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DEVELOPMENT OF NONWOVEN TEXTILES

SI/HUN/74/809

HUNGARY.

Technical report: Introduction of production of chemically bonded nonwoven textiles (webs)

Prepared for the Government of Hungary,
by the United Nations Industrial Development Organization,
executing agency for the United Nations Development Programme

Based on the work of Philip A. Smith,
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United Nations Industrial Development Organization
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Explanatory notes

Except for the words "web" and "batt", none of the terms used in the present report will be unfamiliar to anyone with experience in the nonwoven fabrics industry. In the present report, "web" means only the sheet of fibres taken off the card; "batt" means the multiple layers of web from a cross-lapper or the sheet of fibres taken from an air-lay or paper machine.

References to "tons" indicates metric tons.

The following abbreviations are used:

CV	coefficient of variation
m/min	metres per minute
m^2/year	square metres per year
rev/min	revolutions per minute
SD	standard deviation
U	Zellweger-USTER unit of fibre fineness

The Hungarian monetary unit is the Forint (Ft). During the period of this mission its value in relation to the United States dollar ($) was $1 = Ft 20.83.

ABSTRACT

In May 1975 the Hungarian Ministry of Light Industry requested the United Nations Industrial Development Organization (UNIDO) to assist it, through an enterprise and the Hungarian Textile Research Institute, in the development of nonwoven products and processes.

The two-phase project, the first phase of which is reported here, "Development of Nonwoven Textiles" (SI/HUN/74/009)[1/] was approved in October 1975. An expert in nonwoven textile production went to Hungary for two months and completed his mission in September 1977.

The greater part of the work described in the present report has been concerned with a nonwoven line at a factory named Lőrinci Vattagyár, in Budapest. This line had recently been installed, and although it was already in operation, there were a number of faults in the machine settings and in some of the fabrics being produced. A good start was made in identifying the causes of these faults and in curing them, but this work is by no means complete. However, since this work is the main content of the project SI/HUN/74/009, it is hoped to complete this work next year. It is also hoped that methods of investigation established during the mission reported here will permit the factory staff to solve some of the problems themselves.

A report was presented on the use of nonwovens in the medical field in western countries, and this has been discussed with the staff of a factory producing medical products.

A report has been written suggesting alternative products to be made by Lőrinci Vattagyár.

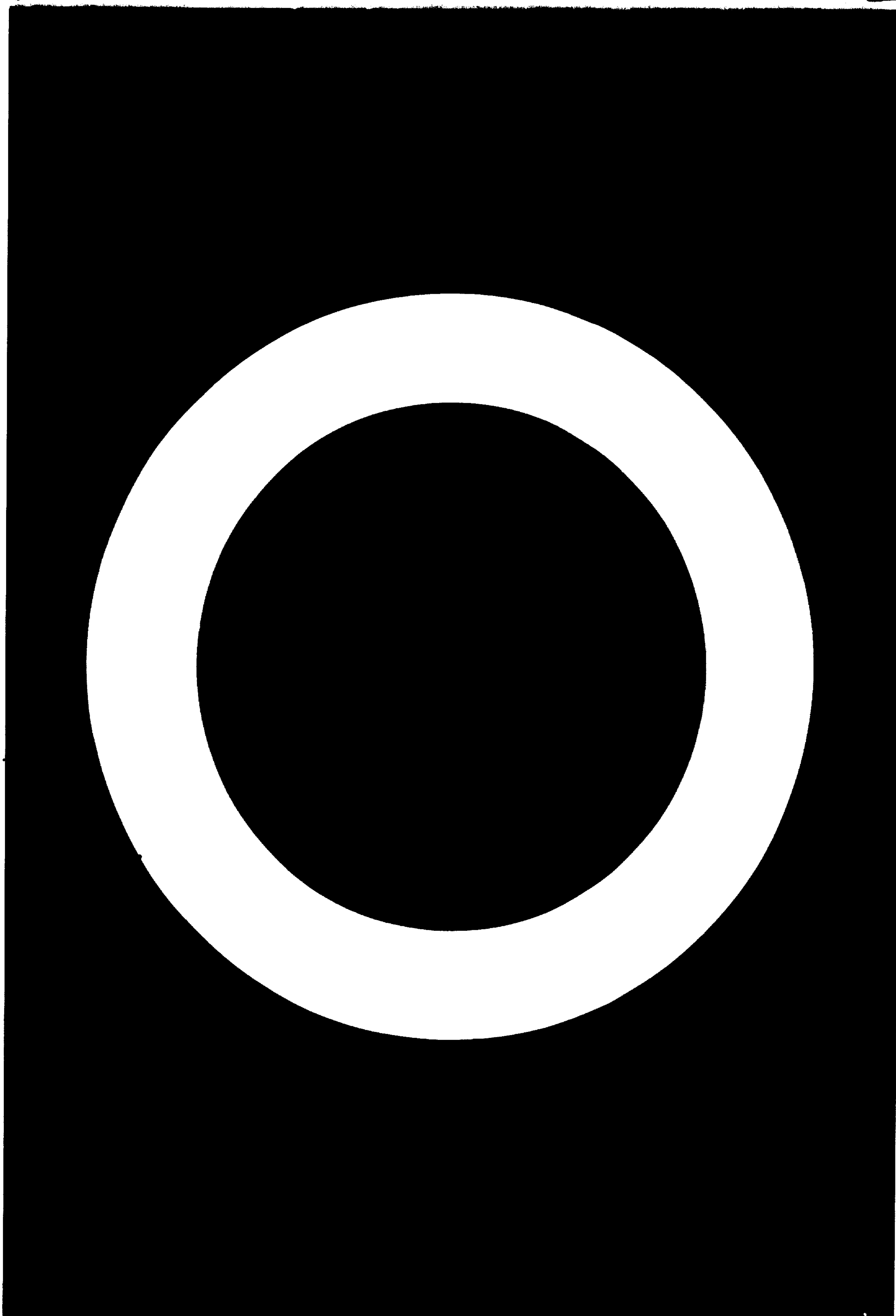
A report has been prepared summarizing the present situation in the nonwoven industries of Western Europe and North America.

The Hungarian Textile Research Institute has been visited, and possible uses for low-grade cotton and textile wastes have been discussed, and recommendations were made.

Two other nonwoven plants were visited and technical problems have been discussed with their staffs.

Initial plans for a new non-woven line to be installed at Lőrinci Vattagyár have been discussed. The initial recommendation will be submitted as soon as possible.

1/ On 1 January 1977 the project number was changed from IS/HUN/74/009 to SI/HUN/74/809.



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INTRODUCTION

Project background

In 1974 the annual production of chemically bonded nonwovens in Hungary was 2.5 million m^2, of which 90% was used for interlinings. The Ministry of Light Industry planned to increase the production by 7 million m^2, of which 60% would be interlinings. The original objective of the mission reported here was to select machinery for the new production, but this had to be modified, as explained below.

In addition, the Hungarian Textile Research Institute was currently working on two problems. The first was how to use cottons of grades 4, 5 and 6 in the most cost-effective way in the textile industry, one possibility being to use some or all of it in the nonwoven industry. The second problem is that, at present, the total annual amount of textile waste available in Hungary is greater than the consumption of waste by the textile industry. It is therefore essential to find additional ways of using this waste, some of it, possibly, in the nonwoven industry. The second object of this mission was to advise the Hungarian Textile Research Institute on these two problems. As far as is known, no previous work has been done in this area except by Hungarian investigators.

Objectives of the mission

In May 1975 the Hungarian Ministry of Light Industry requested the United Nations Industrial Development Organization (UNIDO) to assist it, through an enterprise and the Hungarian Textile Research Institute, in the development of nonwoven products and processes. The two-phase project "Development of Nonwoven Textiles" (SI/HUN/74/009)[1/] was approved in October 1975. An expert in nonwoven textile production was sent to Hungary for two months, completing his mission in September 1977.

The original objective of the mission was to select machinery for a nonwoven line to be installed in the factory Lőrinci Vattagyár. Since this machinery was already installed and in operation when the expert arrived, it was necessary to modify the terms of reference of the mission by bringing forward some work that had originally been scheduled for a subsequent mission (SI/HUN/74/009), and also adding a new element, namely the selection of machinery to produce

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1/ On 1 January 1977 the project number was changed from IS/HUN/74/009 to SI/HUN/74/809.

lightweight (15 g/m^2) nonwovens. Since the revised work programme (annex I) really combined a two-month project with a four-month one, it was never really envisaged that it could be completed. It is hoped, however, that the follow-up mission will be authorized so that the entire project can be completed.

I. FINDINGS

The nonwoven line at Lörinci Vattagyár

The accuracy of the weighing hoppers was not very high and should be improved (table 1).

