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THE ROLE OF FIBER FINISH ON DRAFTING BEHAVIOUR

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ABSTRACT

The general behavior of slivers during drawing is simulated by means of a faller device mounted on an Instron Tensile Tester. The load generated during drafting is measured and the shape of load displacement curves is critically analyzed. The differences between lubricated and non-lubricated slivers tested at different speeds are presented, along with an indication of the influence of the number of active fallers. It is shown that the peak drawing force could be used as a possible criterion in judging the effects of lubricants on drafting.

KEYWORDS: Drafting Force, Fiber Finish, Pin Drafting, Gillbox

Introduction

A great deal of work has been carried out in the field of drafting and a number of aspects such as drafting force (1-7), generation of static (8-14) and fiber movement (15-18) have been investigated. The sliding friction between fibers in a sliver during drafting has not however been investigated in detail. The present work is abstracted from a study on the parameters used to select "processing aids" for worsted fibers. The ultimate selection is based on a compromise involving considerations of safety, cost, static suppression and lubricity.

Experimental

Experimental set up. In order to investigate the behavior of a sliver during drafting a simple experimental set up was developed and a schematic is shown in Figure 1. The device consisted of an Instron Tensile Tester (model 1026), a computer system, and a specially constructed unit for mounting fallers between the jaws of the tester. Fifteen pairs of fallers were mounted between the jaws with a spacing of 10 mm

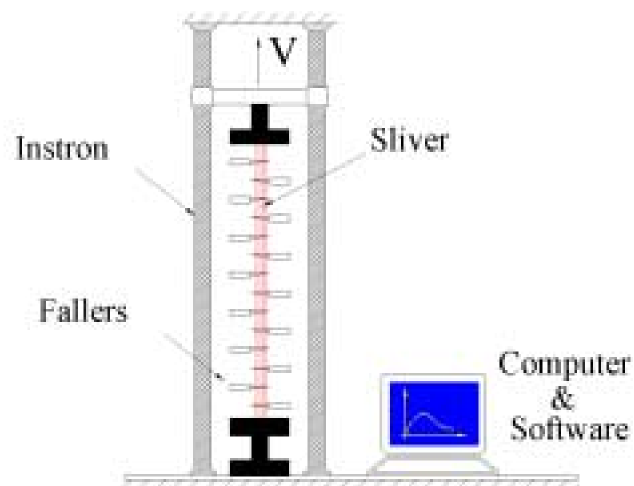

Figure 1 – Experimental set-up

between each faller. The fallers, which had 12 pins per inch, were mounted so that they pivoted at one end to enable placement of the test sliver and to facilitate the possibility of testing with different numbers of fallers in the test zone. The sliver is gripped by the top and bottom jaws of the tester, and the sliver is extended through the pins. The load extension data is recorded and analyzed by a computer, which is interfaced with the tester.

While the present set-up could not provide continuous drafting, and could only operate at relatively slow speeds, it was believed that the approach would lead to useful data. It was thought that in particular useful comparative information would be obtained on the influence of lubricants, settings and sliver weights.

Experimental Conditions. In the preliminary trials tests were carried out on slivers of various linear densities, which had been produced from acrylic (20 micron, mean fiber length 114 mm) and wool (26 micron, mean fiber length 81.5 mm). The "front ratch settings", (the distance between the front faller and the Instron's upper jaw) was set to 30mm, 45 mm and 60mm and the distance between the two jaws was set to 325mm. Six different experimental speeds, ranging from 50 m/min through 500 mm/min. were used during the initial testing phase. Prior to each test the sliver was pretensioned to 50 gf.

In the final trials 10ktex wool sliver (23µ and mean fiber length [H] 75.4mm) was used. This wool, which had an initial grease content of 0.46%, was prepared with the various "lubricants" given in Table 1. For each lubricant, applications of 0.3% and 0.6% were used, and the various samples were tested using all 15 pairs of fallers, a range of test speeds from 80 mm/min through 500 mm/min, and front ratch settings of 30 mm and 45 mm.

