What we have to do to make our skis glide faster?

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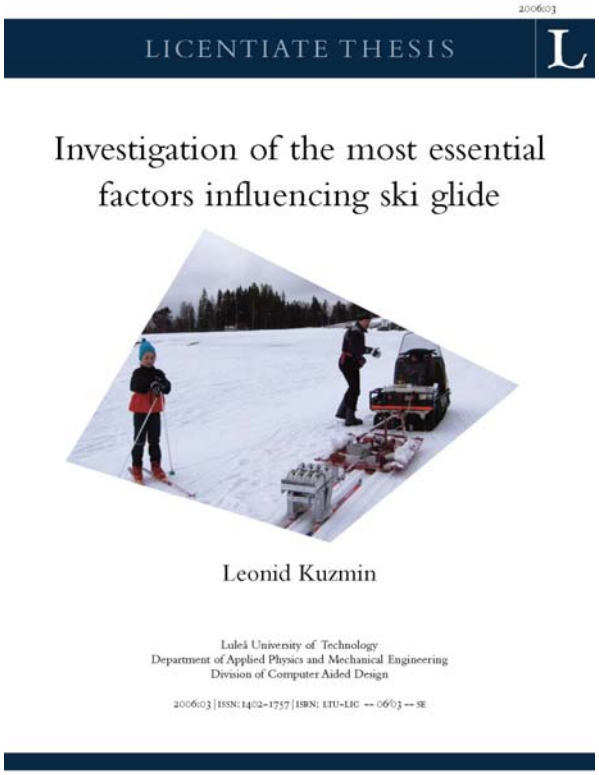
Or, to put it more precisely. What we do not have to do to make our skis glide faster?

Two revolutions are occurred at last century.

1917

2006



and reactions,

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TV4

Discovery CHANNEL

and reactions

KURIREN

Glidvallning helt onödig enligt Kuzmin

LULEÅ, KURIREN.

Forskaren Leonid Kuzmins avhandling, där han hävdar att glidvalla oftast är överflödig, väcker upprörda känslor hos både skidåkare och tillverkare av valla.
Vissa hot har också framförts, framförallt mot Mittuniversitetet, där han bedrivit sin forskning.

– Folk från ett stort vallaföretag har pratat med min dekanus, och sagt att om jag inte slutar med mitt arbete ska de förstöra universitetets renommé. Det tycker jag är ett märkligt sätt att reagera på seriös forskning. Man borde istället komma till mig direkt och framföra argument mot mina forskningsresultat, säger Kuzmin till Norrbottens-Kuriren.
Reaktionerna har också fått Luleå tekniska universitet att tänka på säkerhetsfrågor i samband med att Leonid Kuzmin den 9 februari lägger fram sin licentiatuppsats, och håller licentiatseminarium vid universitetet i Luleå.

Our guiding thread

Why is ice and snow slippery?
The Tribo-physics of skiing

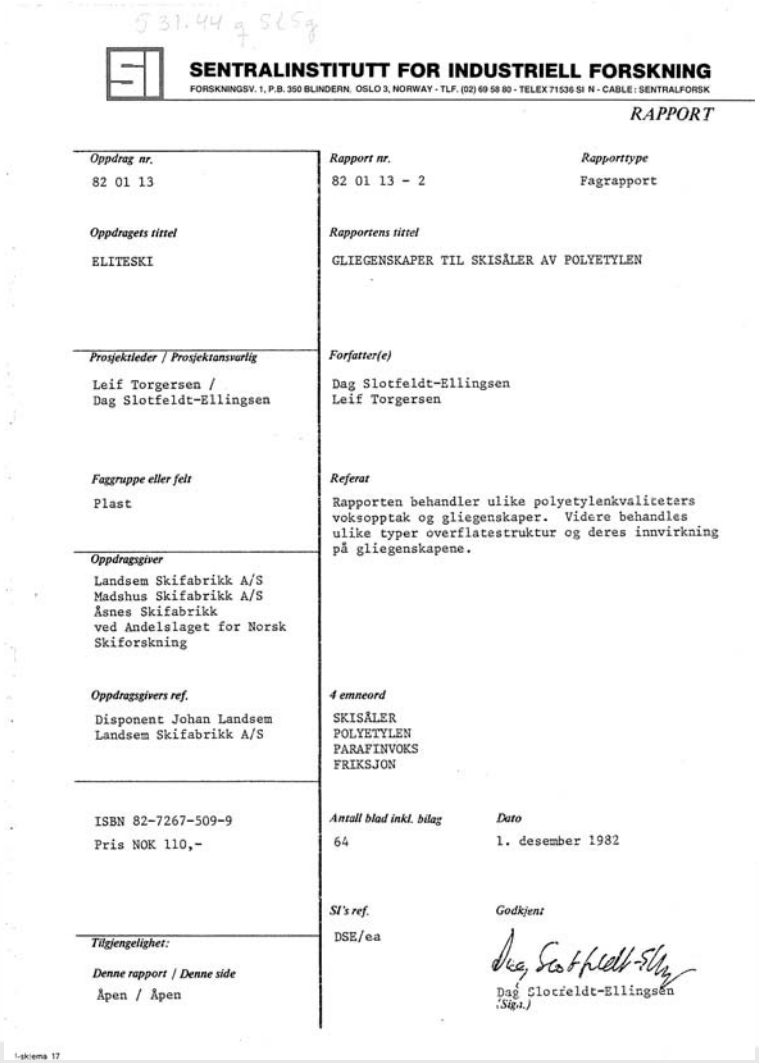
Lars Karlöf[1], Leif Torgersen Axell[1], Dag Slotfeldt-Ellingsen[2]