Table 1. Test on weighing hoppers[a]

Viscose setting 200 g		Polyester setting 770 g	
	392		662
	240		728
	319		582
	330		740
	292		702
	408		720
	268		700
	304		740
	269		719
	255		719
Mean	307.7 g	Mean	701.2
Lowest	240	Lowest	582
Highest	408	Highest	740
Standard deviation	56.25	Standard deviation	47.65
Coefficient of variation	18.3%	Coefficient of variation	6.8%

Note: The mean is almost exactly 30%, but it could vary from 24.5% to 41.2% in individual weighings.

a/ Viscose content (per cent): lowest, 24.5; highest, 41.2.

The automatic blending bin was running almost empty because the floor-lattice was running at too high a speed.

The long-term regularity of the fabric produced was not very good. It was thought that this fault originated in the chute feed, which was more suitable for feeding cards at very high production, and that the condition would be made worse by the irregular feeding of waste and by starting and stopping the line.

Table 2. Test on chute feed

Tests taken every hour. Material VI, 30 g/m^2.

Chute settings 110 g; 105 g; 10 g. No waste fed during the period of trial.

Time (hours)	Weight (grams) of the material at chute feed	Batt weight (grams) ($\frac{1}{4}$ m^2)	Fabric weight (grams) (a) ($\frac{1}{4}$ m^2)	Fabric weight (grams) (b) ($\frac{1}{4}$ m^2)	Difference (a-b)
10	1 980	6.2	8.1	7.8	.3
11	2 030	5.5	7.4	7.5	.1
12	1 900	6.0	7.5	7.6	.1
13	2 045	6.0	7.3	8.0	.7
14	2 190	6.0	7.7	7.9	.2
15	1 900	6.0	7.7	7.7	.0
17	2 035	6.2	8.0	8.0	.0
18	2 110	5.7	7.7	8.0	.3
19	2 145	6.0	8.2	8.0	.2
20	2 205	6.5	8.0	8.0	.0
21	2 195	6.0	8.2	8.0	.2
22	2 165	6.5	8.5	7.7	.8
23	2 065	6.0	8.2	8.5	.3
24	2 105	7.0	8.2	8.0	.2
1	2 055	6.2	8.5	8.0	.5
2	2 075	6.5	8.0	8.0	.0
3	2 105	6.5	8.0	7.5	.5
4	2 035	6.2	8.0	8.0	.0
5	2 055	6.2	8.2	8.0	.2
7	2 085	6.5	8.7	8.5	.2
	41 480	123.7	160.1	158.7	4.8
	Mean 2 074	Mean 6.18	Mean 8.0	Mean 7.9	Mean .25

	Chute feed	Batt weight ($\frac{1}{4}$ m^2)	Fabric weight ($\frac{1}{4}$ m^2)
Lowest value (g)	1 900	5.5	7.3
Highest value (g)	2 205	7.0	8.7
Per cent difference	11	13	12
Standard deviation (g)	85.2	0.33	0.32
Coefficient of variation (per cent)	4.1	5.4	4.0

Since there was no known method of testing the regularity of a chute-feed to a nonwoven card, one had to be devised. After some trial and error, a suitable method was found, and a 24-hour test was run on the machine line. This test showed that, with no waste being fed, the long-term regularity was satisfactory on the quality (VI) tested (table 2).

The carding machine was found to be in very good condition and to be producing a high-quality web. Its only fault was that it was producing too much waste.

The cross-lapper was in very good condition and produced a good batt, with the exception of slight creases near the edges. These were very difficult to avoid, but it was thought that they were unimportant.

The Fehrer K 12 air-laying machine was found to be responsible for three types of faults. The most important one was that it caused short-term irregularity or "cloudiness" in the batt. The mechanical settings on the machine were changed, but very little improvement was found. The possibilities of changing the aerodynamic conditions were so wide that there was insufficient time to make alterations. (It should be explained that the faults only showed on certain types of products, and when other types were running no changes could be made. Furthermore, at other times the plant had to produce high-quality materials for export, so this again limited the time available for trials.)

The two other faults were the formation of small balls of fibre created by a rolling action between the swift and various stationary plates, and strings created by fibres catching either on the stripping rail or on the baffle plate and other fibres twisting around them. It was found that the removal of the baffle plate eliminated both of these faults, but unfortunately it increased the cloudiness.

Although it is possible to judge cloudiness visually, it was felt that some method of objective measurement was needed. Three methods were studied: weighing 10 x 10-cm pieces of fabric; weighing 5 x 5-cm samples and cutting a 1-cm wide strip on the machine and passing it through a Zellweger-USTER yarn-regularity tester. It was found that both cutting and weighing methods gave results with very wide confidence limits, so that a very large number of tests would be needed to get a significant result. The strip method gave a very accurate result but it required an extra knife to be fitted to the machine. Furthermore, the testing had to be done at the Hungarian Textile Research Institute.

The needle loom was found to have the stripper plate set too high, so that the needles remained in the batt too long. It also caused the batt to be shaken in the needling area. The loom speed of 300 rev/min was slow compared with the batt speed 9 m/min. Also, the needle pentration seemed to be rather low, even after allowing for the unusual position of the first barb.

The method of impregnating was by foam, applied from one side, the solid squeeze roller being designed to squeeze the foam through the batt into spaces cut into the engraved squeeze roller. Previous trials had shown that if a light, airy foam were used, the binder would not penetrate the batt completely. However, if a denser foam were used, the batt became too wet (300% add-on), which led to binder migration in the dryer. An intermediate type of foam was being used which gave some binder migration and rather less binder on one side than the other. However, this led to loose fibres and pilling on one side of the fabric and also to fabric delamination.

A more serious fault also occurred in the drier, which caused the fabric surface to be dotted at random with areas about 3- to 5-cm long and 2- to 3-cm wide, raised above the surface like bubbles. For simplicity, these will be referred to as "bubbles" henceforward.

These bubbles occured only with the fabric that contained the highest percentage of viscose. Also,they were found to disappear if the plant was run at about half speed (4 m/min instead of 9 m/min). The bubbles were also found to be strongly associated with thin places in the fabric. It was found that the viscose fibre shrank at least 3% in length on drying, and that the bubbles represented a length difference of only 1.5%. It is therefore thought that the bubbles were caused by different rates of shrinkage, which in turn were caused by different rates of drying in the thin and thick areas. There was no proof that this theory was correct, but it appeared to explain most of the observed facts.

The hot calender was not seen in operation, so no comments can be made about it. Although the print-bond unit was not seen in operation, it is worth commenting that the normal method of print-bonding is on to a wet batt. All pre-bond methods are regarded as expensive owing to the cost of operating the drier. The spray-bond unit was seen to be working very well and to be making a good-quality product. Other findings will be found in the reports of the weekly discussions with the plant management (annex II).

II. RECOMMENDATIONS

The weighing hoppers

It was already recognized that the weighing hoppers were inaccurate. Their accuracy could be improved by setting the evener roller closer to the inclined lattice, so that the stream of fibres would be thinner. The lattice could also be operated more slowly to reduce the rate of feed. This would also reduce the production rate of the hoppers, but this would be immaterial because the production rate was already far higher than was necessary.

The automatic blending bin

It had already been realized that the blending bin was not being used to best advantage. An order had already been made to reduce the speed of the floor lattice. This was correct. In addition, the position of the photo-electric cells should be moved so that the bin would be kept more nearly full.

Testing of chute feeds

Tests similar to that shown in table 2 should be done on each product, both with and without waste being fed, in order to check that the feeding of waste does not upset the operation of the chute feed. A similar test could also be run with the plant starting and stopping, but this may be considered rather negative, since the plant must be stopped from time to time and is never stopped without a good reason.

The feeding of waste

The first recommendation is that a trial be made to reduce the card waste by reducing the suction of the fans. Care must be taken that this reduction does not affect the quality of the card web. Tests on the card waste showed that the short fibre content was very low, so there was no objection, from a quality point of view, to re-feeding card waste. However, this material was more open than the raw fibre and could thus disturb the operation of the chute feed. It was therefore most important that waste be fed continuously not intermittently. Suitable feeding points are the weighing hopper for the major component and the blending bin. Which ever method is chosen, the effect on the long-term irregularity should be checked, as suggested above.

The Fehrer K 12 air-lay machine

The short-term regularity of this machine should be improved. The two following methods should be costed and the cheaper one chosen: either to call in an expert from the supplier, who should be in a position to make the alterations quickly but who would probably charge highly for them, or to have the alterations made by the plant staff, using either visual assessment or the 1-cm strip method to judge the results. The guiding principles are as follows:

The top fan strength and the setting of the main air guide should be just sufficient to keep the swift clear, and no stronger.

The suction from below should be stronger than the air currents above.

The baffle plate should be polished smooth and should be set at such an angle that strings are no longer formed.

It may be advantageous to reduce the length of the forming zone by placing a smooth plate under the screen.

Different products may need different settings.

Continuous measurement of weight per unit area

Instruments measuring the weight per unit area are being fitted to nonwoven lines, so it would be worth while to cost devices of either the capacitance type (Zellweger-USTER in Switzerland are the experts here) or of the β-ray type (Rico Verbandstoff Werke, Budapest, have an instrument and could advise on its operation). Either system would give a continuous record and would permit irregularity to be measured. At more expense it would be possible to apply automatic devices to control irregularity over the very long term.