Preliminary Trials

Zones of Drawing Curves. Sliver drawing curves (load-extension curves) are different from those obtained for fibers, yarns and fabrics since they do not exhibit any clear

Table 1 Lubricants Used

"Oil"	Description
Spirail SKA	Wax emulsion type lubricant recommended for spinning
Oxitex 70	Non-ionic, immiscible in water only
Hansa KG 6001	A combination of oxyethylated fatty esters and aliphatic acids, miscible with cold water
Croslube BD	Water soluble, pH 7 (1% aqueous solution), weakly anionic
Selbana 4554	Combination of special fatty acid esters with antistats and nonionic emulsifiers, miscible with water at room temperature.

breaking point. Typical drawing curves obtained are shown in Figure 2. When fallers are used the drawing force increases much more quickly and the peak forces are much larger When no fallers are used the drawing curve is much longer and smoother.

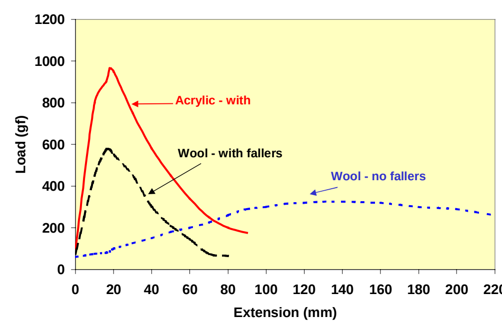

Figure 2 - Typical Load Extension Curves

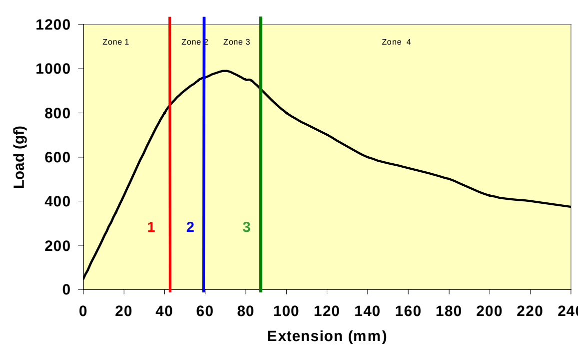

Figure 3 – Idealized Load Extension

In order to analyze and compare the drawing curves produced when the fallers are active it was found convenient to divide the curve into four zones. These are shown in Figure 3 where:

- Zone1 is the first region is the *initial linear zone* where the load rises rapidly (up to line 1);
- Zone 2 is the *post linear zone* which extends from line1 to line 2;
- Zone 3 is the *transitional zone*, which starts and ends when the drawing force is within 10gf of the maximum load (region between line 2 and line 3);
- Zone 4 is the final region is the *descending zone*, which follows line 3.

The curves obtained from initial trials with 6 ktex wool sliver were analyzed in terms of the different "zones" and the results are summarized in Figure 4. It is evident from these curves that the testing conditions do not appear to have a major influence on various zone lengths. The minor trends, which seem to be exhibited, are:

- The length of zone1 seems to be marginally increased with increasing ratch;
- The length of zone 2 seems to be marginally reduced with increasing ratch,
- The total length of zones 1+2+3 seems to marginally increase with testing speed.

The length of the linear zone is about 7-8 mm and since a typical breaking elongation for the wool sample used was roughly 33 mm (based on 40% elongation) it is evident that the behavior of the sliver in the linear region is likely to be heavily influenced by the fiber elasticity and crimp. Beyond this region fibers start relative movement and the curve is the result of several factors. There will be changes from static to dynamic friction and potential stick-slip phenomena. In addition there will be an increase in normal pressure between fibers and between fibers and the pins. This is followed by the transitional zone, where the relative