[1] Swix Sport AS, Research and Development, Servicebox, 2626 Lillehammer, Norway.
[2] SINTEF, Box 124, 0314 Oslo, Norway.

In memory of Martin Matsbo (1911-2002)

Oslo, 30. September, 2005

One classified research



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RAPPORT

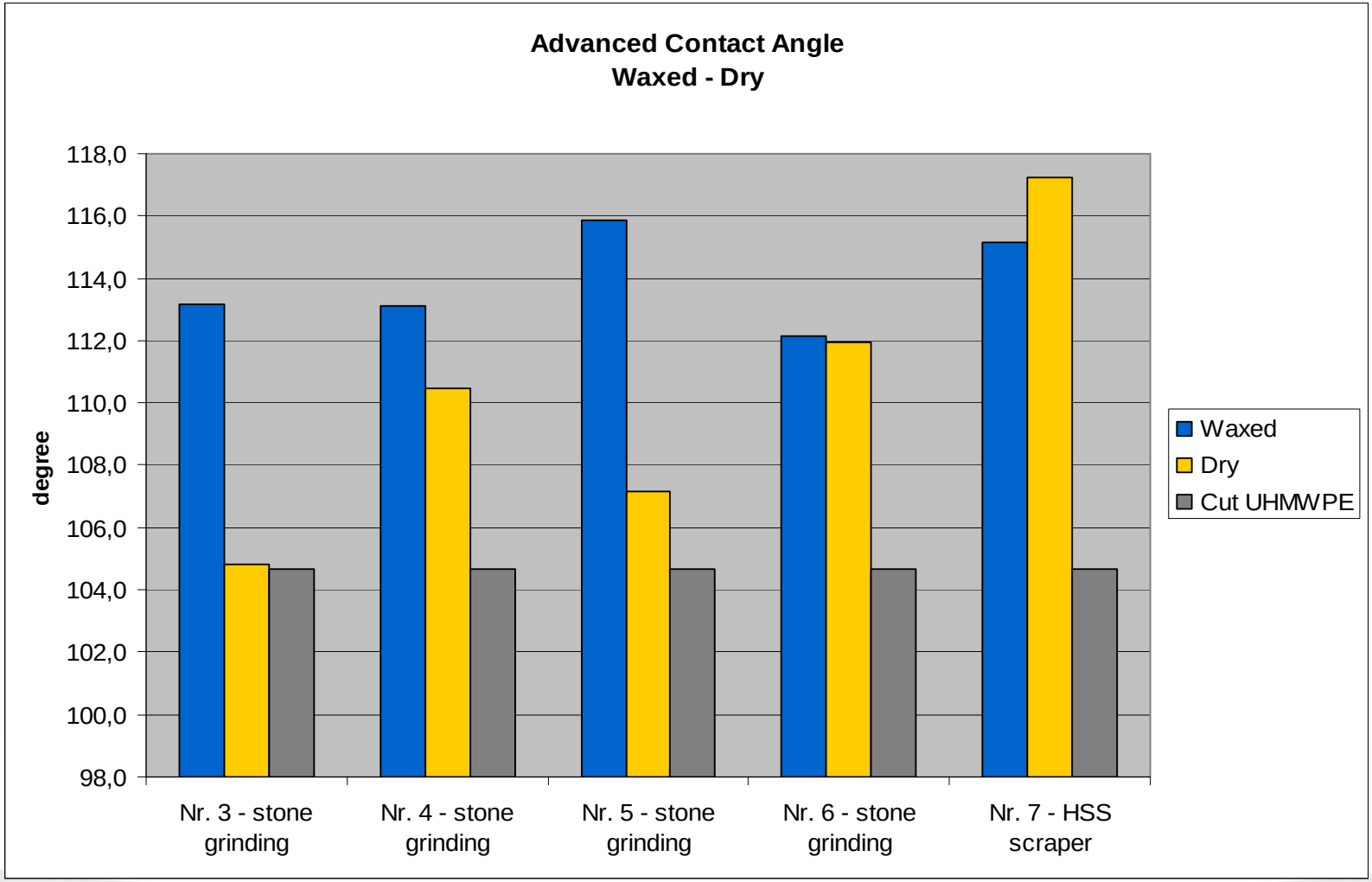
Oppdrag nr. 82 01 13	*Rapport nr.* 82 01 13 - 2	*Rapporttype* Fagrapport
Oppdragets tittel ELITESKI	*Rapportens tittel* GLIEGENSKAPER TIL SKISÅLER AV POLYETYLEN	
Prosjektleder / Prosjektansvarlig Leif Torgersen / Dag Slotfeldt-Ellingsen	*Forfatter(e)* Dag Slotfeldt-Ellingsen Leif Torgersen	
Faggruppe eller felt Plast	*Referat* Rapporten behandler ulike polyetylenkvaliteters voksopptak og gliegenskaper. Videre behandles ulike typer overflatestruktur og deres innvirkning på gliegenskapene.	
Oppdragsgiver Landsem Skifabrikk A/S Madshus Skifabrikk A/S Åsnes Skifabrikk ved Andelslaget for Norsk Skiforskning		
Oppdragsgivers ref. Disponent Johan Landsem Landsem Skifabrikk A/S	*4 emneord* SKISÅLER POLYETYLEN PARAFINVOKS FRIKSJON	
ISBN 82-7267-509-9 Pris NOK 110,-	*Antall blad inkl. bilag* 64	*Dato* 1. desember 1982
	SI's ref. DSE/ea	*Godkjent:* Dag Slotfeldt-Ellingsen (Sign.)
Tilgjengelighet: *Denne rapport / Denne side* Åpen / Åpen		