Future testing of short-term irregularity ("cloudiness")

Two other methods are available:

Cutting and weighing 10- x 10-cm samples. For statistical reasons, between 400 and 1,000 measurements would be needed to get a reasonably accurate result. The other is the 1-cm strip method. A decision must be made as to which method would be the more convenient.

Needle loom settings

It is recommended that the following changes be made, one at a time, in the order given here, in each case returning to the previous setting if conditions get worse for any reason:

Reduce the height of the stripper plate until there is just sufficient room for the batt to pass through freely. This change is intended to make the needles release the batt earlier, since they cause an intermittent stretching of the batt.

Increase the penetration of the needles by raising the bed plate in steps of 1 mm until adverse effects are seen, then move down 1 mm. It might be necessary to alter the stripper plate at the same time, depending on the exact design of the needle loom. This change is intended to increase the effect of needling and to mitigate the delamination problem.

Increase the speed of the needle loom to 800-900 rev/min, which is far enough below its rated maximum speed of 1,200 rev/min to create no problems. This change is intended to cause the needles to release the batt more rapidly, but it will also increase the total needling effect. If the needling is now found to be excessive, it should be reduced either by reducing the penetration of the needles or by removing alternate rows of needles.

If lines of needle marks appear, running across the batt, this indicates that the batt advance (stroke of the needle loom) is equal to or a multiple of the needle row spacing. The speed of the loom should be altered slightly without altering the batt speed.

The life of the needles appears to be in the region of 2,000 to 3,000 hours, since they do very little work. To check, it is necessary to examine one or two needles under a microscope, looking only at the first barb. When the life is determined, needles should be changed according to a schedule, changing alternate rows of needles at intervals equal to half of the needle life. It would be necessary to keep a log of the number of hours the needles are used in order to plan the changes.

The infra-red unit

It is recommended that the most suitable fibre to use on the infra-red bonding unit is a bicomponent polypropylene fibre obtainable from Japan. (There may be other sources.) A bicomponent fibre is recommended to avoid collapse of the batt, and polypropylene is recommended because it is easy to bond without degrading the fibre. If, after trials, it is found that the fabric produced is not cost effective, attempts should be made to sell the whole unit to another factory. There appear to be no units of this type operating in Western Europe, but Hungary may lead in this respect.

The impregnation unit

In order to avoid a one-sided nature of the fabric, it is recommended that foam be applied to both sides. In order to reduce migration, the lightest foam should be used that will penetrate completely to the centre of the fabric. The gap between the impregnation rolls should be reduced to the minimum, again with the intention of reducing the moisture content after impregnation in order to reduce migration. If the foam is applied from both sides, the engraved roller would no longer have any purpose. There should be a trial in which the engraved roller is covered with fabric to simulate a smooth roller. The reason for this is that the engraving tends to hold foam and then release it to the batt after squeezing has taken place. It is thus difficult to get a low moisture content using an engraved roller. The use of two smooth rollers and foam application from both sides is a very practical method of impregnation.

Bubbles and drying conditions

If the Fehrer K 12 machine can be made to produce a more even batt, the problem of bubbles should disappear or at least be reduced. If bubbles still continue to form it would seem that the only solution would be to dry the fabric while it is held under some width-wise tension. Possible ways of doing this are:

> To run the drier at very low temperature so that the fabric does not reach the critical moisture content until it has been expanded by the flexible roller and can then be dried in close contact with the drying cylinders.
>
> It might be possible to hold the fabric tight against the drier lattice by means of a strong downward air current. However, the fabric would have to be released at each end of the drier, so it would be important that the critical moisture content be attained in the middle of the drier rather than at the end. It is suggested that this occur in the middle of the second layer, since drying would be far too rapid in the middle of the first layer.
>
> Bubbles could be allowed to form and then be ironed out on the cylinder drier. This procedure would involve damping the fabric in some way at the print-bond unit and re-drying.

Since all of these methods involve holding the fabric against a cross-direction tension during drying, they are likely to lead to shrinkage on re-wetting; that is, instead of expanding by 3% and returning to normal length, the fibre would expand by about 1.5% and contract permanently by 1.5%. It is important to make sure that this effect would not seriously affect the end-use.

For a similar reason, the tension in the machine direction should be kept as low as possible, particularly because machine-direction tension encourages cross-direction shrinkage. Ideally, the machine-direction tension should be just great enough to prevent shrinkage taking place in that direction.

Alternatively, if the bubbles are effectively removed by improvement of the Fehrer batt, the drying conditions should be adjusted to eliminate migration. This indicates lower temperatures, just high enough to dry the fabric completely (120°-130°C).

The print-bond unit

Experiments should be made to print on to a wet web, these products being compared with the pre-bond ones. The batt could be wetted at the liquid impregnator and carried through the cold drier to the print-bond unit. The spread and penetration of the binder can be controlled by many factors including: the moisture content of the batt, the viscosity of the binder and the addition of coagulating salts to the impregnating water.

Recording machine running time

In order to determine running efficiency and to establish the principal causes of stoppages, a book should be kept in which the time and duration of each stoppage is recorded, along with the reason for it. Such a record might point up particular parts of the machine that require special maintenance or additional spare parts.

Planned maintenance

A scheme of maintenance should be introduced that would ensure that each key part of the entire machine would be examined at a regular interval, the length of which would be determined by its expected life. An important aspect of the plan would be that any part found to be slightly worn or known from experience to be reaching the end of its serviceability would be replaced at the maintenance period rather than waiting until it breaks. While such a policy would cause an increase in the expenditure for spare parts, experience has shown that it would be more than compensated for by increased operating efficiency and the reduction of secondary breakages, that is, breakages of other parts owing to the failure of a first one.

Development of new products

Some form of new product development should be initiated within the Hungarian industry. The expert was unfamiliar with the financial and commercial structures of the country, so he could not specify exactly how this should be done. However, the system described below is used in Western Europe and functions very well.

Every firm employs salesmen, their number constituting from 0.5% to 1% of the total labour force of a firm with a few large customers to 5% or more when there are many small ones. In addition to selling, these men form an essential link with the customers, forecasting future demand and bringing back ideas of what the customers want. These demands may be for entirely new products, modifications of existing ones or copies of or substitutes for competitive products. The salesman is also always looking into other areas and visiting other firms to find new applications for the goods that he sells. Once a new need has been identified, it becomes the function of the development department, which makes a new product and passes in back to the salesmen, who then have the task of discovering whether it can be sold at a price and in sufficient volume to be profitable.

This system works very well in bringing new goods into production quickly and avoiding the waste of time and effort in developing uneconomic ideas. There is no readily evident reason why such a system should not be used in a centrally planned economy, and perhaps it already is. The long-term future of a factory depends very much on its sales and development sections and on co-operation between them.

Miscellaneous

The terms of reference of the mission (annex I) provided that the expert was to prepare and submit studies in certain fields. These studies have been completed and are attached to the present report as annexes III through VII.

Quality control

A definite quality-control system should be worked out on statistical principles; that is, within 2 and 3 standard deviation limits, taking into account the limits set by the customers. Such a system is presented as annex VII to the present report.

Recommendations for the new production line

Owing to the time spent more urgent work, this aspect of the mission was not completed. However, the expert has continued this work at Leeds and has kept in touch with Lőrinci Vattagyár by mail and telex.

Other recommendations

The recommendations of the expert concerning the use of waste and of low-grade cotton etc. are presented in annexes to the present report and are therefore not repeated here.

Annex I

WORK PROGRAMME

To study the machinery line at Lőrinci Vattagyár to make suggestions for improving its efficiency, and in particular to try to correct the one-sided nature and uneven surface appearance of the product when a high percentage of viscose is run and to attempt to run 100% viscose.

To suggest other products that could be made on the line

To visit the Hungarian Textile Research Institute and, in collaboration with it or with Lőrinci Vattagyár, to develop a method for testing the fleece (batt after air lay) produced by the Fehrer K 12 air-lay machine.

To attempt to improve the regularity of the output of this machine.

To summarize the present situation of the nonwoven industry in western countries.

To collaborate with the Hungarian Textile Research Institute in investigating the use of low-grade cottons and waste fibres in nonwovens.

To make the needed inquiries and, if possible, to prepare a plan for developing a machine line to produce lightweight (15 g/m^2) at Lőrinci Vattagyár.

To report on the use of nonwovens in hospitals in Western Europe.

To prepare a quality-control scheme.

To visit other nonwoven factories in Hungary.

To prepare a report of the completed mission.

Annex II

WEEKLY DISCUSSION MEETINGS WITH THE MANAGEMENT OF LÖRINCI VATTAGYÁR

Meeting of 31 August 1977

It was pointed out that the plant was unusual in having four bonding systems but only one web-making system. However, it was stated that this balance suited the limited markets of Hungary and also that, provided the plant could produce 7 million m^2/year, made up largely of 30 and 60 g/m^2 interlinings, it would make an adequate profit.

It was pointed out that the blending bin was running empty, and this would not give good mixing. Modifications were already ordered for this machine.

