On dry lubricants in ski waxes

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1. Introduction

The friction mechanisms playing an important part at the sliding interface of a slider and snow is both dry and wet friction (Karlöf L. and others, 2005). The most dominant friction that occurs is a mixed friction phenomena, i.e. both dry friction and wet friction (Barnes and others, 1971). The area under the ski and board where dry friction occurs is the dominant contributor to the total friction (Evans and others, 1976).

$$m_{dry} \geq m_{wet} = m_{tot} \tag{1}$$

In general ice and snow is a “slippery” material and this is mainly due to the special material characteristics of ice, i.e. low shear strength, relative high values of hardness, even close to its melting point and the phenomena of surface melting, a thin liquid like layer developed at the surface of a solid at temperatures below the bulk transition temperature, i.e. melt temperature.

Dry friction occurs due to deformation, fracture and yielding of asperities in two contacting surfaces during sliding ref. Thus, by introducing an agent between the two sliding surfaces with lower strengths in the direction of shear the deformation energies will be lower and the friction due to deformation may be reduced. This is what is achieved when a fluid is introduced between to sliding surfaces i.e the wet frictional part.

Clean snow is made up of many snow crystals, thus the layer on which we ski obey the properties as described above. Contamination of snow can be both due to soluble and insoluble dirt. Soluble dirt changes the chemical properties of the snow. An example of this is salts that may change the melt temperature of the snow, which results in a relatively thicker layer of lubricating water. Insoluble dirt is everything else that is accumulated on the snow surface, it can be both hard macroscopic particles, residues from kick wax or non-soluble atmospheric dirt. When the snow is contaminated its mechanical properties are changed. This means that the tribology that describes gliding on snow needs to be revised i.e. the knowledge about waxes and wax selection is changed. Additives like solid lubricants may help to reduce the friction imposed by the contamination, in particular by solid particles.

2. Mechanisms causing reduction of friction by solid lubricants

When gliding on snow, two of the more important properties of ski wax is to create an hydrophobic surface, repelling water, and a surface that adapt the hardness of the ski base to the underlying snow. When gliding on a dirty snow surface a third element is introduced. This element does not show the properties of snow. Therefore the properties of ski glide wax working on clean snow needs to be supplemented by a third one. Under such circumstances it may be useful to introduce an agent in the ski wax that adapts to the contamination, especially the hard insoluble contamination. At each point where gliding on particulate contaminants occurs the probability of dry friction is increased. Since contacts of the dry friction contribute most to the total friction it is important to find a way to lubricate these areas. Solid lubricants are especially suited for dry friction reduction.

The idea behind solid lubricants is that the lubricant has large compression strength but low shear strength. The compression strength aid in separating the two gliding elements (Fig. 1) and the low shear strengths lower the total energy needed to move the elements which causes a reduction in friction. Common solid lubricants like graphite, molybdenum disulfide or boron nitride show these characteristics.

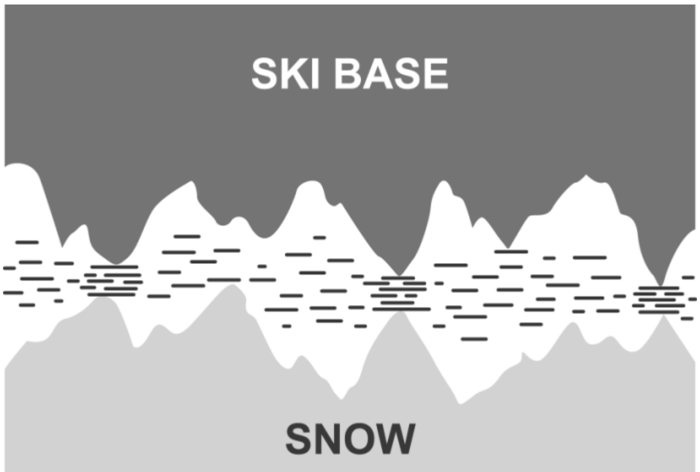

Figure 1. Detail of two sliding surfaces. Where asperities are in contact they either has to deform or one of them will yield. By introducing a solid lubricant a separation of asperities is achieved. If the separating material has lower shear strength than the asperities the deformation energy is reduced resulting in lower friction.

