What is Friction and What Does it Have to do with Rubber?

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How many times have you heard "What is an O-ring?" Without knowing it, O-rings are used in so many things in our daily lives and we just aren't aware of it. Friction is the same way. We rely on friction in our daily lives. For instance, friction is what keeps our tires glued to the road so your vehicle doesn't slide out of control. Tires without friction would be like driving on ice. I know, many of you are thinking "What about walking on ice?" It's the same thing, we rely on the friction between the soles of our shoes and the ground to keep us from slipping. By now I am sure the wheels are turning in your head and you're probably thinking of many other examples where the friction, or lack of friction, between two surfaces benefits us.

Friction is a force that opposes the movement of one object against another. There are three type of frictional forces, static, limiting and kinetic.

Static friction is the friction acting on and object when there is a force applied to the object while it is not moving. Lets explain this. Take an O-ring, or something that is not very slippery, and put it on a desktop. With your hand start to push on the o-ring in the direction you want it to slide without actually making it move. Now you are applying a force on the O-ring and it is not moving. Why? Because static friction is opposing the force you are applying to the O-ring. The frictional force is stronger than the force you are applying to the O-ring preventing it from sliding.

Limiting friction is the friction acting on an object just before it begins to move. This is often called breakout friction or its breakout point. Limiting friction is usually the highest friction, meaning, it usually takes more force to get something moving than to keep it moving. Lets explain this further. Ok, you should still have your hand on your O-ring and applying a force to it without making the o-ring move. Now, gradually increase the amount of force you are applying to the O-ring until it starts to move. Did you notice that once the o-ring started to move it required less force to keep it moving than it did to start it moving. Try it again but pay attention to the amount of force you are applying to the o-ring until it starts to move. The point just before the O-ring starts to move is called the limiting friction. It is were the frictional force is at its highest, usually.

Kinetic friction is the friction acting on an object while it is moving. To explain this one lets do a little comparison. You felt the frictional forces on the o-ring as you applied force to it while it was moving--right? Now, do the same thing to a piece of ice that you did with the O-ring. You will find that it takes less force to slide the ice across the desktop than the o-ring. This is because there is less kinetic friction between the ice and the desktop than the O-ring against the desktop. There is less frictional force opposing the ice moving on the desktop than the O-ring. Parents, this sounds like a pretty cool science fair project huh?

Friction is originated from *electromagnetic forces* and *exchange forces* between atoms and molecules. Electromagnetic forces and exchange forces (strong force) are two of the 4 fundamental forces, strong force, electromagnetic, weak force and gravity. Exchange force is any force that has to do with the exchange of particles. Technically all 4 forces can be classified as an exchange force.

Electromagnetic force is the force which holds the atoms together and keeps the electrons from flying off somewhere away from the atoms nucleus and also holds the atoms together to form molecules. You probably heard the phrase, “Like charges repel, opposite charges attract.” Two positive or two negative particles will repel while a positive and a negative particle will attract. Atoms are made up of neutrons (neutrally charged), protons (positively charges) and Electrons (negatively charged). The nucleus contains the protons and neutrons. The electrons travel around the nucleus in orbits similar to the planets in our solar system revolve around the sun. Neither the planets or electrons fly away because they are held in place by exchange forces. Electrons by the electromagnetic force and planets by gravity or gravitational force. It is the electromagnetic force that also keeps atoms together in molecules and causes an attraction or repulsion between two atoms.

Strong force (exchange force) is a fundamental force that acts on the nucleus of and atom. It is the force that binds particles together to form the neutrons and protons in the atom. The strong force is the strongest force. It can cause two protons to hold together despite the fact they are both positively charges and want to repel due to the electromagnetic force. The attraction of the strong force is stronger than the repulsion of the electromagnetic force.

So what do these forces have to do with friction? Certain molecules are going to attract to each other increasing frictional forces and some molecules repel reducing frictional forces. Lets look at what some call the most slippery material on earth – polytetrafluoroethylene (PTFE) or commonly referred to by its trade name Teflon®. PTFE is a long string of carbon atoms joined together with two fluorine atoms attached to each carbon atom. Fluorine, when attached to a molecule doesn't like any other molecule around it. It repels any other molecule even other molecules with fluorine atoms, hence its low coefficient of friction or slipperiness.

Coefficient of Friction

Lets say while you are sliding the O-ring across the desktop and you slide it through some grease left over from your french fries at lunch and suddenly the o-ring moves very easily with little force. You just modified the frictional coefficient or “Coefficient of Friction” with a lubricant. The same thing can be done to O-rings or rubber parts to reduce the coefficient of friction. 3 things can be done to reduce the coefficient of friction on rubber parts. You can coat the surface with a lubricant, add an internal lubricant to the compound, or modify the surface with fluorine, also called surface modification.

A lubricant can be applied to the surface of a rubber part to reduce the coefficient of friction. Some of the more common lubricants are silicone, molybdenum disulfide(MoS2), talc (baby powder), graphite, carnuba wax. These are temporary and do not stay on very long. They are primarily used to make installation easier. The surface can be coated with a polytetrafluoroethylene (PTFE or more commonly called Teflon®). PTFE coating is a thin layer of PTFE applied to the surface and them baked on in an oven. This is a little more permanent but can wear off or be scratched of the rubber. PTFE coating is not only used to reduce the coefficient of friction but the coatings are available in several colors which makes for great part identification on assembly lines. Another method of surface coating rubber is called chlorination. The rubber is introduced to chlorine gas which causes micro cracks on the surface which holds an external lubricant. This method is more permanent than PTFE coating.

Another method of lubricating rubber is to add a lubricant to the rubber compound as it is being mixed.

The internal lube will slowly leach to the surface over time. This is great for dynamic applications where the rubber seal is moving during its use. Common internal lubricants are carnuba wax, PTFE, molybdenum disulfide (MoS2), graphite.

The newest method of reducing the coefficient of friction is “Surface Modification.” In this method the hydrogen atoms that are bonded with carbon atoms on the surface of the rubber are replaced with fluorine atoms. Remember fluorine above in the PTFE? When fluorine is bonded to a molecule it doesn't like other molecules -- It repels them making the molecule slippery. Also, fluorine is the most electronegative element. Electronegativity is the atoms ability to attract and share electrons with other molecules. What this means is once the fluorine atom bonds with the carbon atoms in the rubber molecule it doesn't easily come off making this process superior. The surface modified rubber can be used in dynamic applications where the O-ring moves and needs to maintain a low coefficient of friction surface that won't wear off.

Satori Seal can provide O-rings and seals with low coefficient of friction properties by any of the above methods. Please call on of our friendly customer service representatives at 800-322-8366 and they will be glad to assist you.