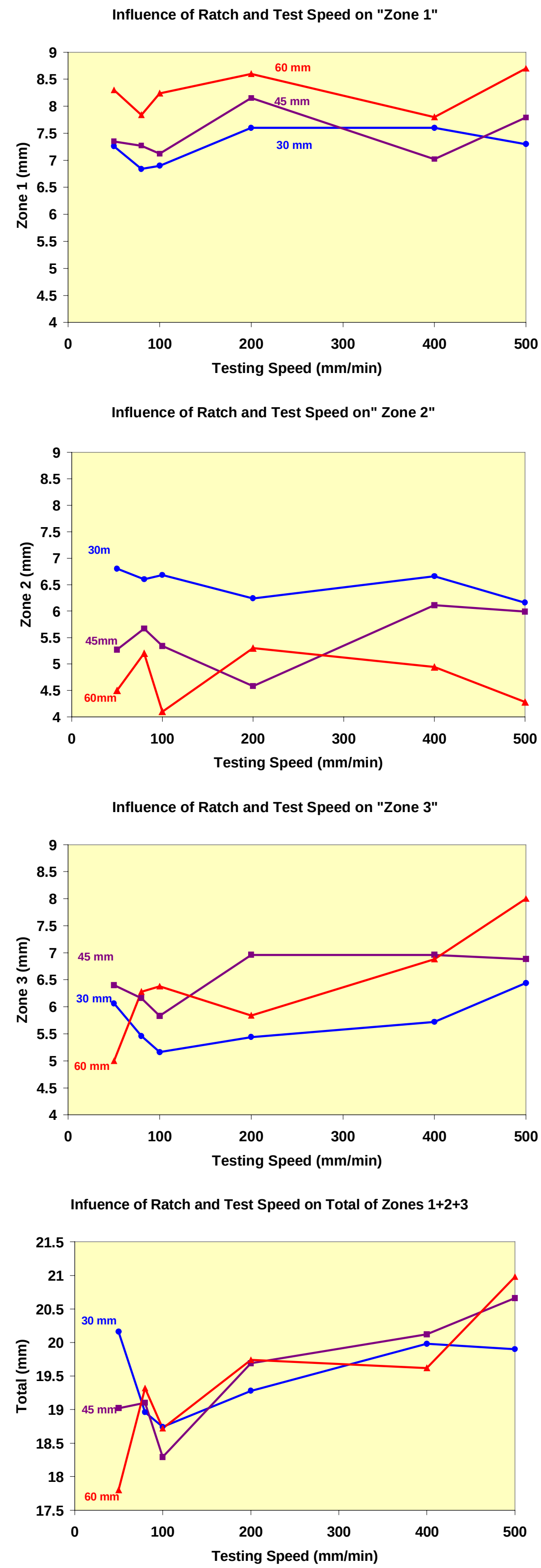

Figure 4 – Influence of Test Conditions

movement of the fibers becomes more important, and the elastic component of the fiber gradually reduces. The total of the first three zones is about 20mm and after this displacement the sliding of fibers becomes dominant and the drawing force gradually reduces.

Slope of Curves. It is also possible to compare the shape of the curves in terms of the slope of the linear zone and Table 2 shows the data from the preliminary trials with the 6 ktex acrylic sliver. It is clear from this table that the slopes of the curves are very similar irrespective of drawing speed or front ratch setting. These results indicate that the shape of the drawing curve mainly depends on the properties of the sliver including: fiber type, fiber length and fineness, sliver preparation, plus the type of fallers, etc.