An analogy to such materials is a deck of cards (Fig. 2). The cards can take considerable pressure when a downward pressure is applied but they slide when a transverse force is applied.

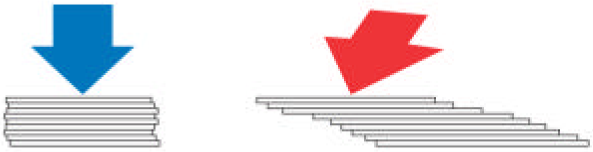

Figure 2. The concepts of solid lubricants as depicted by a deck of cards, uni-directional force is supported whereas for transverse forces the material shear easily along its slip planes.

3. Physical description of solid lubricants commonly used in ski waxes

Below is a summary of physical properties of commonly used solid lubricants:

- Low friction coefficient.
- High lateral strength, low transverse strength. Between highly loaded surfaces the lamellar structures of solid lubricants prevent contact. In the direction of motion the lamellas/layers shear easily over each other. The reason for this is that the distances between the atoms in the hexagonal crystal structure are larger between the layers than within the layer (Fig. 3.). This holds for the two common solid lubricants Graphite and molybdenum disulfide.
- Polytetrafluoroethylene (PTFE) is another example of a solid lubricant used in ski waxes. Unlike to the other solid lubricants mentioned PTFE does not have a layered structure. The PTFE molecules rather slip along each other similar to layered structure.
- They all perform well in a humid environment
- Good mixing capabilities with ski and board wax

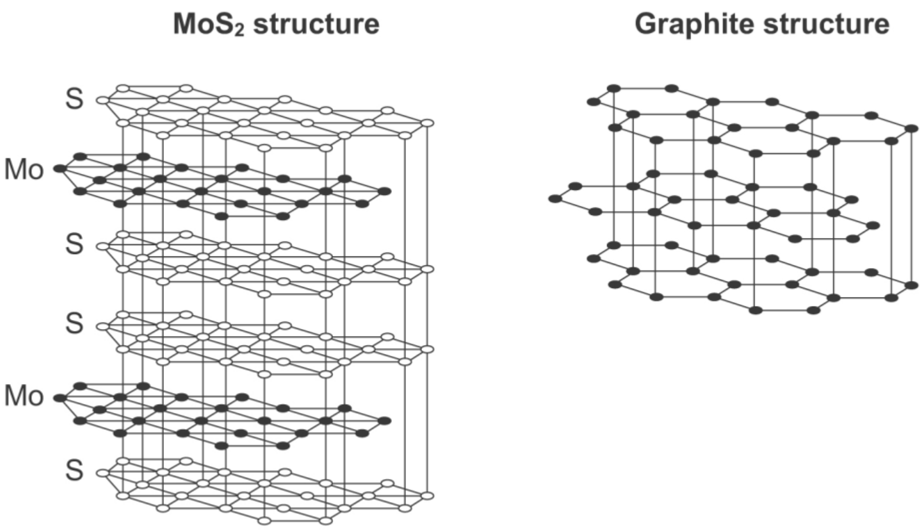

Figure 3. Molecular structure of molybden di-sulfid and graphite, two commonly used solid lubricants.The layered like structure has considerable downward strength and lower shear strength.

4. Concluding remarks

Swix BD waxes contain solid lubricants. These waxes have proven to work well on old coarse grained snow, dirty snow and abrasive man made snow. The snow crystals of old coarse grained snow have few asperities that easily can yield. At low temperatures when the lubricating liquid water layer is poorly developed the deformation of the snow crystal is slow which means that snow is hard and not as slippery which gives higher friction. Dirty snow containing particles other than ice increase the friction because the particles have not developed a lubricating layer of water. The abrasive manmade snow also increases friction. All these examples require another lubricating material than normal ski wax. Thus under such circumstances is ski and board waxes with a solid lubricant as an additive the wax to prefer.

Figure 4. A situation where solid lubricants will improve your ride, guts and attitude.

References

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