Chute feeds in general are not as regular as weighing hoppers over the long term because they feed a constant volume of fibres, and even with the vibrating sheet, the bulk density (grams per litre) of the fibres tends to change. It is true that they may be slightly better in the short term, but this would be corrected by the layering on the cross-lapper. It is surprising that Spinnbau recommended a chute feed rather than a weighing hopper.

The quality of the carding and the operation of the cross-lapper were very good.

The Fehrer K 12 air-lay machine had three faults:

The short-term regularity was poor. Unfortunately, this is a characteristic of air-lay machines making lightweight webs, but it is hoped to make some improvement with the help of a new system of measuring the irregularity.

The occurrence of "strings", which were thought to be formed by fibres catching on small snags on the machine, followed by other fibres joining them and forming "pseudo-yarns".

Small balls of fibre not present in the carded material. Since these are not present in the card web, they must be formed by a rolling action, either between two sets of rollers or between a roller and a stationary plate in the Fehrer K 12 machine.

The one-sided impregnation system did not appear to be a good idea. It seemed to lead to a fabric with too little binder on the lower surface and rather too high a liquid add-on. To correct either of these would make the other worse.

It is thought that the strength of the air-currents in the drier may be a cause for the bubbles. However, there are other possible causes that should be investigated.

It was suggested that the edge-waste could be collected pneumatically, because the operative had some trouble collecting it when the cutting knives were running blunt.

In order to check on the running efficiency and the causes of stoppages, it would be useful to keep a sheet noting when the machine stopped, why it stopped and when it was re-started.

In order to reduce mechanical breakdowns it was suggested that a system of planned maintenance be set up. Basically, every machine part should be inspected regularly at periods determined by the expected wear life. Any part thought to be likely to break before the next inspection should be replaced. The slight increase in the cost of spare parts would be more than paid for by increased running time. This is particularly true of a nonwoven line, where the stoppage of any one machine puts entire line out of action.

Discussion 7 September 1977

The Fehrer K 12 air-lay machine and short-term irregularity

It was shown that, with the baffle plate in position, some fibres continued to cling to the tambour, and these fibres eventually rolled into balls and fell onto the web. With the baffle plate removed, the swift ran clear and no balls were formed.

It was also found that no strings were formed, because fibres were no longer thrown back against the stripper rail. However, it was found in production that there was excessive fly, so it was decided to find a suitable combination of air currents or position of the baffle plate to satisfy all conditions.

It was thought that the short-term irregularity or cloudiness was caused by the feed roller of the K 12 releasing clumps of fibre instead of single fibres to the tambour. Unfortunately, a cross-lapped batt is difficult to feed, because fibres are almost parallel to the feed roller. A telex from Fehrer stated that settings down to 0.0 mm could be used between the feed roller and the feed plate, and it was agreed that closer settings would be tried.

Long-term irregularity

A number of methods for testing the weight per unit area at the chute feed were discussed. There is no standard method of doing this on a nonwoven card. Ideally, it would be desirable to test while the machine was running, but it may be necessary to do tests only when the machine stops or to stop the machine briefly while the test is made.

It was pointed out that another cause of long-term variation was the speed of various lattices compared with the fixed-input speed. It was agreed that the material could be sometimes stretched sufficiently to cause a width shrinkage of 5 or 6 cm.

Bubbles and drier adjustments

The air speed in the lowest section of the drier had been reduced, and it had been found that many fewer bubbles had been formed, though the fabric had not been perfect. However, there some unknown change occurred, and the fabric went back to its original state. It was not possible to determine the nature of this change.

Subsequently, the whole drier was re-set to produce lower air speeds, with the top and bottom jets balanced to give a slight downward pressure. The secondary air supplies into the drier were all closed. These alterations had no noticeable effect on the appearance of the fabric.

It is intended to investigate the bubbles further by means of cross-dyeing to show up concentrations of viscose, concentrations of bonding agent and the weight per unit area of the bubbles compared with the fabric on average.

Measurement of short-term irregularity

Experiments are being made to compare: weighing 10 x 10-cm samples, weighing 5- x 5-cm samples and cutting a 1-cm-wide strip on the machine and feeding it through a machine for measuring yarn irregularity (Zellweger-USTER).

In the first test, 5- x 5-cm samples gave a coefficient of variation only 1.5 times greater than the 10- x 10-cm samples (theoretical value 2), so further tests are being made to see if the first result is correct. The strips have been delivered to the Hungarian Textile Research Institute but no results were available when the present report was being written.

Card waste

The question of the quality of card waste will be discussed further.

Discussion of 16 September 1977

Long-term irregularity

A successful method has been developed for monitoring the regularity of the chute feed. Other possible causes of long-term irregularity are:

> Changes in the foam density or solid contents of the binder; suitable methods for measuring these were discussed
>
> Changes in the stretch or shrinkage caused by changes in various lattice speeds. The second two causes would be investigated if the first cause proved to be negative

The Fehrer K 12

It was decided to set the "workers" at 0.5 mm following the manufacturer's recommendation. The feed roller would be set as close to the feed plate as possible without actually touching it. Following this, experiments should be made with the fan speed, the position of the air control and the angle of the baffle plate to obtain an even batt without faults.

The needle loom

The stripper plate should be lowered as much as possible.

At present the loom speed of 300 rev/min and the batt speed of 9 m/min meant that the batt was being stretched about 3 cm while the needles were in the batt. It was recommended that a higher loom speed (800-900 rev/min) be used, which should be well within the capacity of the machine.

Making allowance for the needle barbs being unusually close to the needle point, a slightly higher needle penetration of 8 to 9 mm was suggested.

The needle life in this application is difficult to predict, but it is suggested that the barbs be examined after 1,000, 1,500 etc. running hours, using a microscope. A life of at least 2,000 hours is likely, but needles should be changed by rows, not the whole board when a change is made.

The suggested needling conditions should reduce delamination, but if there appears to be too much needling, alternate rows of needles should be removed.

Bubbles

It was shown that bubbles were found in light areas of the web. It was also found that the final fabric expanded by 3.5% when wetted without tension. Although it was impossible to measure the expansion of single fibres, since they were so short, the expansion and contraction of single rayon fibres must be at least as great as this. It was found by measuring across an area of bubbles that a stretch of 1.7% was sufficient to remove the bubbles completely. Since this figure was significantly below 3.5%, it was thought that the bubbles were caused by different rates of shrinkage, caused by different rates of drying in the lighter and heavier areas. It is intended to make tests to prove or disprove this idea as soon as the quality runs again.

Three methods were suggested to prevent or limit the bubbles. In order of preference these are:

To produce a more even batt on the Fehrer K 12, which should then cure the problem

To run the drier at a very low temperature, so that the fabric emerges in a damp state and the final drying is done on the cylinder drier after the fabric has been stretched by the expanding roller

To damp the fabric after the drier and dry it again on the cylinder drier

Both the second method and, particularly, the third one may lead to some shrinkage of the fabric after wetting, so that this aspect must be considered.

Measurement of short-term irregularity

Cutting and weighing 10 x 10 cm samples gave a result of 6.5% CV ±2% after 36 samples had been weighed.

With 5 x 5 cm samples the result was 7.6% CV ±1% after 300 samples.

Measuring with the 1-cm strip gave a % of 6.8% ±0.2% (CV% 8.5% ± 0.25%) with the baffle plate on and a U% of 9.2% ±0.2% (CV% 11.5% ±0.25%) without the baffle plate.

To obtain the same degree of accuracy would require about 2,000 weighings of 10 x 10 cm samples or 4,800 weighings of 5 x 5 cm samples.

Hence, the 1-cm strip method, which is equivalent to 1,000 weighings of 1 x 1-cm samples, is a far quicker method of obtaining a precise result, but it requires the use of an additional cutting knife and the services of the Textile Research Institute.

Alternative methods which could be considered in the future are the use of a capacity-type measuring gauge or a β-ray gauge, which could give a continuous record of the weight per unit area and could also be adapted to measure the irregularity either by taking a number of readings manually or automatically.

Measurement of long-term irregularity

It was decided to take a series of weighings of 50 x 50-cm samples cut at intervals from one batch roll in order to study the pattern of irregularity.

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Plans were made for a further experiment on quality V9 at high and low speeds.

It was pointed out that the weighing hoppers were not working very accurately, but that the accuracy could be improved by slowing down the rate of feed. This should be done either by setting the evener roller closer to the inclined lattice or by slowing down the lattice.

A whole-day test on long-term variation had shown that the chute feed did alter slightly and that similar alterations occurred at the Fehrer K 12 and in the final product. The indications were that the variations reached a maximum of $\pm 6\%$ from the mean and that this was caused by the chute feed. The addition of binder appeared to be regular, since the final fabric was as regular as the Fehrer batt. Similar tests were required while feeding waste and on other qualities.

The question of quality control was raised, especially where and how often to test. The answer would form part of the next discussion.