Table 2 – The influence test conditions on slope of drawing curve

	SLOPE OF DRAWING CURVE		
Test Speed	Ratch		
	30mm	**45mm**	**60mm**
50 mm/min.	88 degrees 41'	88 degrees 18'	87 degrees 55'
80 mm/min.	88 degrees 35'	88 degrees 25'	88 degrees 02'
100 mm/min.	88 degrees 38'	88 degrees 22'	88 degrees 07'
200 mm/min.	88 degrees 45'	88 degrees 24'	88 degrees 10'
400 mm/min.	88 degrees 44'	88 degrees 25'	88 degrees 00
500 mm/min.	88 degrees 41'	88 degrees 21'	88 degrees 00
Mean values	88 degrees 41'	88 degrees 23'	88 degrees 02'

The affect of sliver processing is shown in Figure 5, which includes drawing curves for different acrylic slivers. It is clear from this figure that, as expected, sliver weight has a systematic influence on drawing force. It is also clear that the relative extension to achieve peak load is similar for the different sliver weights.

Influence of Front Ratch and Number of Active Fallers. For each front ratch the number of fallers was reduced by pivoting the lowest pair of fallers out of the sliver. The results obtained are shown in Figures 6,7 and 8, from which it can be clearly seen

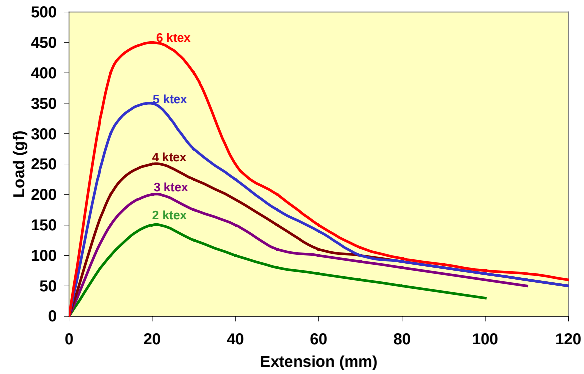

Figure 5 - Acrylic Drawing Curves

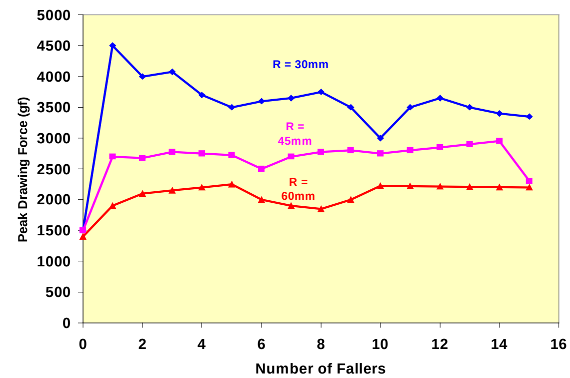

Figure 6 - Peak Force (20ktex Acrylic)

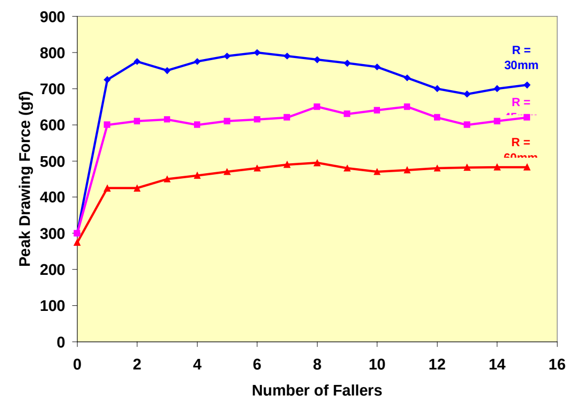

Figure 7 – Peak Force 9ktex Wool)

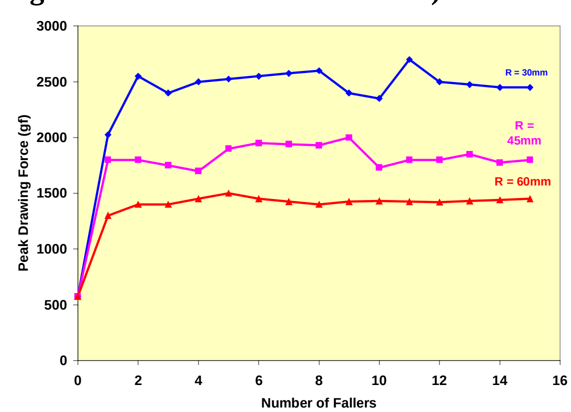

Figure 8 – Peak Force (20 ktex Wool)

that the front ratch plays a significant role in the peak drawing force achieved. This is attributed to the greater section of fiber length that is controlled by the fallers when the ratch is smaller, which increases the contact area and the normal pressure between fibers.

