SKI FRICTION AND THERMAL RESPONSE

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The low friction encountered in skiing is a result of the friction-heating-melting process associated with a slider moving over snow (Bowden and Hughes, 1939, Proc. Roy. Soc. Lond., A172, 280). This process creates a thin meltwater layer that reduces the area of solid-to-solid contact between the snow and the gliding surface of the slider. This theory has recently been quantified (Colbeck, 1988, J. Glaciol. 34, 78). It is the testing of this theory that is presented here.

The temperature distribution was measured in two downhill skis: a child's ski and a Rossignol DH racing ski, incorporating 5 and 32 thermocouples, respectively. During ski runs, the temperature in the skis was recorded once every one or two seconds to determine their transient response. The thermocouples were strategically located so that transverse, longitudinal and vertical temperature profiles could be measured. The thermal response of the metal edges in the racing ski was also recorded.

Results show that temperature rises of 5 or 6°C were obtained even for short, gentle runs. This indicates a strong thermal response to the heat of friction. The following observations were also made:

1. Figure 1 shows quite clearly that the ski base has thermally stabilized near the melting temperature. This suggests that the melting temperature is the limiting temperature of the ski/snow interface during skiing.

2. Figure 2 illustrates the phase-lagged, amplitude-damped thermal response of heat propagating up through the ski.

3. Figure 3 depicts the influence of alternating load on heat generation. As load increases, temperature increases.

4. Heat generation increases as the ambient temperature decreases. This is because it is harder to form a meltwater layer at low temperatures, so friction remains high.

5. Temperature increases from the front to the rear of the ski. This is a result of accumulating heat.

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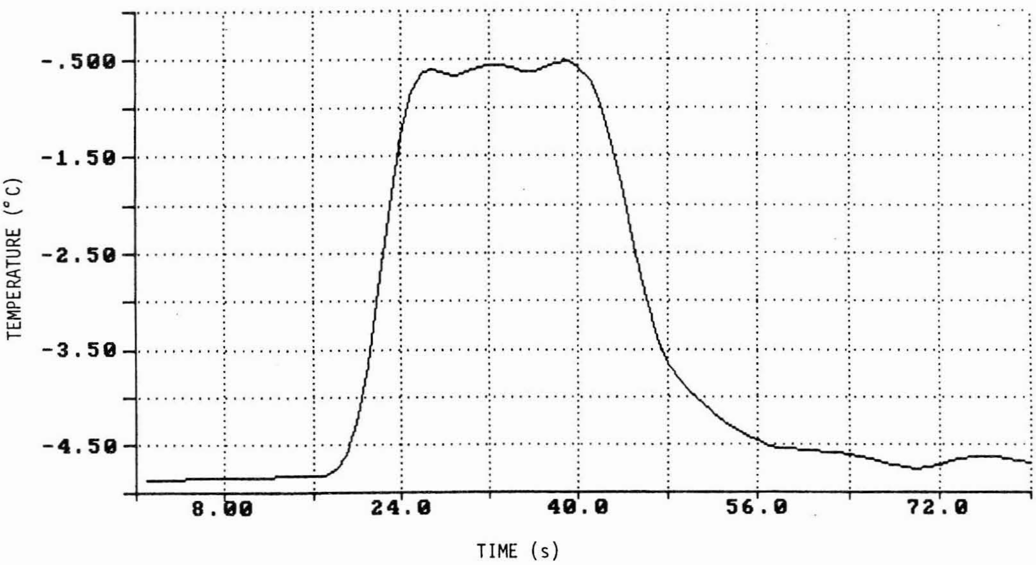

Figure 1. Response at base of ski.