The essential data for the new line was as follows:

Weight	15 to 40 g/m^2
Production	30 million m^2 in 5,000 hours
Fibre	Either 100% viscose or 100% polypropylene

The dimensions of the space available would be supplied. All other details, such as the method of batt preparation, method of bonding and type of binder were subject to recommendation and discussion.

Annex III

SUGGESTED NEW PRODUCTS FOR LÖRINCI VATTAGYÁR

The terms of reference of the mission (annex I) provided that the expert was to suggest other products that could be made on the line. Several kinds of such products are considered here. Nevertheless, it is important that due consideration be given to the proposal made in the section Development of new products in the body of the present report.

Spray-bonded products

The most successful products made at Lörinci Vattagyár appeared to be the spray-bonded ones. Hence, provided that the correct price can be got for these types of material, their production should be expanded. Several very large firms in western countries produce only spray-bonded materials.

Some of their end-uses are the following:

Air and gas filtration. Used for coarse filters in air circulation systems and the chemical industry, for example, for the removal of polluting dust (this should be a growth product) and some automobile air filters. (These might have to be exported, or they could be sold in the domestic spare parts trade.)

Lightweight products to be sold to other factories. These can be used for making articles such as anoraks, dressing gowns and brassières. It is possible to bond layers of fabric to either or both sides of the spray bond to make a product that is easy to make up; the fabric bonding can be done at the same time as spray bonding.

A more heavily bonded product for the upholstery trade. For this type of product it is better for the fibres to stand more upright (as opposed to lying in the plane of the fabric), so it may be necessary to cut down the area in which the fibres are laid down on the Fehrer K 12 machine. This product will complete with the solvent-bonded product mentioned below and possibly with the thermoplastic product.

A very coarse product for cleaning pans, baths sinks etc. Some pieces of this material of unknown origin (15 cm x 15 cm) are being sold for Ft 10. This product was patented by MMM Co. in the United States, but the patent seems to have expired in about 1975. Since patents start at different times in different countries, it is important to check that there are no valid patents in Hungary or any country to which the product might be exported, because the patent holder would be sure to prosecute. The product is very heavily loaded with bonding agent, so its manufacture is probably an extremely dirty process. Its production at Pestlőrinc seems inadvisable, but a more suitable spray-bond unit is available at another branch. The approximate details of construction are: nylon fibres 15-20 decitex; length in range 50-100 mm.

The bonding agent is 40 to 50% phenol-formaldehyde precondensate in water, plus 50-60% abrasive. In terms of grain size and material, the range of abrasives is very wide and depends on end-use; for example, some expensive types use emery powder and are used in engineering. Another large market in the United Kingdom is pads for floor cleaning, which are 40 to 50 cm in diameter. About twice as much bonding agent - abrasive mixture is applied as the fibre weight, calculated on the usual dry basis. It is also important to leave a small percentage of free phenol in the bonding agent; this attacks the nylon fibre and weakens it, so that the fibre wears away at about the same speed as the abrasive. A special product that contains no abrasive is made for cleaning baths and the like so that their surfaces do not become scratched.

Needled products

Although it would be possible to make needled products, the plant would probably not be competitive. Needling should only be used in conjunction with other bonding methods. For example such a product, 46 cm x 46 cm, which sells for Ft 11, originates in the German Democratic Republic.

Infra-red bonding

If this infra-red bonding unit is to be useful, it should be used with bicomponent fibres, since simple thermoplastic ones causes more collapse of the batt structure. Also, a fibre with a large difference between its melting point and degradation temperature is required; for example, polypropylene. A suitable one is polypropylene type ES, made by Chisso in Japan. The product can be varied by altering its fibre decitex, the percentage of bicomponent fibre and bonding conditions, and particularly the pressure exerted at the large-diameter roller. The products will normally be similar to spray-bond types, but firmly bonded throughout their thickness. Some typical end-uses are for coarse gas filtration and upholstery padding. If products of this type prove unsuccessful, it would be better to sell that part of the plant if a reasonable price could be obtained for it.

Solvent bonding

This method of bonding was patented by Courtaulds, but the patent has probably expired. In England, one line runs exclusively on this product, and other lines use it from time to time, so it is obviously a method with good possibilities. The normal method is to apply a small quality of a latent solvent (probably 3-5% Bondolane, made by Shell) before carding, for example when the fibre lubricant is applied. This solvent does not affect carding and should not affect the Fehrer K 12 air-lay machine. Immediately after laying the batt is taken to the drier, where bonding and evaporation of the solvent take place. Until recently the process has only been used on acrylic fibres, solvents probably have been or could be found for polyester and nylon. The product is similar to spray-bonded ones, but the bonding is firmer all the way through the fabric. Its end-uses are air filtration and upholstery padding.

Impregnated fabrics

In view of the present difficulty in producing impregnated fabrics, it is difficult to suggest new products. However, some of these may be easier to produce than the present products.

Household cleaning cloths (durable). It would not appear worth while to complete with Johnson and Johnson (USA) in the production of J cloths, because a special apparatus is needed to make the holes, and the product appears to be well established on the Hungarian market.

However, a durable cloth could be more attractive over the long term. Such cloths are on sale in Hungary, for example, Vileda 30 x 40 cm, at Ft 24, and a German Democratic Republic product of lower quality 32 x 32 cm, at Ft 12. A more expensive Vileda product for cleaning automobiles sells in England for about Ft 40.

Some of the details of the production are in BP710,082, 716,178 and 826,570, which have all expired. However, here to it is important to check that there are not other newer, patents in Hungary.

Basically, the fibres used are polyester, for strength, blended with rayon, for absorbency. Any binder could be used, but an acrylic binder would appear to be preferred. To obtain a soft and porous structure, the binder should contain salt or starch, which would later be dissolved away to leave pores. The product from the German Democratic Republic does not appear to use this technique, which would require some simple washing-off equipment. There should be some coarse polyester fibre to cause the fabric to retain some thickness after impregnation. Finally, delamination is a serious problem; some technique to cause binder coagulation should be used, rather than relying on drying conditions. These cloths could be very profitable if there were sufficient consumer demand for them.

Backing cloths for coating, etc. There are a number of end-uses where fabrics basically similar to interlinings are used. These include backing fabrics for polyvinyl chloride (PVC) coating, to make cheap imitation leather and backing fabric for carpet underlays, where foam rubber is spread over the nonwoven material. Such underlays are used in almost every house in England, partly for comfort but also because they greatly increase the life of the carpet. They do not appear to be used widely, if at all, in Hungary.

Upholstery fabrics. The jute hessian which was traditionally used on the undersides of arm chairs, settees, dining-room chairs and the like is being replaced by nonwovens, normally using polypropylene fibre for strength and cheapness. Often this is thermally bonded by hot calenders, but probably an immersion-bonded fabric could also be designed.

Filter fabrics. For finer filtration of air and gases and for some wet filtration, impregnated nonwovens are being used. A possible problem is that each filtration application may need a different fibre bonding system to give the correct chemical resistance or a different decitex to produce the desired pore size or the appropriate weight per square metre. The manufacture of this product involves the holding of stocks or the making of many short runs, but this need not be a disadvantage provided the fabric was costed to take this into account. At present, however, the regularity of the fabric does not appear to be high enough to justify an attempt to penetrate this market.

Absorbent mats for bars etc. In western Europe there has been quite a large market for colourful mats printed with the name of the brewery etc. to be placed on bars and tables to absorb spilt beer. The product is about 2 mm thick and quite spongy. It is durable, and over the last 2 or 3 years it has won practically 100% of the market. It is uncertain whether there would be a market for it in Hungary.

Road-stabilization fabric. This type of fabric is now in very great demand, but it appears that the spun-bonded fabric imported from Austria is quite expensive. It might be worth while to produce a substitute material, but this would require long runs at very high speed. Ideally, the fabric should be made with polypropylene,followed by hot calendering, but since there is no suitable calender in Hungary it would be advisable to experiment with acrylic binder.

Print-bonded fabrics

Durable washing-up cloths. As mentioned earlier, it is probably not worth while to complete with the Johnson and Johnson J cloths, but this product is much thicker (1-2 mm) and is print bonded with a heavy binder concentration. This makes it at least appear more durable than the J cloths, and also makes it possible to claim that the hard spots of binder help in the cleaning. This is a relatively new product and could still be under patent held by either Bondina Vilene or Freudenberg.

Durable dusting cloth. This fabric is all rayon and is printed in a pattern that gives fair strength but does not spoil the drape and soft handle. It has had reasonable success in England, but it is likely that many people would prefer a woven fabric. The nonwoven is naturally cheaper and may be impregnated to polish or to collect dust.

Durable washing-up cloth. Another washing-up cloth has been made by using two print-bonded nonwoven surfaces with a layer of foam in the centre. The complete article is about 2 mm thick, each being stamped out and heat sealed at the edges simultaneously. This last operation would require new equipment.

The ideas put forward here are ones that have been successful in England, but it is difficult for an outsider to say which, if any,would be successful in Hungary.

