SAWTRI SPECIAL PUBLICATION

From Mohair Fleece to Fabric
An Account of Sawtri's Research

by
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PREFACE

Mohair falls in the category of protein fibres such as wool and other animal hairs. Yet, there are chemical and physical differences between mohair and other fibres. In this resumé some account is given of these differences.

The processing behaviour of mohair is vastly different to that of wool and in this respect SAWTRI has done pioneer research work. Although many of SAWTRI'S research findings might have been known to the mohair textile industry, these facts have never been disclosed in open publications. In fact, the processing of mohair has always been considered as a highly secretive undertaking.

SAWTRI hopes that, through this resumé, and through its complete list of publications where more detail is required, a contribution is being made to our knowledge of one of Nature's most wonderful fibres.

FIBRE DIAMETER OF MOHAIR BY THE AIRFLOW METHOD

Currently, the mean fibre diameter of a consignment of mohair is of the utmost importance to the producer, buyer and processor. There is a general tendency to base all transactions in mohair on 'micron' measurement since a difference of a single micron makes a vast difference to the average price of a lot of mohair. Micron measurement on the projection microscope, although the most reliable, is slow and tedious.

In view of the wide application of the airflow method for the determination of the mean fibre diameter of wool, the possibility of adapting this method for use with mohair was investigated.

It was found that the method could be applied on the conventional apparatus by using 3.5 g of mohair instead of 2.5 g as is normal for wool and by increasing the pressure from 18 cm to 25 cm of water on the manometer. All the calibration samples (wool) and mohair to be tested should be properly randomised.

It was established that length of fibre and kempiness had very little, if any, effect on the airflow readings. This also applies to the small degree of medullation that may be encountered in normal mohair samples.

With very coarse mohair, the coefficient of variation for diameter is relatively large and sampling extremely difficult. It is, therefore, to be expected that the accuracy of the airflow meter will become more unreliable as the mean fibre diameter increases.

FIBRE IDENTIFICATION IN WOOL/MOHAIR BLENDS

The blending of fibres has become normal practice in the textile manufacturing industry and, consequently, the need has arisen for routine analytical techniques to distinguish between fibres of different types. This has recently become of importance with mohair textiles because cases of adulteration with certain cheaper long wools, such as Buenos Aires wool have been detected.

Chemical methods of fibre analysis fail altogether due to the very close chemical relationship between the two types of keratin fibres. Certain histochemical techniques which are applicable to the unprocessed mohair and wool fibres also fail when applied to dyed end-commodities. Histological investigations of the fibre scale structure have indicated that no unequivocal answer to the question can be obtained on the basis of scale size and shape due to the large variations even within a fibre sample obtained from a specific animal.

Recent microscopical studies on fibre profiles and utilising polarised light have shown that the pronounced differences between fibre types can be relied upon to distinguish beyond doubt between mohair and such wools as Wensleydale, Leicester, Lincoln and Buenos Aires. This qualitative indentification of fibres unfortunately is a rather tedious procedure which does not lend itself to routine quantitative analysis of blends, although it can be applied with a fair degree of accuracy to individual samples.

MECHANICAL PROPERTIES OF MOHAIR AND KEMP FIBRES

The S.A. mohair clip contains varying amounts of undesirable, medullated or kempy fibres. The normal fibres are expected to have different mechanical properties to that of the kempy fibres.

It has been found possible to apply the Uster irregularity tester in the rapid and accurate determination of the linear density (tex) of fibres varying in diameter from 16 to 80 microns. The tensile strength per tex unit was found to be higher in the case of mohair and kemp fibres than in that of merino wools. The elongation at break of all three fibre types was approximately equal.

In the case of mohair fibres, bending and extension moduli do not differ appreciably. Kemp fibres, however, could be divided into groups with approximately equal and significantly different moduli, respectively, In the latter case, the differences have been ascribed to the medulla of some kemp fibres being practically empty in certain specimens but filled with medullary cells in others.

In an investigation of the differences between true mohair and kemp fibres, breaking strength and breaking extension measurements were carried out. The correlation between breaking strength and linear density obtained by the method just described and by calculations based on fibre diameter measurements have been compared. It was found that the linear densities of kemp fibres measured in this way correlated better with breaking strengths than when Tex values were calculated on the basis of fibre cortex cross-sectional areas.

Indications were found that the cell material of the medulla, which does not contribute significantly towards the breaking strength of the fibre, has a dielectric constant comparable to that of the fibre cortex.