The research from 1982, but is actual even today.

Pages 14-15 in our guiding thread

- The purpose of ski wax is to reduce adhesion forces, to reduce surface tension, and to prevent ploughing by adjusting the slider base hardness to the hardness of the snow;
- For example, by applying harder waxes the slider surface hardness is increased;
- Further, by making the surface more hydrophobic, adhesion is reduced at the contact points;

The steel scraped ski base is very hydrophobic without any glide wax



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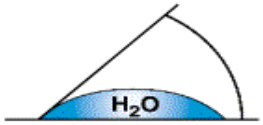
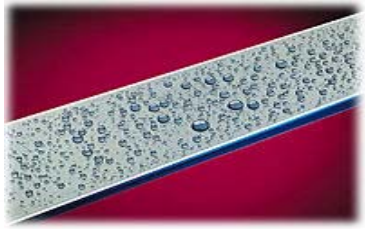
Very interesting values of contact angle on *http://www.swix.no/NorD413.htm*

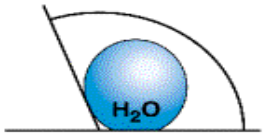
SÅLE PREPARERT MED TRADISJONELL GLIDER



Vannets kontaktvinkelen er mindre enn 90°.

SÅLE PREPARERT MED CERA F



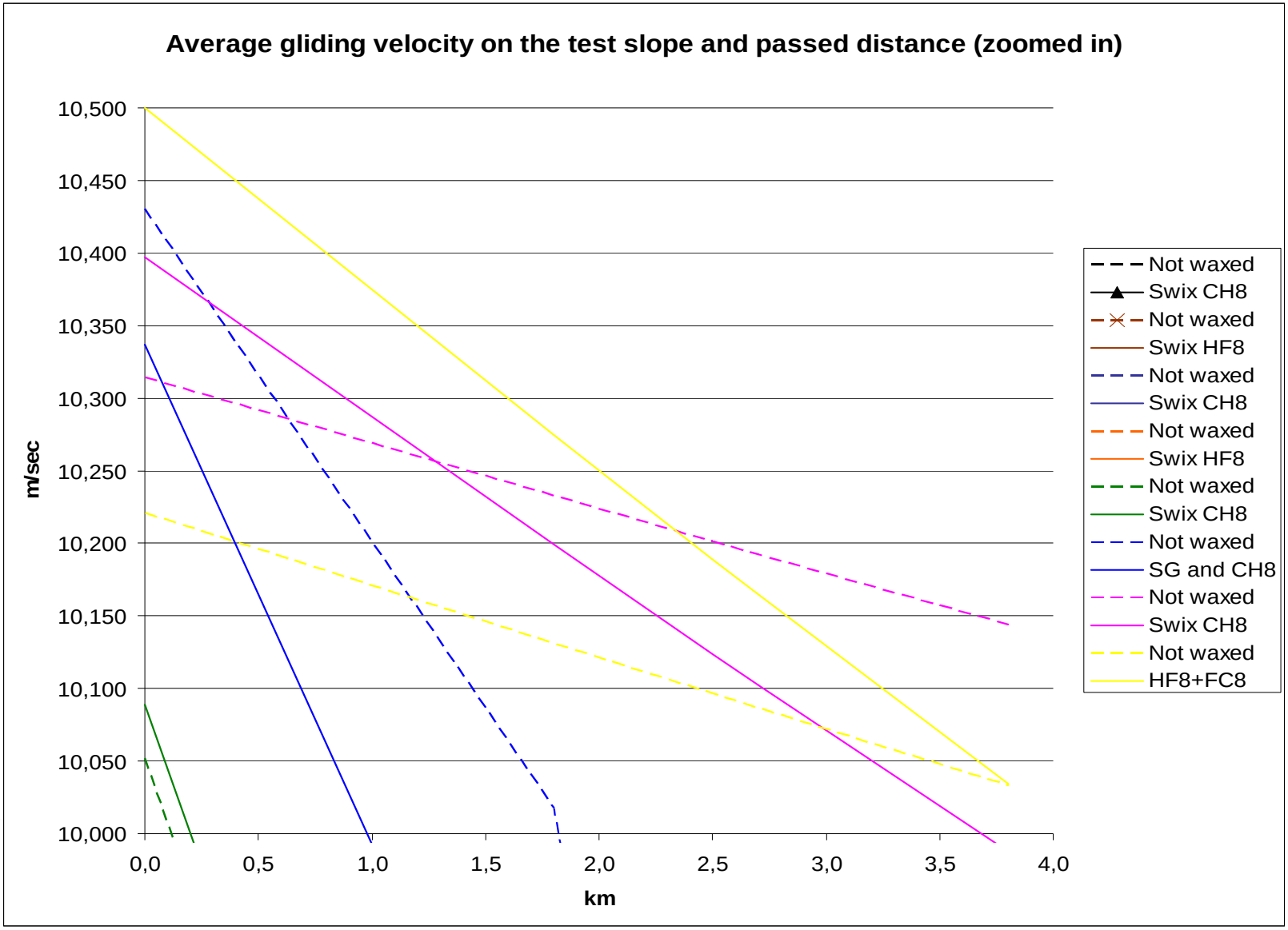


Vannets kontaktvinkel er større enn 90°; gir mindre friksjon mellom såle og snø.

Page 11 in our guiding thread

- In fact, PE is one of the polymeric materials having the lowest surface energy (more hydrophobic). Only fluor-polymers have lower surface energy.

That agrees very well with our results (http://epubl.ltu.se/1402-1757/2006/03/LTU-LIC-0603-SE.pdf, Paper A).


Average gliding velocity on the test slope and passed distance (zoomed in)
10,500
10,450
10,400
10,350
10,300
10,250
10,200
10,150
10,100
10,050
10,000
m/sec
0,0
0,5
1,0
1,5
2,0
2,5
3,0
3,5
4,0
km
Not waxed
Swix CH8
Not waxed
Swix HF8
Not waxed
Swix CH8
Not waxed
Swix HF8
Not waxed
Swix CH8
Not waxed
SG and CH8
Not waxed
Swix CH8
Not waxed
HF8+FC8

One classified research page 55

Vi har studert hvordan smuss fester seg på gliflaten på en normalt vokset for- og bakski.

Undersøkelsen viste at smusset fester seg i ujevnheter på skisålen (hakk, groper, riper, hår, ruglete flater osv.). Våtføreskiene bør derfor under forhold med mye smuss overflatebehandles på en måte som gir en mest mulig glatt flate. Sålen bør være hard og slitesterk.