The role of the number of active fallers is unusual since the drawing force does not always increase with an increase in the number of fallers. Indeed it can be observed that there is major increase in drafting force with the introduction of the first pair of fallers and there after the number of additional fallers seem to have little effect. Statistical analysis of the data showed that there is only a real difference in the drawing force when the first two pairs of fallers are introduced and thereafter there is no significant difference in drawing force with additional fallers. The shapes of the drawing curves were examined for different numbers of fallers and it was found that Zone 1 was linear when 4 pairs of fallers were used for wool and 6 pairs of fallers were used for acrylic. The addition of more fallers slightly improved the linearity of Zone 1 but this was a marginal effect. Taking into account the distance between the fallers and the front ratch setting it was estimated that at least 75% of the fibers were controlled by the upper jaw and these fallers (i.e. 4 for wool and 6 for acrylic).

Influence of Sliver Weight. It has been shown in Figure 5 that the sliver weight has an effect on the drawing curves. If the load is normalized (by dividing by the linear density of the sliver) it can be seen from Figure 9 that for the acrylic fibers the resultant curves are almost identical.

Effect of Drawing Speed. While it has already been shown in Figure 4 that the drawing speed has little influence on the shape of the curves, it was believed that this parameter might influence the peak load. The results obtained for the 6 ktex acrylic sliver are shown in Figure 10 and statistical analysis reveals that there was no difference between the peak loads obtained at different speeds, except for one point at a front ratch setting of 60mm.

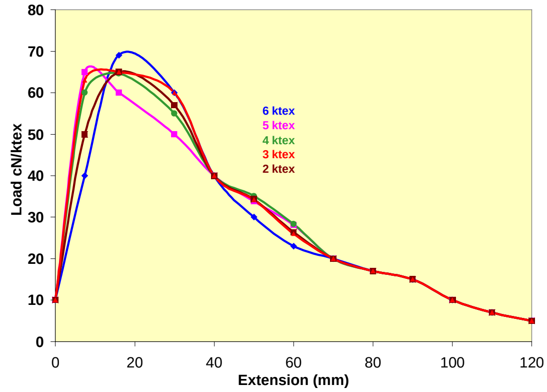

Figure 9 - Normalized Curves (Acrylic)

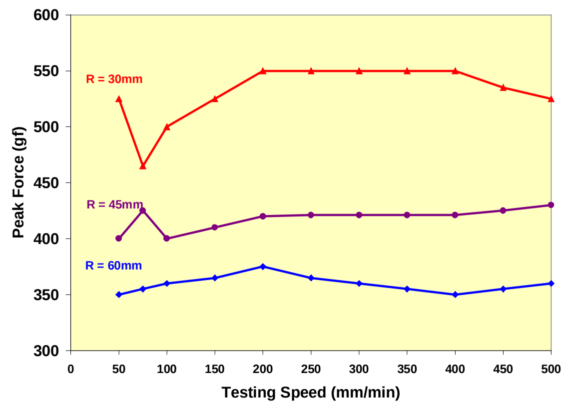

Figure 10 – Effect of Speed (6 ktex Acrylic)

The Behavior of "Lubricated" Wool Sliver During Drawing

Experiments were carried out using 10ktex wool slivers, which had been treated with the "lubricants" listed in Table 1. In addition an "untreated" sliver was also tested to act as a reference value. The slivers were evaluated using the set-up shown in figure 1 and in all cases all of the fallers were in place. In order to reduce the experiments and maximize the data an experimental design was set up [details of which are available elsewhere (19)], and using statistical techniques, such as analysis of variance, it was possible to determine the influence of various parameters and to establish whether further specific experiments were necessary. The analysis revealed that statistically all factors considered were significant, but that the influence of drawing speed and front ratch had a much greater impact on drawing force than the type and amount of oil added.