To investigate the bending moduli of mohair and kemp fibres, an apparatus was built by means of which the static bending moduli of fibres can be determined. By passing a current through a sensitive galvanometer a force is applied to a fibre by the deflecting pointer. The lengths of portions of fibres and their deflection under the applied force are then measured by means of a travelling microscope.

The bending moduli (E_b) for mohair and kemp were determined and the results compared with the extension moduli (E_s). Although differences for individual fibres for these two moduli are in some cases very large, the sample means of $\overline{E_b}$ and $\overline{E_s}$ show very little difference.

THE PROTEINS OF OXIDISED MOHAIR

The fractionation of the high-sulphur proteins (gamma-keratose) of oxidised mohair by column electrophoresis and the subsequent separation of these fractions by gel filtration gave, for each electrophoretic fraction, a number of proteins which, although of about the same electrophoretic mobility, differed widely in molecular weight.

The amino acid composition of the different components for a particular column electrophoretic fraction revealed differences. These differences were also emphasised by a study of the N-terminal end-groups of the components obtained by gel filtration. The electrophoretically homogeneous fractions of gamma-keratose, prepared from oxidised adult mohair and subjected to gel-filtration on Sephadex S–100, gave sub-fractions which were compared with fractions obtained through similar treatment of wool. Differences in physical properties as well as in amino acid composition, were observed.

MOHAIR SCOURING

Scouring is the first major process in the processing of mohair. Effective scouring is aimed at a minimum degree of entanglement, minimum yellowing, and the preservation of the high lustre of this fibre.

Mohair scouring experiments on the Petrie and McNaught harrow system were aimed at establishing optimum processing conditions. Aspects such as the economy and efficiency of the process without causing damage to the quality and natural lustre of the hair received attention.

It appeared that the rate of feed of mohair could be raised considerably without an increase in consumption of the nonionic detergent used. A sharp decrease in detergent consumption was actually found when the rate of feed was increased from 200 lb/hr to 300 lb/hr. The curve obtained when plotting detergent consumption versus rate of feed flattened out somewhat on increasing the rate of feed in further steps of 100 lb/hr up to 500 lb/hr. At the latter rate of feed it appeared that the dryer (perforated drum type) had become overloaded and could not dry the scoured product sufficiently unless undesirably high temperatures were used.

A more detailed study of the influence of rate of feed, temperature and builder additions on the scouring of mohair was also made. From the point of view of detergent consumption *only,* the optimum conditions appeared to be the highest rate of feed investigated (500 lb raw mohair/hr), coupled with the highest temperatures used (60° and 55°C for the first and second bowls, respectively) and a soda ash addition of 3 lb/100 lb raw mohair to the first bowl (Glauber's salt was added to the second bowl). However, at the very high feeding rates the capacity of the dryer was a limiting factor; due to detrimental effects on the colour of the scoured product it seemed unwise to exceed a temperature of 55°C in either of the first two scouring bowls. Finally, it was felt advisable to restrict soda ash additions in the first bowl to 2 lb/100 lb of raw mohair in order to obtain the best results, judged by the colour of the hair.

Mohair was scoured with two detergents (soap and a nonionic detergent) at different rates of backflow. The same temperature and mechanical conditions were used for all experiments. The same quantities of soap and nonionic detergent were also added for each individual backflow rate* employed, and the efficiency was estimated by the amount of residual grease. Rates of backflow used were 10%, 15% and 25% for soap, and 10%, 25% and 50% for the nonionic. With soap the residual grease content increased with increasing backflow while with the nonionic it decreased from 0.8% at 10% backflow to 0.3% at 50% backflow.

With soap at 10% backflow and nonionic at 50% backflow the same percentages of residual grease were obtained in the scoured product. Soap consumption was established at 1 lb 7 oz/100 lbs raw mohair and that of the nonionic at 12 oz/100 lbs raw mohair.

*By backflow rate is understood the percentage of the volume of liquor in a specific bowl replenished by liquor from a successive bowl using the well known counterflow system.

RESIDUAL GREASE CONTENT OF SCOURED MOHAIR

For quality control of the residual grease in scoured mohair, a rapid and fairly accurate method is required. The well known conventional column-and-tray method does not work because of chanelling of the solvent in the column of mohair.

The column-and-tray method was therefore modified for application to scoured mohair by prescribing the cutting up of the mohair and blending with fat-free cotton-wool prior to packing of the extraction column.

This study was further extended by making use of a laboratory cutting mill for the preparation of samples. Such a mechanical method for the preparation of samples to be tested was found to work extremely well.

CARDING

The second major process in the processing of mohair, is carding.