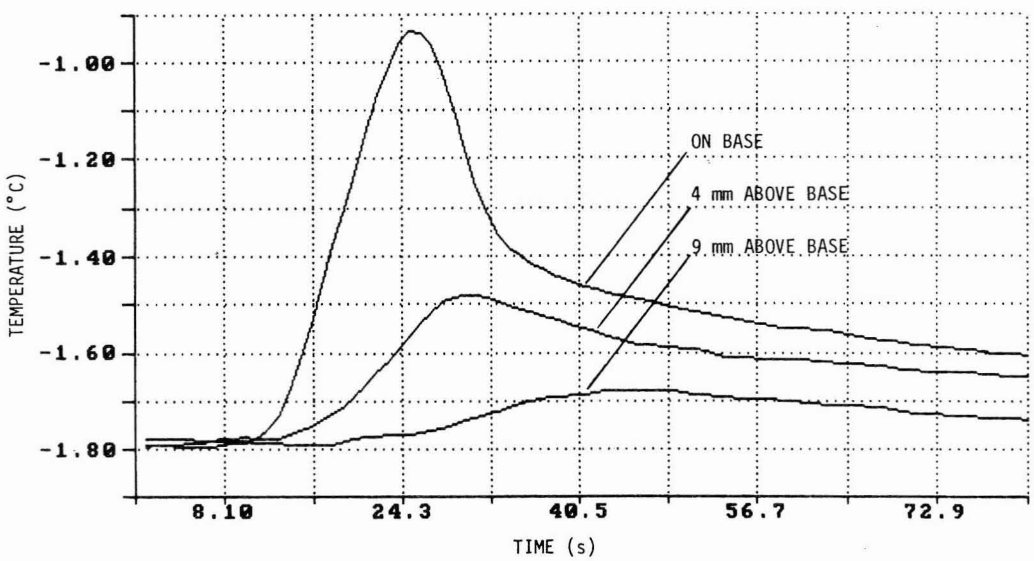

Figure 2. Response of vertical profile.

6. A skier in a downhill (tuck) position distributes his/her weight non-uniformly across the ski.

From these observations, it is clear that there are a number of variables (not all of which have been discussed here) that control the heat generation in a slider. We also conclude that a meltwater layer does indeed exist at the ski/snow interface, but that it is not uniform. Further evidence suggests that this meltwater layer is influenced by the thermal properties and the geometry of the slider. Owing

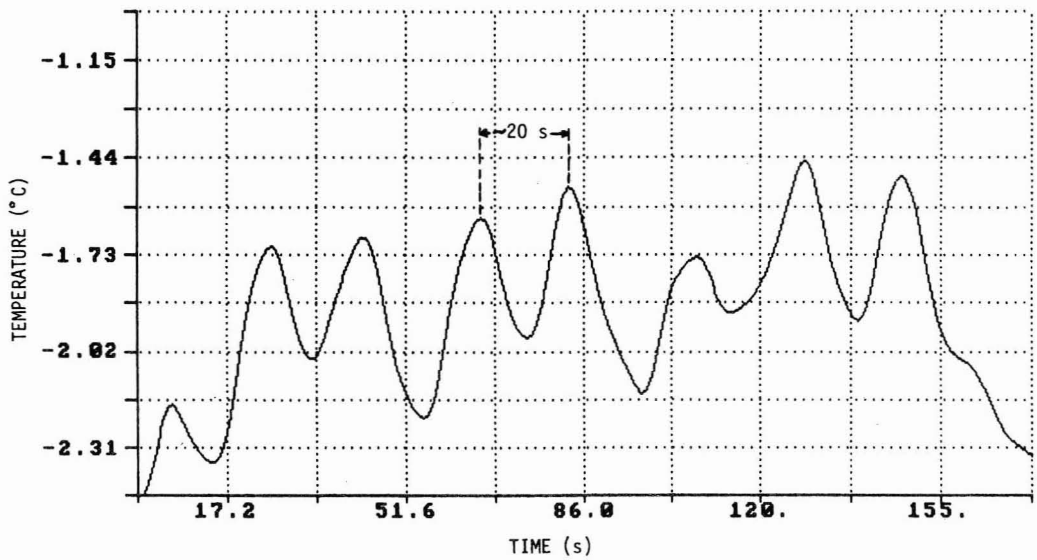

Figure 3. Loading and unloading with a ~ 20 s cycle.

to the complex structure of the racing ski, the heat flow within it is quite complicated and an understanding of the heat flow pattern would aid in determining the meltwater thickness distribution. It is the optimization of this water film that will reduce frictional resistance and enable skiers to go faster.