atoms are not able to easily separate.

Atoms then settle into ‘best fit’ shapes in rows and columns or in pyramids or other interlocking shapes, as crystals. But the orderliness is at the large scale. Close at hand, the atoms are agitated and in constant vibration, like a spring bed next to a power drill.

Clumps of crystals

Most materials consist of a multitude of tiny crystals packed close together. Crystals usually have a variety of planes through which they can be cleanly cut (called shearing planes) and several bits of crystal can fuse cohesively into a firm block of the material. Polishing the material then consists mainly of cutting off the protruding portions of crystals along shearing planes in the same direction, which is possible to a lesser or greater extent, depending on the material.

In the case of compounds of different atoms, like marble or quartz, or stones, which are oxides or silicates, the crystals are somewhat complex and the polished surface in not necessarily fully uniform. But in the case of pure metals, the clumps of atoms have many shear planes and metal surfaces can usually be polished very well. Metals are thus even more ‘ductile’ and can be ‘shaped’ while polishing, where a protuberance here could ‘flow’ into a depression there, to create a smoother surface.

Friction and Lubricants

But for all the polishing, metal surfaces in contact cannot slide over each other without shears and lacerations, which show as heat and friction. A liquid interface generally helps, by holding the rough edges apart. The liquid itself is not rigid, as it has not solidified to form crystals, and can flow instead of resisting motion. Liquids with different degrees of viscosity are suitable as lubricants for different pairs of surfaces.

A material like graphite consists of crystal-like sheets, one on the other. Finely ground graphite is sometimes used as a lubricant. The sheets then slide over each other and help the things move, like a sled helps going quickly over snow.