Influence of Lubricant Type and Level. It is interesting to note that for the different lubricants used during the present study, the shape of the drawing curves were very similar. Indeed the statistical analysis showed that there was very little difference in the slopes of the various drawing curves. Furthermore when the extension values (Zone 1+2+3) of the different lubricated samples were compared, it was again found that there was no statistically significant difference. It was thus established that the peak drawing force was the primary criterion for differentiating between the lubricants.

Tables 3 and 4 show the mean peak drawing force averaged over all five testing speeds, and their coefficients of variation. It is clear from these tables that the mean values of lubricant 4554 and lubricant 70 are lower and their CV values are smaller than the other samples. A further feature is that the drawing force measured with lubricant is higher than without lubricant. It can also be observed that the drawing force is higher for the higher add-on level of lubricant but this effect is small. Table 5 gives an overall relative rating of the various lubricants used in the present trials.

Table 3 - Mean Drawing Forces and CV% (0.3% Oil)

		4554	70	6001	SKA	BD	No Oil
Ratch = 45mm	F_{max}(gf)	573.8	616.52	648.24	618.62	636.84	601.28
	CV%	5.24	7.93	11.11	9.64	11.71	9.81
Ratch = 30mm	F_{max}(gf)	756.52	748.88	823.36	793.56	820.79	759.4
	CV%	5.39	8.58	11.4	12	10.83	9.77

Table 4 - Mean Drawing Forces and CV% (0.6% Oil)

		4554	70	6001	SKA	BD	No Oil
Ratch = 45mm	F_{max}(gf)	581.24	593.72	660.6	624.88	633.64	601.28
	CV%	8.65	4.1	10.6	7.56	11.75	9.81
Ratch = 30mm	F_{max}(gf)	772.32	780.88	848.12	789.36	805. 4	759.4
	CV%	5.7	9.24	10.3	10.6	12.69	9.77

Table 5 – Relative Order of Drawing Forces for Different Lubricants

Experimental Conditions	Relative order of Drawing Force
Ratch = 30mm, oil = 0.3%	4554 < 70< SKA < BD < 6001
Ratch = 30mm, oil = 0.6%	70 < 4554 < SKA < BD < 6001
Ratch = 45mm, oil = 0.3%	4554 < 70 < SKA < BD < 6001
Ratch = 45mm, oil = 0.6%	4554 < 70 < SKA < BD < 6001

Influence of Test Speed. Figure 11 shows experimental curves that demonstrate the change in peak drawing force with testing speed. It is evident from these curves that, while there may be some minor inconsistencies, all of the curves tend to follow the same trend of passing through a minimum as test speed increases. Similar behavior has been reported for lubricated yarn and metal guides [20,21] and the trend exhibited follows the general behavior of boundary lubrication described by a Stribeck curve [22]. When the fibers have lubricant they clearly display a minimum value of drawing force when the test speed is about 200mm/min. While outside the scope of the present paper, it is of interest to note that measurements of static electrification in the slivers, (when carried out under similar atmospheric conditions), followed a similar trend with minimum static being produced in lubricated slivers at about 200 mm/min drawing speed [19].

Conclusions

The paper outlines a technique to simulate the drawing of fiber through pins, such as is encountered on a gill box. While there are obvious differences because the present test is essentially "static" as opposed to the dynamic situation during drafting, it was believed that this should provide some insight into the role played by lubricants. The use of various factors such as the slope of the curve, peak force, and dividing the drafting curve into regions, can be used to compare the different curves.