Annex IV

A SURVEY OF THE MANUFACTURE OF NONWOVEN FABRICS IN WESTERN COUNTRIES

Economic background

Economic conditions in the western countries have not been good for the last two to three years. This has been particularly true of the textile industry in general, but the nonwoven branch of the industry has escaped this recession largely by finding new products and new uses for existing ones.

While table 3 gives an indication of the total size of the industry in Western Europe, it should be treated with some caution. In particular, the figure for "hygiene" may also include cotton-wool wadding, which is not really a nonwoven, and the classification of the tea-bags with carpets is most unsatisfactory. However it is the best available.

Table 3. Production (tons) of nonwovens in Western Europe in 1975

Hygiene	24 100
Medical	6 000
Bed and table linen	2 400
Wiping cloths	8 000
Clothing (disposable work wear)	500
Interlinings	9 800
Filtration	4 900
Substrates for coatings	6 000
Decoration (e.g. wall coverings)	2 100
Upholstery, abrasives, public works	10 400
Tea-bags, carpets and miscellaneous	17 800
	92 000

It is interesting to compare this figure with the production in 1971 (40 000 tons), indicating a rapid rate of growth, and the production in the United States in 1975 (200 000 tons) which shows the enormous size of the American market. About 25% of the European total is made in the United Kingdom;

France and the Federal Republic of Germany are the other main producers, with Sweden being an important producer of the wet-laid.

Table 4 gives the share of the market in the United States, but it is classified differently from table 3, so comparisons are difficult.

Table 4. Share (per cent) of the United States nonwoven market in 1975

Nappy cover stock	14
Sanitary pads/tampons	6
Wiping cloths	9
Surgical packs and gowns	6
Interlinings	11
Filtration	10
Substrates for coatings	7
Home furnishings	6
Carpets and carpet backing	10
Durable papers and packaging	4
Miscellaneous	17
	100

Apart from the greater use of nonwoven filter fabrics in the United States, the two tables show quite good similarity; the discrepancies are probably caused by differences of classification.

It is felt that the best way to survey the field is by method of manufacture; this approach is used here.

Parallel-laid, saturation-bonded products

Mostly cotton cards are used, but also some roller and clearer cards. Modern cards will give an output speed of about 45 m/min. There are no new developments in this area, the products are used mainly for disposable wiping cloths and nappy cover stock.

Parallel-laid, print bonded

This process is being used for products similar to those of the previous one, but the print bond gives a softer handle to the fabric.

Cross-laid, saturation bonded

This method is probably the most common in the industry and is used, for example, for interlinings, some filtration fabrics and some substrates for coating. The normal process is carding, cross-laying followed by a batt-drawing, impregnation and drying. Speeds of up to 15 m/min on 20 g/m^2 web are used; for heavier-weight fabrics, two or more cards are used to maintain a higher speed in the impregnator and drier. There are no major developments in the standard fabrics, but two special products are worth mentioning: chamois leather-like cleaning cloths and nonwoven backing for artificial leather. This is now quite a large but specialised industry. The fibres used are polyester for strength and rayon for absorbency. The fabric is heavily needled with a battery of up to six needle looms in line and is then shrunk in hot air or hot water to obtain greater consolidation. (Some or all of the polyester is high-shrinkage fibre.) The fabric is impregnated with bonding agent not to bind the fibres but in order to fill the voids. Finally, the fabric is normally split into two, three or four layers on a slitting machine.

Cross-laid print-bonded fabrics

Not very much of this type of fabric is made, exceptions being the washing-up cloth and duster discussed in the section suggested new products. The Johnson and Johnson products (J cloths and the like) are probably also made this way, but the process also includes a secret and patented method of making holes.

Cross-laid spray-bonded fabrics

These products are very subject to delamination, but even so several firms produce only this material for all forms of padding and quilting.

Cross-laid solvent-bonded fabrics

This method is used mainly with acrylic fibres. It gives bonding all through the fabric and therefore less delamination.

Cross-laid with thermoplastic fibres

Only limited amounts of these fabrics are made; they can be divided into three types:

Bonded by heat without pressure, for example, with an infra-red or hot-air drier. In this case, there is some advantage in using bicomponent fibres to maintain the fabric structure, but little if any are made commercially

Bonding by hot calender. This produces a very strong but very stiff fabric, whose main use is in shoe manufacture. Total production is not very large

Bonding by "point-bond" calender. By bonding only in limited areas, a fabric with good strength and drape can be made. Very light-weight fabrics have been made for blouse or dress material, medium-weight fabrics for men's suitings and heavyweight for chair covers. However, although these products have been shown freely in the textile trade, there do not appear to be any on sale yet. This method has been used more successfully to produce interlinings.

Air-lay saturation bonding

This method is used to a certain extent for producing interlinings and the like, but it is much less common than the cross-laying method, particularly for lightweight fabrics. Its advantage is that a virtually random structure can be obtained, but the batt-drawing method is usually considered adequate. The Isomizer now made by Proctor and Schwartz will also produce a random result, starting with a cross-laid batt. This system will probably be a strong competitor for the lightweight field (up to 50-60 g/m^2). Air-laying will continue to be preferred for heavier-weight random fabrics.

Air-lay spray-bonded

In this field the special property of an air-lay machine with a very short depositing zone is very useful. The fibres can be made to stand at 30°-45° to the plane of the fabric, which makes the end-product more resilient. Furthermore, it does not delaminate. The method is quite widely used.

Air-lay and needle

This method is being used by some firms to make needled carpeting, the production of the air-lay machine on coarse fibre being very high. However, only one type of fibre can be used, which means it is not possible to include a layer of waste at the back. Other heavy fabrics can also be made in this way.

Cross-lay and needle

A number of products are made by this process:

Blankets. Over one-half of the blankets produced in the United Kingdom are made by this method. Usually, two cards and cross-lappers are used, and a layer of warp threads is inserted between the two layers. Sometimes a scrim fabric is used, but this is becoming rarer. The fabrics are raised lightly after needling.

Carpets. These are made in the same way as the blankets mentioned above. Polyester, nylon and polypropylene fibres are used, normally dyed before carding. In some cases a backing fabric is used, but often not, particularly if a patterned surface is to be made.

After needling, the carpet may be totally impregnated, from the back, or it may be heat-bonded, using bicomponent fibres. In all cases the object is the same, namely to lock the fibres in position and to prevent fibre shedding during wear. Many firms are producing either a ribbed pattern or a cut-pile pattern using forked needles. Although several Di-loop machines have been bought to produce a high-pile fabric, no material seems to be available commercially. Needled carpets are used mainly in hotels, hospitals, schools and offices, but some private houses also use them.

Technical felts and filter fabrics. These articles cover a wide range of fabric weights and fibre types. They are generally made by needling fibre on to one or b th sides of a woven fabric. The filters are mainly for air and gas filtration, but the next development will be wet-filtration fabrics.

Papermakers' felts. This is a very specialized field, one with very wide needle looms and cross-lappers. Fabrics have developed from the simple batt-on-base type (that is, batt needled onto a heavy base fabric) to batt with light-weight fabric, batt with warp threads only and the latest development is batt without any base. The method of achieving this is secret, but is probably bicomponent fibres melted together after needling. The baseless fabrics are only suitable for a few end-uses at present, but their use may develop.

Wet-laid fabrics

These articles are estimated to compose 15% of United States market It is not surprising that all firms that make wet-laid nonwovens are ones with papermaking experience. In each European country there are only two or three machines that operate on nonwovens, but they produce at such a rapid rate that they satisfy the demand. In most cases, for cheapness, about 50% paper pulp and 50% fibre are used, but it is possible to use even quite long and coarse fibres (about 8 decitex, 50 mm) alone.

The following methods of bonding are used:

Bonding agent with an electric affinity for the fibres added into the slurry water. This method is no longer popular because the bonding agent is lost during the de-watering.

Spray bonding. Since this is done on to a wet batt, the bonding agent diffuses through it, which does not happen when spraying on to a dry batt.

Print bonding. This is basically similar to the dry-laid process but is done at a much higher speed. It gives a softer handle, just as in the dry-laid process.

Saturation bonding. This can be done either on a wet batt or after the batt has been dried once.

The second and third of these four methods are to be preferred. The products of this section of the industry are used for: coverstock, tea-bags, disposable wiping cloths, filter fabrics, disposable overalls for work, disposable gowns for medical use, disposable sheets, disposable table cloths, glass-fibre mats for glass-reinforced plastics, and sausage skins.

It is thought that paper will be made by a dry process (air-laying) in the future: experimental plants are already running on this system. If the process works on paper fibres, it seems likely that it could be modified to make nonwovens, and these would become new, very high-production types of air-laid nonwovens.

Spun-bonded fabrics

The spun-bonding process has so many advantages that the normal dry-laid fabrics would have little future, were these advantages not offset by several important disadvantages. The most important of these are:

The very high capital cost of the plant, even taking into consideration its very high rate of production.

It must always start from new polymer and thus cannot process waste or even reprocess its own waste.

The cost of plant breakdown or change over to a different type of product is very great, so that each spun-bonding plant makes only a few types of fabric.