The undesirable kemp fibres in mohair can be removed during all stages of processing from carding to combing. In carding, kemp is removed through selective collection of kemp by the card clothing on all the rollers, as well as through ejection together with burrs. The increase in kemp content of the material accumulating in the card clothing increases linearly for the first 6 to 8 hours running, after which period a saturation value is slowly reached. After about 13 hours running the rate of selective uptake of kemp by the card clothing is much less than after 6 hours. This necessitates *regular fettling of the rollers after about 10 hours running.* The selective uptake of kemp results in a card sliver which contains *less* but *longer kemp* than the scoured material. The loose fibres in the outer layers on top of the rollers contain less kemp than the outgoing card web, while the material in the clothing contains a high concentration of Kemp Fibres indicating a migration of kemp fibres towards the inside of the rollers.

Different rollers collect kemp differently. It was found that the strippers have the highest selective kemp collecting power but the amount of material collected is relatively small. Regular cleaning of the strippers will thus only effect the removal of a small amount of waste material but with a high percentage of kemp.

An increase in roller surface speed results in an increase in the rate of kemp uptake through the action of higher centrifugal forces on the relatively heavier though thinner mohair fibres. In addition, the less dense kemp fibres will encounter a much higher accelarating force in an air current than the thinner but denser mohair fibres. A well-chosen air current could therefore also be used for further separation of kemp and mohair if the fibres are in a disentangled state.

The material collected by the card clothing consists mainly of short fibres, although the average length of the kemp fibres in the fettled material is not very much shorter than that of kemp originally present in the scoured mohair.

Breakage of kemp fibres during carding would tend to decrease the average kemp length in the card sliver, but this is counteracted by the over-all removal of the shorter kemp fibres through collection by the rollers. Consequently, a card sliver is obtained with higher mean kemp length than in the original scoured mohair. On the other hand, for the mohair fibres the total mean fibre lengths of the card sliver and of the scoured mohair are equal, which implies that all the short fibres resulting from breakage on the card were collected by the rollers and removed by fettling. The strippers collect only very short mohair fibres but for some reason or other do not show the same preference for the short kemp fibres. The kemp fibres collected on the strippers are only slightly shorter than those collected on the other rollers.

The breaking force of kemp is much higher than that of mohair but with kemp being much thicker, the **breaking stress** is much higher in the case of mohair fibres. Due to the strength of both kemp and mohair, fibre breakage in carding was found to be very low.

The frictional forces for mohair are slightly higher than for kemp, which will also result in a slightly higher amount of breakage of the former. Scoured material with a kemp content of 2.18% (by weight) was used in this experiment and after carding the card sliver contained 1.78% kemp. Thus, a removal of about 20% of the kemp originally present, was effected. With more effective cleaning (especially of the strippers at regular intervals) much more kemp can probably be removed.

NOBLE COMBING

Mohair can be combed on either the Noble comb or the French comb. For high class quality goods, the tops obtained by Noble combing are sometimes subsequently passed through a Lister comb.

A series of gilling and Noble combing experiments was carried out on BSFH mohair to determine the influence of various factors on processing efficiency.

Although a third preparer gilling operation further improves fibre alignment it is not sufficient to justify more than two gillings.

The removal of kemp during Noble combing is not significantly affected by changes in dabbing depth, throw-over or temperature. During combing the average kemp content decreased from over 2% (by weight) in the gilled sliver to about 0.8% in the top with 25% of kemp in the noil. The mean fibre length of the kemp fibres in the noil is greater than that of the mohair fibres. This proves that the Noble comb is an effective selective remover of kemp fibres.

Fibre breakage of kemp during combing appears to be exceedingly low and only the short kemp fibres present in the card sliver pass into the noil, whilst the longer kemp goes through into the top. By and large, the overall fibre breakage was less than 5% and was mainly confined to the mohair fibres. Whilst variations in dabbing depth and throw-over did not adversely affect fibre breakage, low temperatures created a significant increase in the amount of fibre breakage. The most beneficial comb temperature was found to be between 70° and 80°C.

FRENCH COMBING

Currently, there seems to be great interest in the French combing of mohair.

As the cohesion of the fibres in mohair slivers is very low, special care must be taken not to break the slivers during any stage of processing; a support by means of aprons is often necessary. Two particularly difficult stages are the output of the rectilinear comb and the subsequent feed of the combed sliver into a gill box. The fibres delivered from the comb are loose and disentangled, and the cohesion between them is very low. The overlap of the fibre tufts during combing should be large enough and the output web thick enough to prevent the sliver from breaking as it enters the can. It is necessary to use spring-loaded bottom supports in the cans throughout. It is also rather troublesome to feed this combed sliver into a gill box because the sliver must travel a fair distance in the creel before it reaches the positive grip of the back rollers. A normal can feed creel was used during all experiments. A better arrangement may be an apron which can support the sliver from the edge of the can to the nip of the back rollers of the gill box.