It is shown that the use of two sets of fallers, combined with an appropriate ratch setting, are sufficient to create a drawing force almost the same as when all sets of fallers were present. In a real drafting set-up the other fallers are necessary to control shorter fibers and retain them until they reach the front zone of the drafting unit. Lubricant is shown to change peak force but this is also influenced by the testing speed.

While in general, viscosity plays a role in the peak drawing force, it was not possible to find a direct correlation in the present study. Similarly surface tension can also play a role in drafting behavior but no simple relationships could be established during the reported trials [19]. While it is possible to speculate on the requirements of good drawing lubricants, such as: -low friction; "good" cohesion; good antistatic properties; environmentally, operator and machinery friendly; there is still considerable improvement in the basis of optimum lubricant selection. For good drawing the lubricant should combine the benefits of low friction under low

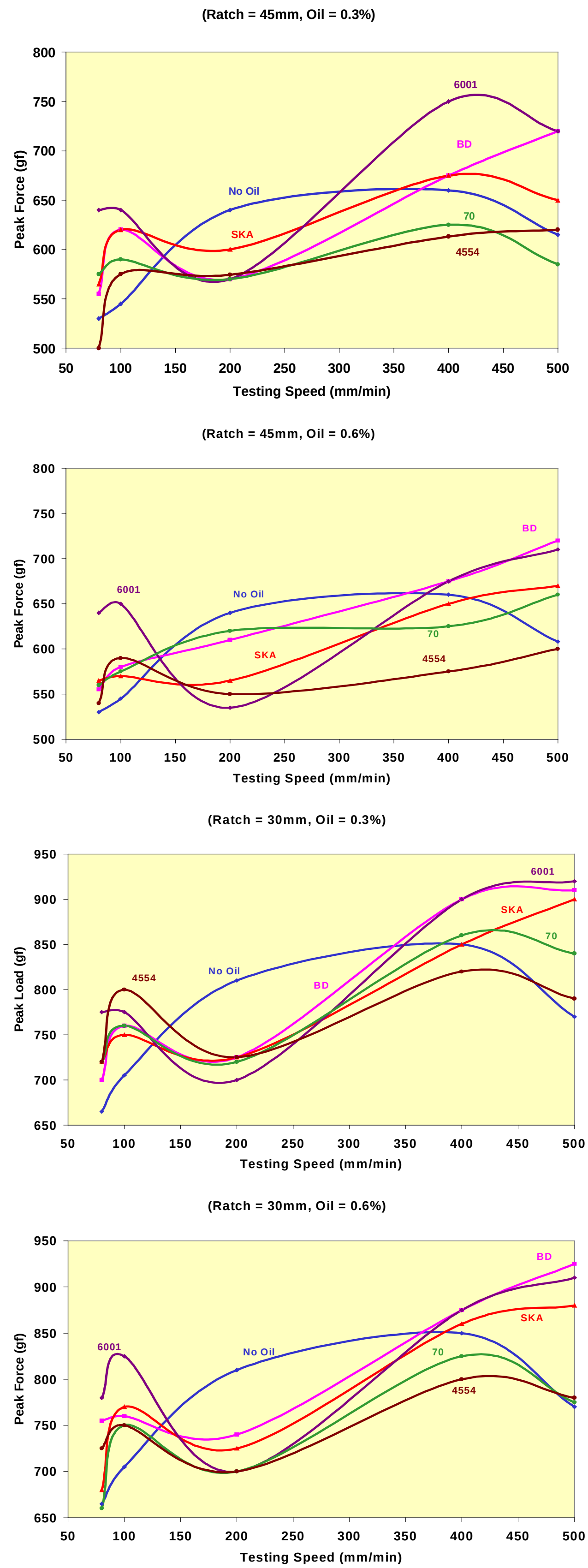

Figure 11. The Influence of "Oil", Testing Speed, and Ratch on Peak Drawing Force

concentrations, low viscosity and sufficiently high surface tension. It is believed that the techniques described in this paper could provide possible tools to aid in this selection.

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