The above means that the very hard ski base with a minimal roughness should absorb less dirt under wet snow conditions. That agrees very well with our results (http://epubl.ltu.se/1402-1757/2006/03/LTU-LIC-0603-SE.pdf, Paper B).

Extremely close turning point

	Time of descent [sec]	
Number of 100 m descent	Nr. 60 - Do not waxed	Nr. 59 - SG and CH8
1	9,567	9,529
2	9,573	9,716
3	9,623	9,778

Stone grinded skis waxed with Swix CH8 after 5,3 km. Air temperature +7,7°C.

The steel scraped ski running surface is not smooth, quite the contrary

Ski and kind of treatment	Contact Angle	Ra	Rq	Rz	Rt
Nr. 3 Stone grinding - pattern 1A. Dry.	104,83	3,66	4,52	31,69	41,33
Nr. 3 Stone grinding - pattern 1A, CH8.	113,14	3,19	4,13	28,79	33,80
Nr. 4 Stone grinding - pattern 1B. Dry.	110,48	4,75	5,72	31,46	35,26
Nr. 4 Stone grinding - pattern 1B, CH8.	113,14	4,78	6,08	35,08	36,84
Nr. 5 Stone grinding - pattern 2A. Dry.	107,18	2,76	3,51	26,10	31,62
Nr. 5 Stone grinding - pattern 2A, CH8.	115,88	2,73	3,49	23,94	26,50
Nr. 6 Stone grinding - pattern 2B. Dry.	111,92	3,12	4,02	27,48	30,14
Nr. 6 Stone grinding - pattern 2B CH8.	112,15	3,07	3,89	24,78	29,63
Nr. 7 Treated with HSS scraper. Dry.	117,26	4,60	5,71	32,11	34,69
Nr. 7 Treated with HSS scraper, CH8.	115,17	3,75	4,64	28,91	33,03

- Ra is the average roughness, Rq is the root-mean-squared roughness, Rt is the peak-to-valley difference, and Rz is the average of the ten greatest peak-to-valley separations on the sample.

Page 25 in our guiding thread

- Since ice is harder than PE in most temperatures and has a larger change in hardness as well one of the purposes of wax is to adjust the hardness of the sliding surface to match the hardness of the snow.

Our measurements:

STAR Ski Wax (NA):	Hardness - Shore D
0°/-4°C	13,90
-2°/-6°C	28,40
-4°/-12°C	40,10
-8°/-20°C	48,60
P-Tex® 2000	64,20
P-Tex® 4000	67,30
P-Tex® 5000	68,60

May one softer substance to enhance the hardness of one harder substance?

- In consideration of recommendations to wax ski many-many times;
- In consideration of different hot boxes;

We decided to carry out one simple experiment

Our simple experiment

Soft glide wax
STAR NA
0 - -4°C

Melted by
106°C

Hard glide wax
STAR NA
-8 - -20°C

Melted by
128°C

Our simple experiment

- P-Tex® 2000 specimens from the pool with soft wax and Shore® S1 Portable Digital Durometer

Visible result

After 22 hours in soft glide wax STAR NA 0 - -4°C melted by 106°C

After 22 hours in hard glide wax STAR NA -8 - -20°C melted by 128°C

Measuring result

Base	Hard glide wax STAR NA -8 - -20°C		Soft glide wax STAR NA 0 - -4°C	
	After 15 s		After 15 s	
	Hardness Shore D		Hardness Shore D	Weight [g]
Graphite	64,0		64,8	5,806
Transparent	62,2		62,0	5,467
	After 22 h		After 22 h	
Graphite	47,3		44,1	12,038
Transparent	47,0		57,2	7,012

The tested base samples have become much softer and very fragile. The material is fully unusable as a ski running surface.

One classified research page 15

Det er imidlertid viktig å merke seg at hvis man i stor grad smelter materialet og "fyller det" med parafinvoks, vil de mekaniske egenskapene (slitestyrke o.a.) bli drastisk redusert.

- The above means that after glide wax saturation, ski base lose the excellent mechanical properties dramatically. Which agrees very well with our simple experiment.
- QED.