In a series of experiments on kemp removal, the following observations were made:

The percentage kemp in the sliver before combing was 1.5%.

The kemp content of the top was of the order of 0.9% and that of the noil about 11%. If we compare these figures with those obtained on the Noble comb viz. 0.8% and 25% for top and noil respectively, for a kemp content of the precombed sliver of about 2%, it is clear that the noil from Noble combing contained much more kemp than the noil from the rectilinear comb. *This means that the Noble comb is much more effective in the removal of kemp.* The ratio of percentage kemp in the noil to that in the top was about 32 in the case of the Noble comb as compared with between 12 and 24 depending on the settings for the rectilinear comb which, once again, proves the Noble comb to be superior in respect of kemp removal.

No definite trend for kemp removal at different comb settings emerged from the results obtained. However, the figures for the ratio of kemp content in noil and top increase for increasing gauge settings, i.e. from 12.8 at 26 gauge to 17.2 at 32 gauge. This shows that more kemp was removed at 32 gauge than at 26 gauge which is logical if we keep in mind that the kemp fibres are mostly short or medium short fibres.

During the combing of mohair it was noticed that the top surface of the web on the leather appeared very kempy, but when this layer was turned upside down, it appeared kemp-free. The reason for this phenomenon is that most of the kemp fibres are located in the leading end of the withdrawn fringe.

The *percentage noil* produced during rectilinear combing was linearly related to the gauge setting of the comb – an increase in the gill feed at constant gauge caused a slight decrease in percentage noil. The mean fibre length in the top and the noil first decreased somewhat when the gauge setting was increased and subsequently increased for a further increase in gauge setting.

The mohair fibres in the top were significantly longer than the kemp fibres left in the top, while the lengths of the two types of fibres in the noil were about the same. This again differs from Noble combing where the mean fibre length of the kemp fibres in the noil was significantly longer than that of the mohair fibres.

Percentage fibre breakage increased significantly for an increase in gauge setting but dropped rapidly at the very wide setting of 32 mm. The medium gill feed settings resulted in greater amounts of fibre breakage, the best combing performance being for large gill feed settings.

SPINNING

In the spinning of mohair particular problems are encountered due to the smoothness (or slipperiness) of the fibres. Drafting control is difficult and the resultant yarns are often very hairy. In a series of trials the influence of blending with various proportions of wool on the yarn properties and fibre migration was investigated.

Tops of BSFH mohair and 64's warp wool were blended to effect proportions of 20%, 50% and 80% mohair (by weight), respectively. These were mixed on intersecting gill boxes, drawn on a modified Continental system and spun on a double apron ring frame.

Cross-sections of the yarns were studied under a microscope to determine the nature of fibre distribution within the yarn. For this purpose the yarn cross-section was divided into a central 'core' and a concentric 'surface' ring around it. The number of wool and mohair fibres both in the surface and core regions were counted. Statistical analysis indicate that for twists ranging below 14 t.p.i. more mohair fibres were present on the surface of the yarns. Thus, preferential fibre migration occurs when spinning wool/mohair blends under certain conditions.

The wool fibres varied more in locality (core or surface) than the mohair fibres which appeared more consistent in their migration. This, again, indicates that the greater length and strength of the mohair fibres played a predominant rôle in determining the fibre position during yarn formation.

These results stress the importance of using components of compatible diameter and fibre length to ensure a uniform blend. On the other hand, the preferential migration effect may be used to advantage in certain cases. By choosing the components carefully, a yarn can be spun that shows up more of one fibre than superficial knowledge might suggest. It would thus be possible to spin a blend of short mohair and longer wool (with similar diameters) into a yarn which will appear more lustrous than the weight proportions would indicate. Also, because the core contains the longer and softer wool which gives the necessary cohesion and is, therefore, responsible to a large degree for the nature of the bending modulus a fabric from such a material should have a satisfactory drape.

Tops of BSFK mohair (26 microns) and 64's merino wool (22.5 microns) were mixed on an auto-levelling gill box to obtain blends containing 60%, 40% and 20% mohair by weight. These blends were drawn and spun on the Continental system.

The influence of yarn count, composition, twist factor and spinning speed on the spinnability, yarn breaking strength, elongation at break and levelness was determined.

In general, the heavier counts could be spun more satisfactorily. The number of ends down during spinning was the lowest for the 20% mohair blend (the yarn should have a twist factor of at least 2.2 to be spun satisfactorily). Indications are that yarns containing more mohair, should be spun with a higher twist factor to obtain a reasonably satisfactory spinning performance. Yarns containing smaller amounts of mohair could be spun at higher speeds than those with more mohair.