Its main advantage is the possibility of using continuous filament, which gives a stronger fabric than staple fibre with the same amount of bonding, owing to the absence of fibre with the same amount of bonding and to the absence of fibre ends. Labour costs are also very low. In the United States spun bonds form about 20% by weight of the total market, but it is probably only about 10% in Western Europe.

Spun bonds differ so widely from one manufacturer to another that it is probably necessary to consider them individually.

Typar: 100% polyester fibre, method of bonding not known. The main uses are: 75% for tufted carpet primary backing, 12.5% for packaging.

Reemay: 100% polyester fibre, method of bonding not known. The main uses are: 30% for interlinings, 30% for backing for foam-rubber carpet underlay.

Tyvek: 100% polyethylene fibre formed by very fine fibrillation of a polyethylene sheet. Bonding by hot calender, probably point bond. Its main uses are: 40% for a tough, durable paper substitute and 35% for disposable work clothing, particularly for the chemical industry (chemically inert) and for severe weather conditions (North Sea oil rigs) since it is waterproof and tear resistant.

Cerex: 100% nylon bonded by acid gas which softens the fibres. Its main use (65%) is for backing for foam-rubber carpet underlay.

Kimkloth: 100% polypropylene, method of bonding unknown. Its main use (85%) is for internal coverings for matresses and coverings for the bottoms of chairs, armchairs and the like.

Most of the other spun-bonds such as Terram and Sodaspun, a fabric made by Chemie, Linz (Austria) etc. are being used in civil engineering, particularly for road building in muddy conditions. The market demand here seems to be enormous. Other spun-bonds are made from thermoplastic fibres and are bonded either in patterns or by point bonding. (Although the expert has seen many samples, he has seen none in use.)

One further type of spun-bond fabric requires special mention because it could influence the production of coverstock by the dry-laid method. It is made from 100% viscose, so it should be quite cheap. Courtaulds United States produces one such fabric, but little of it seems to have been imported into the United Kingdom. More recently, two Japanese firms have developed new fabric types; and it would seem most important to find the cost and quality of these fabrics as possible competitors.

Spun-laced

This series of fabrics is made by Du Pont (United States) from fairly fine polyester fibres, which are then entangled in a way similar to needling but by a series of fine intermittent jets of water at very high pressure (100 atmospheres). Because these fabrics contain no bonding agent, they are flexible, but they are also strong, owing to the high degree of entanglement of the fibres. It is estimated that spun-laced fabrics now constitute 1% of the United States market (that is, 2,000 tons). The fabrics are made either plain, with simple holes in it the way Johnson and Johnson fabrics are made, or with a fairly complicated lacelike hole pattern. Their main uses are as interlinings and backing fabrics for coating in the plain form, as printed bedspreads in the form with simple holes and as curtains and tablecloths in the form with complicated holes. The fabric is also being used in the medical field.

Stitch-bonded fabrics

The following comments refer primarily to the British market and a little about the United States. In the latter country, one or two large companies have purchased quite a large number of machines of the Maliwatt and Malimo types, but after a few years they decided to stop production because the fabrics produced could not be sold profitably. The machines have now been sold to smaller companies and are now operating profitably.

In the United Kingdom the purchase of such machines was much slower but there were 140 machines there at this writing. Most are of the Maliwatt type, making printed curtaining from rayon fibre, which sells well because its appearance is good and it is cheap, but there have been many complaints about quality, for pilling and poor washing properties. Similar fabrics are used for bed covers and also for upholstery in caravans, which is a very large industry in the United Kingdom. Malimo material is used mainly for conveyor belting, transmission belting and as a substrate for coating, owing to its low extensibility. A few Voltex machines are being used in the United Kingdom for producing artificial fur, but the preferred method there is sliver knitting. There may be no Malipol, Liropol or Malivlies machines at all in the United Kingdom; the writer has not seen any products or heard of the machines there. In the case of the Malivlies machine, the product does not seem to have any market in the United Kingdom. As for pile fabrics, there is a little possibility for patterning. (The British market wants highly patterned towel fabrics produced by jacquard patterning, not printing.) For a similar reason the British stitch-bond machines, Kinstlaid and Locstitch, are not much used in the United Kingdom though quite a number have been sold abroad. It is probable that the use of stitch-bond machines in other parts of Western Europe is less advanced than in the United Kingdom.

Prospects for the future

Disposables. Disposables can be divided into two types. One type, coverstock for example, is replacing a conventional textiles that were thrown away. This type has a good future for growth, particularly in countries where conventional textiles have not already been replaced. In the case of the other type of disposable, where the material is used once and thrown away instead of being cleaned or sterilized (for example disposable sheets and work clothes) the situation appears quite different; the cost of the raw material relative to the cost of labour in the laundering etc. becomes of great importance. Although labour costs continue to rise, raw material prices (cotton, oil and cellulose) will probably rise even faster, so that the use of disposables of this type will decrease. For example, disposable sheets have always been too expensive for use in the United Kingdom, but even in Sweden and the Federal Republic of Germany, where they are still used to some extent, they will gradually become too expensive. In a similar way, the use of disposable workwear dropped by half from 1973 to 1975 in Western Europe, and although consumption is expected to increase again, the ultimate trend will be downwards.

Durables and semi-durables

This class includes articles of three types. In some cases, such as interlinings, where nonwovens already hold most of the market, the nonwoven production can only rise slowly along with the general rise in production.

In other cases, for example needled carpets and possibly stitch-bonded curtains, the public in Western Europe and the United States will begin to expect a better quality and the demand for nonwovens will begin to decrease.

Finally, there probably will still be instances where an entirely new product such as spun-laced fabric will be discovered or where a new use is found for an existing one, as in the case of the road-stabilization fabric. In some cases these might lead to dramatic increases in small areas of the trade. The writer thus expects a fairly slow (5% per annum) overall growth, with some individual sections showing a decline and other sections a more rapid increase.

Annex V

SUGGESTIONS TO THE HUNGARIAN TEXTILE RESEARCH INSTITUTE ON THE USE OF LOW-GRADE COTTON AND WASTE FIBRES

Low-grade Russian cottons

Russian cotton grade 5

Trash content 8-10%; cotton coloured but not too badly. It has already been found that this cotton will spin, and it is recommended that it would be better to spin to coarse counts (Nm 12 to Nm 15 metric and coarser) rather than to make a nonwoven, since the cost of bleaching to remove the trash would be great, and the fibre properties would be damaged by the bleaching process.

Russian cotton grade 6

The trash content of this cotton is very high, and the cotton is very badly stained, almost brown. It should be spun as a blend with better cottons to coarse counts, if this proves possible. If not, it should be bleached and then used to make lightweight nonwovens, using cotton cards. It probably will not be possible to card with a roller-type card, because it becomes very matted during the bleaching. This method has the advantage that the bleached cotton is a substitute for viscose. If facilities for bleaching raw cotton are not available (this is not a common process) or if cotton cards are not available for nonwovens, either the cotton could be sold on the open market, or used in very low-grade nonwovens where the colour and trash content are not serious problems, as in paddings and waddings for upholstery and bedding. While the fibre is too expensive for the second of these end-uses, it would be better to choose the more profitable of the two.

The use of waste materials in Hungary

Comments on the samples made by the Hungarian Textile Research Institute

Road-stabilization material. This type of fabric is used in large quantities; it would be an excellent idea to develop a fabric made from waste to compete with the spun-bond materials, which must start from high-grade polymer. However, the weight of fibre used seemed rather too high, and it is suggested that the fabric be designed to satisfy requirements precisely. It should be also clearly stated which side of the fabric should be uppermost, because it would surely perform better one way up than the other.

Needled blanket. The sample presented would be completely unacceptable to the British market because the preference there is for a thick, lightweight blanket with many raised fibres. However, tastes in blankets vary widely from country to country, and it is possible that such a blanket would be preferred to a British-type one in Hungary. The only recommendation would be to use viscose and acrylic fibres in preference to nylon, polyester and polypropylene, because there is a pilling problem. The loss of fibre in wear and in washing, although not as good, is tolerated in the United Kingdom and now more than half of the blankets made there are needle loom, although not usually made of waste.

Filter fabric. There appears to be a good future for the wet filtration fabrics, but the condition of the surface (smoothness and pore size) is of great importance. It appears that the users of these fabrics in the food and chemical engineering industries are very careless about which side of the fabric to use (with woven fabrics both sides are normally the same), so it is normal in England to make both sides smooth. It may be worth experimenting whether the fabric can be reversed when one side becomes worn.

Upholstery padding. This is a useful way using low-quality waste. Similar products are made in the United Kingdom by needle loom, in some cases it may be possible to use a cheaper scrim or no scrim at all.

Washing-up cloth. This seems a very good idea and appears to be a new product. After durability trials it could be sold as a nonabrasive product. It might also be possible to include an abrasive powder immediately before the hot calender and so produce an abrasive product for cleaning dirty pans.

Thermoplastic tiles. These were a very interesting non-textile product, but they seemed to be needlessly thick. In the United Kingdom they are about 1.5 mm thick and never wear out. This extra thickness may be intended to increase their insulating properties.