Page 14 in our guiding thread

- During sliding, first the thin wax layer at the surface wears off, then the “stored” wax in the base is “sweating” due to a reversed diffusion process and supplies the gliding interface with lubricating material

A simple calculation

Distance covered $D = 10 \text{ km} = 10^4 \text{ m}$

Ski breadth $b = 40 \text{ mm} = 4 \times 10^{-2} \text{ m}$

Glide wax thickness $h = 10 \text{ µm} = 10^{-5} \text{ m}$

Glide wax volume $D \times h \times l = 0,004 \text{ m}^3 = 4 \text{ l}$

We need 4 litres of glide wax for one ski to built 10 µm thick paraffin film between ski running surface and snow during 10 km glide. Is it realistically?

One classified research page 16

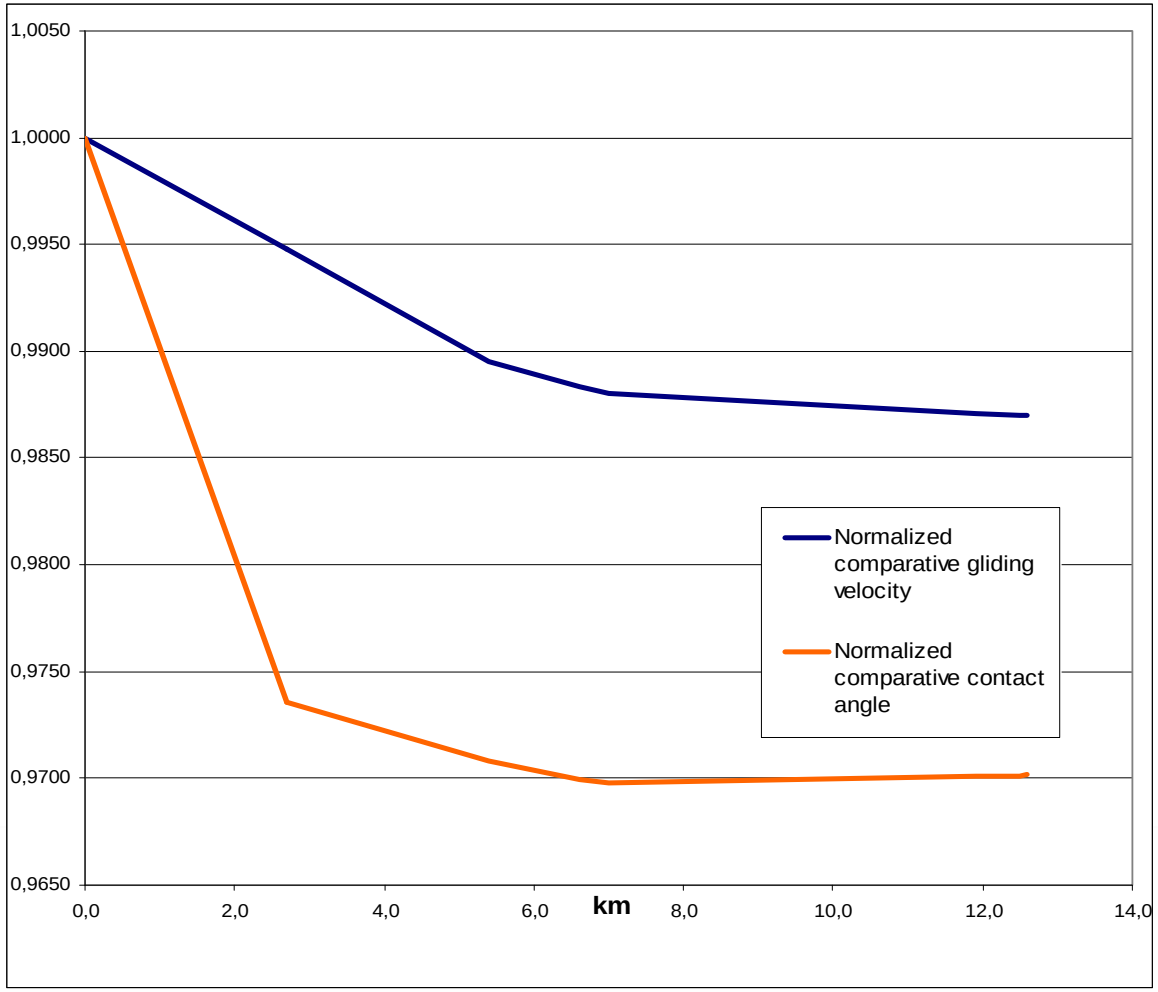
Man tror at graden og hastigheten av denne "utsvettingen" har betydning for glien når det ytre vokslaget er slitt vekk. Da sikre undersøkelser om disse forhold ikke er utført, er man imidlertid henvist til spekulasjoner på dette punkt.