For any yarn count, the strongest yarns contained the *lowest* amount of mohair. However, for all the blends, yarn strength compared favourably with those of commercial yarns tested. The breaking strength increased with increasing twist factor. It was also established that those yarns which were spun at *higher* speeds were weaker than those spun at *lower* speeds.

The extension at break was found to increase with heavier counts and with the amount of wool present, the most extensible yarns containing the lowest amount of mohair. Yarns with higher twist factors had higher elongations at break. The spinning speed affected the elongation in that it was lower for yarns spun at greater speeds.

The yarn levelness was somewhat below average (using Uster standards) being the lowest at 60% mohair. The spinning waste indicated that more mohair was extracted by the aspirators during spinning. Spinning waste was of the order of 1 to 3%. Visual assessment established a direct relationship between mohair content and yarn hairiness.

Subsequently, the spinning performance of BSFH mohair (37 microns) on the Continental system was investigated. It was established that a minimum regain value of about 16% was necessary for a reasonable spinning performance. The performance improved markedly when as little as 10% (by weight) of a coarse wool (26 microns or 30 microns) was mixed with the mohair.

The influence of various *additives* during spinning was also investigated. Additives with antistatic properties which increase interfibre friction and sliver cohesion gave the best results. A good measure of the performance during spinning can be obtained by measuring the withdrawal forces of the slivers, using the apparatus developed by SAWTRI. The higher the withdrawal force the better the spinning performance. Additives such as Durosil and Silic of Messrs Hansawerke and Leomin KP of Hoechst are very suitable.

Backwashing improved the lustre of mohair. The backwashing of mohair is rather difficult and in order to make such a proposition more practical, an insertion of twist in the tops would ensure a more trouble-free passage through backwashing.

Great care must be taken during gilling to ensure that the slivers going into the fallers are equally spaced. If the concentration of fibres is, say, more on the sides, the sliver emerging from the front rollers will be stronger on the outside than in the centre region. During the next process, when the sliver is pulled out of a can, the centre part of the sliver will sag out, causing the sliver length to be longer down the middle than down the sides. If the sliver spacing going into the gill box is really bad, the sliver may split up during the subsequent process causing justifiable concern.

Due to the lack of control, irregularities can easily be introduced and the number of passages must, therefore, be limited. Three drawing stages should not be exceeded. It is also important to make a reasonably strong roving. Apart from the additional strength obtained by using additives, a fine, twistless roving is too weak to withstand the strain when it is pulled off the bobbin during spinning. The amount of roving per bobbin must also therefore, be limited because a heavy package will possess a higher inertia. The creel construction also plays a rôle and the umbrella type is probably the best where no fibres can constrict the movement of the slowly rotating package. Care must be taken at all times to ensure that the package can revolve easily.

Mohair yarns are known for their *hairiness*. The higher the spinning speed the more hairy the yarn. Excess hairiness is to be guarded against because it interferes with the traveller movement. Spinning speeds should therefore not be excessive. If the yarn package is too thick, the hairs on the package push the traveller forward, causing it to rotate at such a high speed that no winding-on takes place. The balloon, therefore, gets, bigger until it is snagged. This problem is overcome by using a heavier traveller than usual, which will increase the friction, assisting the traveller to maintain the lag necessary for winding-on to take place. By decreasing the package diameter the hairs will interfere less with the traveller movement, thereby reducing this problem even more. The number of *winding operations* should be kept down to a *minimum* and dyeing should preferably be executed prior to the yarn stage.

In a study of the spinnability of various types of mohair on the *Bradford system,* some interesting facts emerged. Four lots of mohair having the same diameter (approximately 33 microns) but varying in length (7.3 cms to 11.99 cms m.f.l.) and three lots, having the same length (approx. 10 cms m.f.l.) but varying in diameter between 29.1 and 42.0 microns, were spun on the cap, ring and flyer systems, respectively. Prior to spinning the drawing stages comprised a spindle gill, a draw box, a first reducer and a second reducer. In addition to these spinning systems, some rovings from the second reducer were also spun on a double apron Rieter ring spinner.

As regards the influence of *fibre diameter* and *fibre length,* the following observations were made. Yarns spun from the finer fibres had a greater strength and extension at break, and were more regular. The longest fibres produced the strongest yarns. Extension at break and yarn irregularity were found to be independent of fibre length.

Flyer spun yarns were consistently weaker than their ring or cap spun counterparts. The cap spun yarns turned out to be strongest followed by ring spun yarns. The flyer spun yarns exhibited the lowest extension at break.

