COMPARATIVE STUDY OF TEXTILE PROPERTIES OF HWM-FIBRES SPUN BY DIFFERENT PROCESSES

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INTRODUCTION

I would like to discuss some results concerning the improvement of the physical properties of HWM-fibres, and in particular, present some remarkable properties of a new fibre recently obtained in our research laboratory.

In the past few years there has been a great deal of interest in the man-made HWM-fibres. These fibres may be divided into two groups according to their physical properties, namely Polynosic fibres produced by the Toramomen process and others which do not quite reach the standard of Polynosic fibres. For the sake of brevity I shall call them simply HWM-fibres. These HWM-fibres have essentially an initial wet modulus ranging between 10 and 20 g/den. while the modulus of Polynosic fibres is 20 to 60 g/den. Basic references for these properties are the recent papers by Professor Mark[1] and by Dr. Treiber[2].

COMPARATIVE PROPERTIES OF HWM AND POLYNOSIC FIBRES

To point out the particular properties in which I am interested and the most striking differences between HWM and Polynosic fibres let us look at *Table 1* in which are presented the most important properties of the

Table 1. Properties of HWM and Polynosic fibres before and after treatment with 5 per cent sodium hydroxide solution

Property	*HWM*		*Polynosic*	
	Original	*After caustic treatment*	*Original*	*After caustic treatment*
Conditioned tenacity (g/den.)	3·8–5·0	2·0–3·0	4·5–5·5	3·5–4·5
Conditioned elongation (%)	17–21	30–35	9–14	18–25
Average stiffness (g/den.)	30		40	
Average loop tenacity (g/den.)	0·8–1·0		0·5–0·7	
Wet tenacity (g/den.)	2·6–3·7	1·7–2·5	3·0–4·5	2·5–3·5
Wet elongation (%)	18–23	35–40	12–18	20–30
Wet initial modulus (g/den.)	*10–20*	2–10	*20–60*	10–20
Flex life (0·52 g, 0·001 in.)	*c.* 1000		*c.* 500	
Lateral order	medium		high	
Crystallite length	small		great	
Degree of polymerization	*c.* 500		*c.* 600	

fibres of the two groups both before and after treatment with 5 per cent sodium hydroxide at 20°C. It can be seen from *Table 1* that in spite of the many excellent qualities which distinguish the Polynosic fibres—namely the high tenacity and the high resistance to sodium hydroxide—there are also many drawbacks, caused by their low resistance to lateral deformation, namely low loop tenacity and low resistance to flexing. These negative properties finally cause a marked decrease in the spinning yield of the Polynosic fibres.

If we express the spinning yield as the ratio between yarn tenacity, for instance of a count N_e 20, and fibre tenacity, we get a curve like the one shown in *Figure 1* when we plot this yield against initial wet modulus.

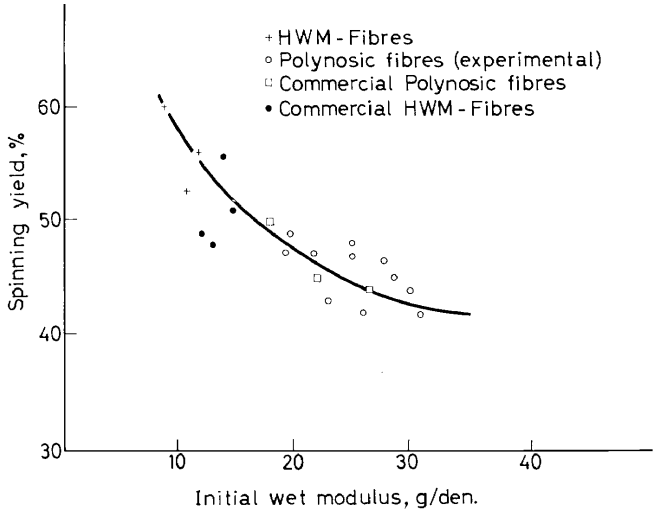

Figure 1. Effect of initial wet modulus on spinning yield in the case of some HWM and Polynosic fibres

Regarding the procedure used for obtaining the various figures it should be mentioned that single lots weighing not less than 50 lb each were spun in a mill equipped with modern machinery. The fibres were conditioned in order to have a moisture content of about 13 per cent and spun to yarns of count N_e 20. Ten samples were taken from each lot and tested according to Bisfa rules. In addition, the regularity of count was checked with the Uster tester.