The above means, there is no research which supports the “sweated wax” theory.
In consideration of all foregoing, it is hard to understand, why we apply the glide waxes on our skis.

Is stone grinding and waxing an optimum procedure?

- Dry stone ground surfaces have a low contact angle, much lower than the scraped surface (104,83° compared with 117,26°).
- Wax **has to be** applied to the stone grinded surface, that ever increases the attraction of dirt to the ski base.
- We may suppose that the manual scraping resulted in some kind of randomly rough surface.

Velocity and contact angle relative to distance on dry snow.



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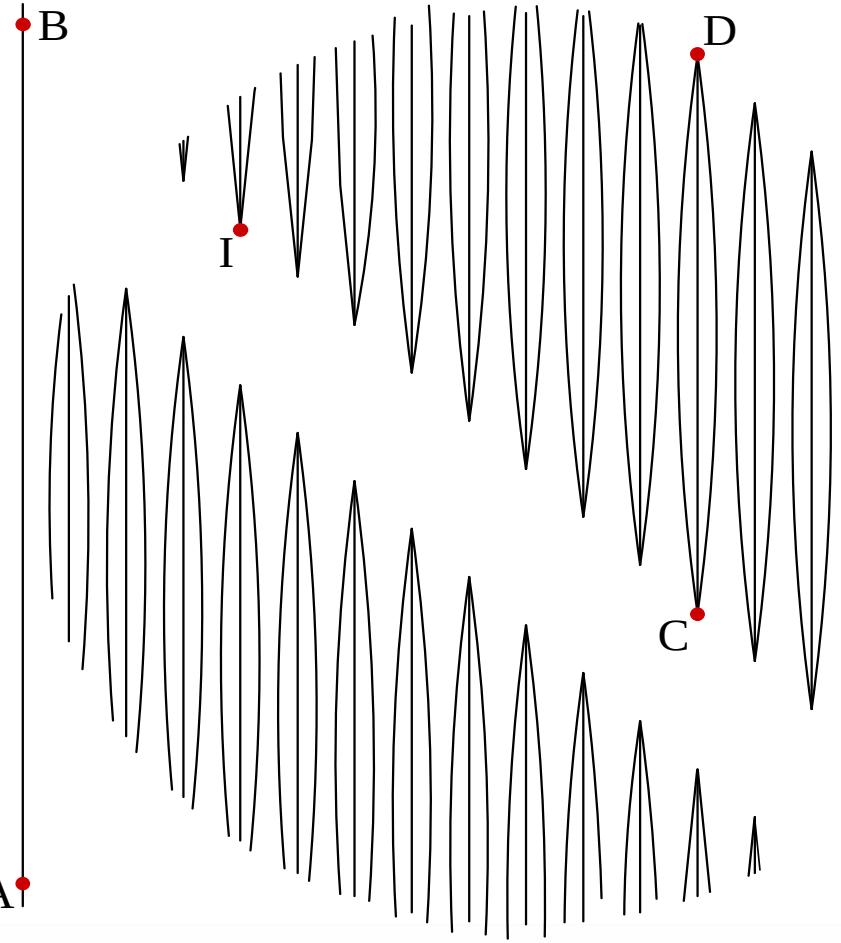
Discussion – dry snow.

- From our results we can draw the conclusion that the waxed (Star NA6) skis lose their glide ability faster than the reference skis (scraped skis).
- In (D.C. Sun, 1996) described accelerated ageing of UHMWPE at a heating rate of 0.6°C/min to 80°C for either 11 or 23 days. This was considered to be equivalent to 4 to 6 or 7 to 9 years of ageing, respectively.
- From above we may see that heat impairs useful properties of the ski base.
- **Our hypothesis: the glide wax wears out quickly and then the ski running surface that has a poor glide ability gets in contact with the snow.**

Patterns orientation

- The minimum pattern element is always parallel to the long side of the ski, the line C-D is always parallel to the line A-B (long side).
- Ski wax technicians are talking about Λ-structure, V-structure and X-structure, but such structures (pattern) only exist as an optical illusion when many small elements follow line C-I, which is not parallel to A-B.
- A transverse structure should be beneficial at low temperatures, whereas a longitudinal structure should be better at high temperatures
- This limitation makes SG processing as deteriorative ski glide procedure under cold weather conditions.