The idea of spinning a low twist mohair roving on the double apron Rieter proved to be a commercially viable proposition. These yarns were the most regular of all the yarns spun and the yarn hairiness compared very favourably with the best yarns spun on the Bradford system.

In respect of *spinnability,* the number of ends down for cap spinning was consistently lower than for ring spinning. Also, finer yarns could be spun on cap than on ring.

Cap spun yarns were found to be *more* hairy than ring spun yarns. The difference in hairiness between a flyer and a ring spun yarn is more subtle with the flyer spun yarn being the better of the two. Yarns spun from the finer fibres were less hairy. For both cap and flyer spun yarns, a lower mean fibre length produced a more hairy yarn. Increased yarn twist also reduced hairiness. Higher twist rovings produced less hairiness on the Bradford system. Of course, high twist rovings could not be spun on the Rieter

Mohair yarns, spun on the worsted system, are often said to be too lean. This lack of bulk is due largely to the straightness of the mohair fibre. An obvious way of increasing the bulk would be to crimp the fibres artificially. Until quite recently, however, this has not been technically possible but recently the I.W.S. developed a method by means of which fibres can be crimped artificially.

It has been found that this method whereby wool fibres are crimped artificially can also be used on mohair. In a trial the differences in bulk and processing performance between a natural and an artificially crimped mohair blend were examined.

Both blends were made up from 75% BSFH mohair and 25% Corriedale, the main difference between the two being that the one was artificially crimped. The crimping increases yarn diameter and gives the resultant fabric a fuller handle. However, the number of ends down during spinning favoured the natural blend.

THE DYEING BEHAVIOUR OF KEMPY MOHAIR

The main feature of a kemp fibre is the wide latticed medulla in which the spaces within the lattice are formed by the collapse of the cells of the medulla. This medulla occupies most of the width of the fibre so that the cortex forms only a narrow ring inside the outer cuticle.

The presence of the medulla causes the kemp fibre to have a lower specific gravity than unmedullated fibres. It also causes the kemp fibre to have specific optical properties which facilitate its visual detection in undyed as well as dyed fibre assemblies. The difference in appearance of kemp fibres is sometimes put to use in the manufacture of fancy cloth or in the production of certain kinds of tweed. Generally speaking, however, the presence of these fibres is considered detrimental to the appearance of high quality wool and mohair worsted materials and they may effect the value of the clip in which they occur quite markedly.

In South Africa very little kemp is found in the major portion of the wool clip and only in the coarser types of mohair is the problem one of major concern. Manipulation of procedure in mechanical processing has produced some promising results but the removal of the kemp fibres by these methods is frequently not quite sufficient. As a result, the dyer has at times been called upon to investigate dyeing methods which would obscure the presence of the kemp fibres.

The frequently expressed contention that kemp fibres do not dye at all is erroneous. The protein material in kemp is capable of absorbing dyestuffs and, although experimental evidence is scant due to the scarcity of samples of pure kemp, there appears to be little difference in the dyeing behaviour of the keratin in kemp and in mohair. It has also been suggested that if kemp does, in fact, absorb dyestuffs, the rate of absorption is so much lower than that by mohair that a pronounced difference in shade results. This, in turn, would create the impression that the kemp fibres are undyed. This assumption is presumably based on the known fact that coarser mohair fibres dye more slowly than finer ones and, considering the very large diameter of kemp fibres, the above deduction seems logical. However, it must be remembered that the dependence of dyeing rate on fibre diameter is based on the inverse relationship between fibre diameter and the ratio of surface area (A) per unit mass (m), i.e. A/m. Thus, as the fibre diameter decreases the A/m ratio increases with the result that a given weight of fibre material offers a larger area through which dyestuff absorption can take place. This results in an increase in the rate of dyeing. The relationship between diameter and the A/m ratio does not apply to kemp fibres which, because of the presence of the medulla, have much greater A/m ratio's than other coarse but unmedullated fibres. For example, simple calculation shows that a kemp fibre of diameter 100 microns and with a medulla diameter of 85 microns has the same A/m ratio as an unmedullated fibre of diameter 28 microns. It follows that kemp fibres, although much coarser than the mohair fibres in a sample, will dye relatively rapidly and at a rate similar to that of the finer mohair. This reasoning has been substantiated by experimental evidence.