Some of the fibres tested belong to the HWM-type, made by the Chatillon Co. on an industrial scale. Others were commercial HWM-fibres and commercial Polynosic fibres. A certain number of Polynosic fibre lots, produced on a pilot plant scale by the Toramomen process were also used for these experiments.

It can distinctly be seen that the spinning yield decreases with increasing wet modulus of the fibres. This means that a yarn spun from HWM-fibres with conditioned tenacity of about 4 g/den., has higher break strength than a

yarn, with the same count, made from Polynosic fibres with conditioned tenacity of about 5 g/den.

METHODS FOR OBTAINING BETTER POLYNOSIC FIBRES

In order to obtain a Polynosic fibre having all the good qualities of an HWM-fibre, several techniques seem to be applicable. The first procedure that is reasonable to try consists in adding a certain amount of a modifying agent to the viscose and a certain amount of zinc sulphate to the spinning bath. This method will indeed, at least theoretically, lead to a useful compromise between the process which is used for the production of Polynosic fibres and the one used for HWM-fibres. We have tried this technique and found that if the amount of modifying agent and zinc sulphate is small, the properties of the fibres are much more similar to Polynosic than to HWM-fibres. On the other hand it was found that if the concentration of zinc sulphate in the bath is increased there is such a marked decrease in the tenacity of the fibres that this technique does not seem to have any practical possibility of application.

Moreover in this case the loss of tenacity is not compensated by a gain in elongation and so we find a marked decrease in toughness and no improvement in spinning yield, which remains at a low level (about 45 per cent).

Another suggestion for obtaining better Polynosic fibres is based on the well known fact that cellulosic fibres swell and their modulus decreases when treated with caustic alkali. This process is no novelty having been mentioned as far back as 1930 in patents of Lilienfeld[3]. It can be seen in *Table 1* that the modulus of the Polynosic fibres after treatment with 5 per cent caustic alkali at 20°C is almost the same as the modulus of HWM-fibres not treated with caustic alkali. Thus, this simple process seems to be very promising, since it can be applied to fibres during the after-treatment, e.g. by addition of the caustic alkali to the desulphurizing bath.

We have applied this treatment in our laboratory and pilot plant to a large number of fibre samples having an initial wet modulus of 30 g/den. and more, and have found that by this means the wet modulus can be actually lowered by about 50 per cent.

With this treatment the fibre slightly loses in crystallinity and orientation. Moreover we have measured a marked increase in the resistance to flex and in the loop tenacity. Not quite so good is the improvement in spinning yield. Sometimes we have even found that the caustic alkali treatment, in the case of fibres with very high tenacity and very high modulus does not cause any increase in spinning yield at all.

What makes things worse is the significant loss in fibre break strength (about 15 per cent) and an even greater loss in yarn tenacity (15–30 per cent) due to the caustic alkali treatment. The change of tenacity and of spinning yield can be observed in *Figure 2*, in which the tenacities of fibre and yarn, before and after caustic treatment are compared—the numbers enclosed by squares and circles refer to the same lot.

I would, however, like to point out that in not a single one of the caustic-treated yarns was tenacity increased. On the whole this process was not a success, in spite of the considerable decrease of modulus produced by caustic alkali treatment.

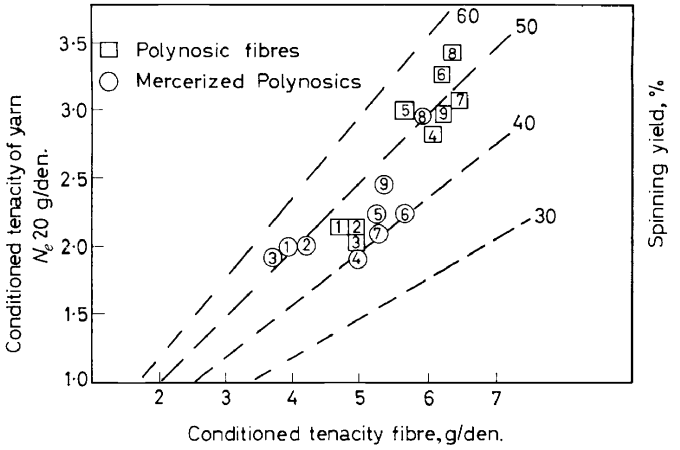

Figure 2. The change of tenacity and of spinning yield in the case of Polynosic and mercerized Polynosic fibres [The numbers enclosed by squares and circles refer to the same lot]

The conclusion that we have to draw from this experimental evidence, is that the modulus, considered by itself, cannot be taken as a guideline for predicting the behaviour of fibres in spinning and the yield of spinning.