Glide waxing of skis is not a sanative treatment, not at all

Exposure to Ski-Wax Smoke and Health Effects in Ski Waxers

M. Dahlqvist,[A] R. Alexandersson,[A] B. Andersson,[B] K. Andersson,[B] B. Kolmodin-Hedman,[C] and H. Malker[D]
[A]Department of Work Science, The Royal Institute of Technology, Stockholm, Sweden; [B]National Institute of Occupational Health, Research Department in Umeå, Analytical Chemistry Division, Umeå, Sweden; [C]Department of Occupational Medicine at the Karolinska Institute, Huddinge Hospital, Huddinge, Sweden; [D]National Board of Occupational Safety and Health, Solna, Sweden

Downhill as well as cross-country skis have undergone revolutionary technical development in recent decades. Parallel with innovations in ski bottoms, new types of ski wax have appeared on the market. At the same time complaints have been voiced increasingly by those who wax

mainly of tar has been replaced with waxes of paraffin supplemented by polytetrafluoroethylene (PTFE), silicone, and graphite. The method of application has also changed from melting over an open flame to the common use nowadays of waxing irons. These are specially designed irons either

of about 130°C or adjustable to

tain as good a glide in the track classic style—to get the skis to without losing the glide. In Swe- to 20,000 subjects are occupa- paration. An intense smoke is ax is applied to the skis. The waxing-iron temperatures. Usu- ver the waxing iron, leading to ax smoke.

have begun to complain about rritation of the eyes, nose, and is study was to study the influ- lth. The study was carried out country championships for ju- rn Sweden for one week in Feb-

Foto: ERIK BERGLUND

five male professional le I. Three were non- smokers, two were light smokers (fewer than 10 cigarettes per day), and one was a pipe smoker.

Smoke and Health Effects in Ski Waxers. Appl. Occup. Enviro 7(10):689–693; 1992.

Paraffin wax (fume)

(CAS No: 8002-74-2)

Health-based Reassessment of Administrative Occupational Exposure Limits

Committee on Updating of Occupational Exposure Limits, a committee of the Health Council of the Netherlands

Pergamon

0021-8502(95)00552-8

J. Aerosol Sci., Vol. 27, No. 2, pp. 339–344, 1996

0021-8502/96 $15.00 + 0.00

TECHNICAL NOTE

FORMATION OF RESPIRABLE PARTICLES DURING SKI WAXING

Kaarle Hämeri, Pasi Aalto, Markku Kulmala, Esko Sammaljärvi, Erik Spring and Pekka Pihkala

University of Helsinki, Department of Physics, P.O. Box 9, FIN-00014 University of Helsinki, Finland

(*First received* 30 *December* 1994; *and in final form* 22 *September* 1995)

Abstract—The formation processes and the final size distributions of airborne particles produced by ski waxing with fluor-powder were investigated. For the present study the flow system for controlled production of inhalable particles from ski wax was constructed. The particle formation was studied as a function of time and temperature. The particle size distributions were obtained using both electrical (DMA) and optical method (OPC). The mean diameter of particles was some hundred nanometers and the mass concentration was found to be tens of milligrams per m^3 in maximum.

Conclusion

- Unfortunately our argumentation does not reserve many alternatives for the ski glide surface preparation. However the residual alternative is very simple.

The amount of waste under steel scraping

Ski base density $\rho = 1,0 \text{ mg/mm}^3$

Waste weight $w = 2812 \text{ mg}$

Waste volume $\frac{w}{\rho} = 2,812 \text{ cm}^3 = 2812 \text{ mm}^3$

Treated surface length $l = 1830 \text{ mm}$

Treated surface breadth $b = 40 \text{ mm}$

Surface skim thickness $x = \frac{\frac{w}{\rho}}{bl} = \frac{w}{\rho bl} = 3,8415 \times 10^{-2} \text{ mm} = 0,038415 \text{ mm}$

So much (0,0384 mm) ski base we take away under the firs steel scraping which takes about 15 min per one ski. Base freshening takes away less than 0,001 mm.

Is it any substance in the today's glide waxing doctrine?

nr. 62 ROM Antal Zolt is in the lead

nr. 62 is caught up

abt 1 min. of descent

1´15´´ of descent, but nr. 62 is still in the lead

Why 24 technicians and 8 millions NOK can not outperform one poor Romanian wax expert?

Credits

- Aftenposten http://www.aftenposten.no/nyheter/sport/langrenn/article1195443.ece Foto: ERIK BERGLUND
- Toko USA http://www.tokous.com/thermo_bag.htm
- www.swix.no

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