Thus, one must conclude that the conspicuousness of kemp in a dyed sample of mohair cannot be due to dyestuff not being absorbed by the kemp fibres or by being preferentially absorbed by the mohair. The actual explanation is one based entirely on the manner in which light is reflected from within the fibre. When light falls onto a coloured material, part is reflected while part is refracted. The latter is reflected at various levels within the fibre and emerge as scattered coloured light. The colour of the scattered light is dependent on the nature and concentration of chromophores in the fibre and also on the length of the light path through the material. The longer the average light path, the deeper is the colour. For this reason coarse fibres appear deeper in shade than finer ones, dyed to the same strength. Kemp fibres, although of large diameter, contain very little solid substance and the path length of the light through the material is thereby decreased. Furthermore, it is known that the light reflects from the surface of the medulla and this decreases the path length even further. Because of these features, undyed kemp fibres have a chalky white appearance while dyed ones appear so much lighter in shade than mohair dyed to the same strength, that the impression is often created that the former are completely undyed.

Since the difference in appearance of dyed kemp and mohair fibres is based on a difference in colour saturation, hues in which such differences are less easily detectable are most suitable for camouflaging kemp. Differences in saturation in samples dyed yellow are more difficult to detect than in other colours and yellow is accordingly the most suitable colour for obscuring the presence of kemp in mohair. Green and red are less suitable than yellow but are better than blue while brown and black give very high contrast between the kemp and the mohair fibres. A further observation has been that the contrast in the appearance of the fibre types can be reduced if pastel shades are used and that differences increase with increasing colour saturation.

FACTORS IN DYEING MOHAIR

It now seems to be accepted that the higher rate of dyeing of finer fibres results from their larger surface-to-weight ratio, while it is considered that the increase in depth of shade with increasing fibre diameter is due to the increased thickness of the coloured material through which the reflected light passes.

The influence of fibre diameter on the rate of dyeing and on the depth of shade of the dyed fibres is a characteristic of all types of fibres and these phenomena must therefore apply to both wool and mohair. The relative rates of dyeing

wool and mohair and the relative depths of shade of dyed wool and mohair fibres of equal diameter have evidently not yet been investigated.

These two fibre types are composed of proteins which are remarkably similar in many respects, and therefore if the dyeing behaviour of wool and mohair fibres of equal diameter differ, a reasonable assumption would be that such variations are due to the large morphological differences between the fibre types rather than to the slight dissimilarities in the constituent proteins.

It is a general contention that mohair fibres, and in particular the fine fibres obtained from very young angora goats, contain a larger ratio of ortho-cortex to para-cortex than do merino wool fibres. It is also known that the ortho-cortex is generally more accessible to dyestuffs than the para component, a fact which is frequently utilised to distinguish between the cortex components by preferential staining. In view of these facts it was hardly surprising to find that the rate of dyeing of mohair fibres exceeded that of wool fibres of equivalent diameter.

The depth of colour of dyed mohair is deeper than that of wool fibres of equal average fibre diameter. The depth of colour of a surface depends on the extent to which it is penetrated by light, and this in turn is governed by the dimensions, structure and refractive index of the material of which the surface is composed. As already pointed out, the basic proteins of which wool and mohair are composed are similar; also, on immersing wool and mohair fibres in o-dichlorobenzene both fibre types became transparent. This observation shows that there is little, if any, difference in the refractive indices of wool and mohair, and it would therefore appear that the difference in depth of shade between dyed wool and dyed mohair fibres of equal diameter is predominantly the result of the difference in the surface structure of the fibre types. Mohair is readily distinguishable from wool by virtue of its lustrous appearance. It is therefore proposed that the difference in depth of shade of dyed wool and mohair is caused by the more lustrous (or glossy) surface of the mohair.

To conclude, for both wool and mohair fibres, the rate of dyeing decreases with increasing average fibre diameter.

The rate of dyeing of mohair fibres is greater than that of wool fibres of equivalent diameter. For both wool and mohair fibres, the depth of shade of fibres containing the same concentration of dyestuff increases with increasing average fibre diameter.

Mohair fibres appear deeper in colour than wool fibres of equal average fibre diameter containing the same concentration of dyestuff. This phenomenon is probably owing to the difference in the surface structures of wool and mohair fibres.

THE WEAVING AND FINISHING OF LIGHT WEIGHT WOOL/MOHAIR WORSTED FABRICS

Due to the hairiness of mohair yarns, weaving poses some problems. As the warp yarns pass through the heald eyes, surface fibres accumulate on the yarns in piles creating warp breaks. This presents the well known phenomenon of 'buttoning-up'.

The finishing procedure of light weight wool/mohair fabrics is a highly secretive affair and it would appear that reputed firms have constructed special machines (or techniques) to accomplish a highly lustrous, resilient cloth.