We believe that other features are much more important in this regard such as for instance chain length and fibre structure, i.e. form of lattice, lateral order and size of crystalline regions. These properties may have decisive influence on the textile behaviour of fibres and especially in their performance at spinning.

VA/S-FIBRE—A NEW POLYNOSIC FIBRE

Following this trend our research was aimed at developing a new type of fibre, which has a very high degree of polymerization, very high lateral order, and very high tenacity. This fibre was prepared recently in our pilot plant by spinning viscose by a new technique. This fibre tentatively named *VA/S-fibre*, has very interesting properties, listed in *Table 2.*

I wish to draw your attention to the exceptionally high wet modulus of this fibre, which appears to have no negative influence on the resistance to lateral deformation, namely loop and knot tenacity and flex life.

Other important features of the VA/S-fibre are (i) Low moisture regain: about 30 per cent less than that of normal rayon. (ii) Very high resistance to caustic and very low solubility in sodium hydroxide solutions. (iii) High spinning yield that can be achieved also for high counts. This means that it is possible to produce yarns that compare favourably with yarn of primary quality cotton, even when wet.

In order to study the VA/S-fibre from a practical standpoint, fabrics were made from the pure fibre and from mixtures with cotton and with synthetic fibres. The fabrics were washed 50 times. Then their dimensional change and tensile, tear and bursting strength and resistance to abrasion were measured after the first desizing wash and at the end of the run.

Table 2. Properties of VA/S fibre before and after treatment with 5% NaOH

Property	*Single fibre*		*Yarn count* N_e 20	20	30	40	60
	Before treatment	*After treatment*	*Before treatment*	*After treatment*	*Before treatment*	*After treatment*	*Before treatment*
Denier	1·0	1·05	257	260	171	127	90
Conditioned tenacity (g/den.)	7·8	7·5	4·0	3·75	3·85	3·8	3·3
Conditioned elongation (%)	10	12	6·5	7·2	6·3	6·2	6·1
Average stiffness	80	65	—	—	—	—	—
Wet tenacity (g/den.)	6·7	6·5	3·0	2·85	2·9	2·8	2·5
Wet elongation (%)	12	15	6·8	7·5	6·8	6·7	6·5
Wet initial modulus (g/den.)	50	36	—	—	—	—	—
Loop tenacity (g/den.)	0·8	0·9	—	—	—	—	—
Knot tenacity (g/den.)	2·0	2·2	—	—	—	—	—
Flex life (0·52 g, 0·001 in.)	1000	1200	—	—	—	—	—
Lateral order	very high	very high					
Degree of polymerization	*c.* 800	*c.* 800					
Spinning yield (%)	—	—	51	50	49·5	49	43

Table 3. Comparative properties of fabrics made from VA/S, HWM and Polynosic fibres

Property	*VA/S*	*HWM*	*Polynosic*
Area shrinkage after 50 washes (%)	1·4	2·7	2·0
Warp tensile strength (kg)			
conditioned after 1 wash	63·8	49·1	35·1
conditioned after 50 washes	52·0	43·0	27·3
wet after 1 wash	58·0	37·2	25·5
wet after 50 washes	48·4	32·7	18·5
Tear strength (kg)			
warp after 1 wash	53·4	47·9	34·2
warp after 50 washes	52·6	42·8	28·3
Bursting strength (kg)			
after 1 wash	34·9	28·1	20·7
after 50 washes	24·5	26·7	16·5
Abrasion (accelerator) weight loss (%)			
after 1 wash	1·0	1·0	2·5
after 50 washes	1·5	1·2	3·0

In *Table 3* the properties of a fabric made from pure VA/S yarns (warp 30/1; filling 40/1) are listed. These properties are compared with fabrics from HWM and Polynosic yarns of the same count and construction. These data prove the outstanding quality of VA/S-fibre both as yarn and as fabric.

Finally I would like to mention that VA/S-fibre shows a normal behaviour at dyeing, both with direct and with vat dyes, the rate of colour adsorption being nearer to that of cotton than to rayon.

The extraordinarily good properties of this fibre at usage are partly counter-balanced by some difficulty in production, e.g. (i) the recovery of reagents is rather troublesome; (ii) the cost of production is somewhat higher than that of normal staple.

On the whole this experience, of which I have given a short summary, shows some interesting new positive developments in man-made cellulose fibres.

References

[1] H. Mark. *Chemiefarsen* **6**, 422 (1965).
[2] E. Treiber. *Lenzinger Berichte* **18**, 15 (1965).
[3] Brit. Pat. 319 293, 323 731.