The following sequence of finishing operations was found to give a commercially acceptable fabric:

Crabbing at the boil
Piece scouring (open width, if at all possible)
Steaming and brushing
Shearing (latter two operations can be repeated, if deemed necessary)
Blowing (decatising)
Hydraulic pressing
Autoclave setting (KD Process).

An attempt was also made to establish whether increasing amounts of mohair in a worsted wool/mohair fabric, gave improved wrinkle resistance and recovery.

With this view in mind, pieces were woven and finished identically, but containing 20%, 40% and 60% of kid mohair, the remaining percentages being 64's quality wool. Laboratory tests on wrinkling did not show any significant differences, and these seemed to be borne out by wearer trials. Increased proportions of mohair did, of course, improve the lustre and sheen of the fabrics.

LENO WEAVING

For the manufacture of sun filter curtaining, using the principle of leno weaving, mohair proved to be eminently suitable. The very lowest qualities of mohair can be used successfully. Urine-stained mohair can be blended in to achieve special effects.

THE USE OF MOHAIR IN UNCONVENTIONAL TECHNIQUES OF FABRIC MANUFACTURE

Previously, reference was made of the problems associated with the weaving of mohair yarns due to their hairiness.

This problem had been completely overcome by using the Co-we-nit technique of fabric manufacture. In this technique, which is a combination of weaving and knitting, use is made of four guide bars. The yarns used on bars three and four are merely laid in and no difficulties are experienced with problems such as hairiness and buttoning-up. In fact, mohair is ideally suitable for the manufacture of upholstery, curtaining (especially sun filter) and dress materials using the co-we-nit principle. In this field SAWTRI has given the lead to the rest of the world – high class

fabrics, having a three-dimensional character, have been produced whereby a new era for the production of materials from mohair has been introduced.

Initially, mohair of the BSFH type was mainly used. Subsequent work proved that for end-commodities where the handle is not of major importance, the very coarse types of mohair can be successfully used.

REDUCING ROUGHNESS IN COARSE MOHAIR FABRICS

Garments and blankets made from fabrics containing coarse mohair fibres are sometimes avoided on account of roughness or scratchiness. It is believed that the scratchiness of these materials arises because the high resistance of the coarse fibres to blending causes them to protrude more than finer fibres from yarns into which they have been spun. On contact with the wearers' skin, these stiff, protruding fibres do not yield in the way fine fibres do, but instead, irritate the skin, thereby causing discomfort.

If the scratchiness problem could be eliminated or reduced, some of these coarse fibre types would be eminently suitable for the manufacture of fabrics for specific uses. For example, coarse, 'washing types' of mohair, when mixed with 15% Corriedale wool to improve its spinning performance, can be used for the manufacture of attractive knitted shawls with a typical mohair appearance.

Some improvement in scratchiness was observed when the fabrics were vacuum-steamed after a 2% (v/v) aqueous solution of ethylene glycol had been padded on to effect a 100% pick up. Substantially improved effects were, however, obtained by padding on an aqueous solution containing 2% (v/v) ethylene glycol and 1% (w/v) sodium bisulphite (100% pick up) and subsequently vacuum-steaming (10 cm vacuum and 10 min steaming at normal pressure).

A similar treatment with a solution containing 1% sodium bisulphite, but without the ethylene glycol, did not decrease the scratchiness of the fabrics. The finish produced by the ethylene glycol-bisulphite treatment survived drycleaning quite well, but the effect was destroyed by laundering.

It is true that many of the fabrics produced from the type of fibres in question would normally be drycleaned rather than laundered. Nevertheless, enquiries indicated that the number of fabrics which would normally be washed was sufficiently large to justify the development of the finish into one which is also fast to laundering.

This objective was achieved by the discovery that polyvinyl alcohol can be employed instead of ethylene glycol in the procedure described above. The handle of the treated fabric is seriously affected by this treatment, but fortunately it is restored when the fabric is washed after steaming. Normal laundering in an automatic domestic washing machine of the drum type using any one of a number of commercial washing powders proved to be suitable for this purpose. Subsequent laundering – total washing times of up to five hours were investigated – did not cause any increase in the scratchiness of the fabrics.

MOHAIR AND THE FUTURE

Although mohair forms a bare 0.1% of the world production of textile fibres, it has not lost ground in the textile world, thanks to effective research and promotion. This fibre is finding increasing use in a diversity of end-commodities. It is no longer a fibre which can only be used in luxury articles but finds it way successfully in articles used in everyday life: blankets, upholstery, curtaining, fully-fashioned sweaters, ladies' skirts, etc.

As research and promotion progress, the use of this noble fibre will be exploited to its full capacity.

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