The use of waste in the United Kingdom

Wool and other long-staple fibres. These are pulled up to fibre on a rag-grinding machine and re-used in the woollen industry. Wastes containing any man-made fibre are much cheaper, since the final product must be labelled "Fibre mixture" as opposed to "All wool".

Cotton and other short-staple fibres

These are re-used in the cotton waste industry and spun and woven to coarse fabrics such as dusters, wiping cloths and thick sheets. Lower-quality material is pulled up and used as wadding in bedding, upholstery and the like after simple needling. Cotton rags not containing synthetic fibres are also used in making expensive technical paper (not nonwoven).

Synthetic fibre waste direct from the manufacturers

Waste fibre of uncertain length or fineness is frequently available. It is used preferably in nonwovens, since the uncertain fibre length is a disadvantage in spinning, and frequently only as a blend with other fibres. As far as is known, only polypropylene and polyethylene are recycled by extrusion, and then only factory waste is used.

Cloths and materials from continuous filament synthetics

These materials are usually chopped by guillotine before pulling. When the present report was prepared, the writer was unfamiliar with their main uses.

Suggested further uses of wastes in nonwovens

White wastes

White wastes could be used in many existing nonwoven products, provided that the waste is well blended in and that only 10 to 20% of waste is used.

Coloured wastes

These are normally more difficult to use than white ones. However, some of the products already discussed could be made with coloured fibre, for example road stabilization and the filter fabrics could be coloured, provided the quality could be guaranteed. There is the important problem of persuading the consumer to accept the product, but this should be possible on a cost/quality basis.

It is possible to use a limited amount of coloured waste (grey or black) in interlinings. Also, coloured waste can be used for about 50% of the total fibre of needled carpets, if these are made in Hungary, but great care should be taken to match the waste layer with the surface layer.

All of these ideas are basically the use of wastes in existing products. Possible products not yet made in Hungary that could use some waste are:

Backing for tufted carpeting

Although the major forms of tufted carpet backing are woven polypropylene and polypropylene spun-bond (Typar) two other forms are used:

Woven polypropylene with a layer of 20 to 30 g/m^2 of fibre needled into it. This is commonly done by air-laying nylon fibre. By doing this, the weight of pile yarn in the carpet can be reduced without the polypropylene backing showing through. This product may be patented by Don Brothers, in Scotland.

A very open scrim fabric (about 2 threads/cm) is covered by a fibre layer, needled and then chemically bonded. Here the choice of bonding conditions should be made by judging the fabric strength after tufting, since it was found with Typar that loosely bonded fabrics were stronger after tufting than tightly bonded ones.

Greenhouse fabric

The basic idea of this fabric is that it permits all of the plants in the greenhouse to be watered automatically. It is made from polypropylene (otherwise it would rot) and contains a small weight of polypropylene scrim for dimensional stability, but this may be found to be unnecessary. It is about 3 to 4 mm thick and needled, but not to a high density. The plant pots must be damp before being placed in position, or the wicking action does not work. The fabric also develops a green mossy growth in use, which is not very desirable. While the expert is not sure to what extent this product has been successful, it would be very cheap to try it on a small scale in Hungary. (The patent rights for this product may be held by Don Brothers or Low Brothers in Scotland.)

The expert does not know whether carpet underlay can be sold in Hungary, but in England it is regarded as essential and has almost the same area sale as carpet. Although a foam-rubber product is the most common, a spray-bond product made from coarse waste fibres is also used. The product should be about 6-mm thick and be as resiliant as possible.

Some other new fabrics discussed in the section Suggested new products for Lőrinci Vattagyár could probably be used to absorb some waste, but probably could not be made from 100% waste.

Annex VI

THE USE OF NONWOVENS IN THE HOSPITALS OF WESTERN EUROPE

Table 5 shows the most recent table production of nonwovens in Western Europe. Unfortunately, it does not give the amount used in hospitals as a separate item, but it has been attempted to estimate the amount of each type that would be for hospital use. This is listed in the final column.

Table 5. The production (tons) of nonwovens in Western Europe in 1975 with an estimate of total use in hospitals

	Total	Hospital use (estimated)
Hygiene (nappies, nappy liners, sanitary pads)	24 100	4 000
Medical (wound dressings)	6 000	5 500
Bed and table linen	2 400	1 600
Wiping cloths	8 000	2 000
Clothing	500	150
Interlings	9 800	-
Filtration	4 900	-
Substrates for coating	6 000	-
Decoration (e.g. wall coverings and window dressing)	2 100	-
Upholstery, abrasives, public works	10 400	-
Tea bags, carpets and miscellaneous	17 800	-
Total	92 000	13 250

Thus, about 14% of the total nonwoven production is being used in hospitals for disposable purposes. In addition to this, there is a quite extensive use of needled carpets in the corridors and reception areas, but not in any wards, owing to the problems of cross-infection and the virtual impossibility of sterilization.

It is difficult to know how the classifications in the table were arrived at, for example, why tea-bags and carpets were classified together, but they are considered in order below.

Hygiene

Disposable nappy pads for babies and geriatric pads for old people

These items are very widely used in hospitals but are also sold in large volume to the general public, so the hospital share is relatively low. A typical product consists of a thin nonwoven with viscose waste, bleached cotton waste and cellulose fluff being used as the absorbent layer. A recent development in this field is to have a first layer, which could be the nonwoven made from a hydrophobic fibre. In this way, the water (urine) passes through the first layer and is absorbed, and the baby or patient stays dry. This helps to prevent nappy rash and bedsores. It is important that the hydrophobic layer be in direct contact with the absorbent layer. If it lifts away for any reason, for example, the design of the nappy and the way it is held on to the baby, then the urine is not absorbed and the baby is wetter than with a normal nappy. Hence, very careful design is needed.

Another important development is a so-called "super-absorbent" material made of cellulose, which can be obtained either in powder or fibre form and which will absorb about 100 times its weight of water. It is still rather expensive, but some firms are experimenting with its use for disposable nappies, chiefly because it will permit a less bulky nappy to be made.

The nonwoven fabric used is about 15 to 20 g/m^2 and may be dry- or wet-laid. The main criterion is cheapness, so viscose or polypropylene fibres are used, and a cheap, non-irritant binder. New spun-bonded viscose material may be used in the future. They are of Japanese origin and are known as Asaki Hygie gauze and Mitsubishi T.C.F. (All of these lightweight fabrics used as coverings are known as "coverstock" and will be referred to again.)

Sanitary pads

Strictly speaking, these items may not fall into the category of hospital use, but they are normally of cotton, viscose or both, highly compressed, and they may or may not be covered by coverstock. In the United Kingdom, an un-compressed type is also commonly used, and in this case a cover-stock is always needed. One or two manufacturers may still use woven gauze, but most use nonwovens of previous types. The expert knows little about this subject but can find out more if needed.

Disposable nappy liners

These are mainly sold by retailers, but are also used in some hospitals. Basically, this is also coverstock, as described above, but used with a terry towel nappy of conventional washable type to catch most of the dirt and make washing easier.

Surgical theatre drapes

Several types of nonwoven are used, normally about 60 g/m^2 and either wet- or dry-laid. (Two layers of crêpe paper bonded together with polypropylene is also used, but this is not really a nonwoven.)

Spun-bonded fabrics are not used at present, owing to their high cost, but the Japanese viscose spun bonds, referred to above, may become important in the future. However, none of these fabrics is regarded as entirely satisfactory by the medical profession, so only a few hospitals use them. (Although the National Health Service covers the whole of the United Kingdom, each large hospital, or in the case of the smaller hospitals, each hospital group, follows its own policy. Although there are still a few private hospitals, they normally have very poor facilities (for example, no X-ray equipment and no operating rooms), so are used mainly by people who require only nursing.)

Medical

Wound dressings

There is a very high penetration of nonwovens into this section. The basic construction is a nonwoven face (coverstock 15 g/m^2) with an absorbent backing of viscose and/or cotton, with perhaps cellulose fluff as a final layer. The most usual method of sterilization is by gamma-radiation, the packet being printed with ink that changes colour when the correct level of radiation has been reached, as a check to prevent unsterilized packets from being used. Ten plants use this system in Western Europe; usually the plant is not owned by the textile company but by a governmental agency (the Atomic Energy Authority in the United Kingdom, for example.) Although other methods of sterilization could be used, such as steam, heat or ethylene-oxide, the radiation method has advantages for both the manufacturer and the hospital.

Two developments are worth noting here, both designed to prevent the healing flesh from sticking to the dressing. In one, aluminium is evaporated under vacuum on to one surface of the nonwoven; in the other, a very thin layer of polypropylene is included to be placed next to the skin. From memory, this film weighs about 5 g/m^2 and is made by extruding the polypropylene film in the normal way, and then embossing the film with a pattern of dots, in which the dots become thicker and the spaces thinner. When this film is stretched in both directions, the dots remain unchanged and the spaces split into fibres, thus giving a netlike structure. The process is used by Smith and Nephew in the United Kingdom, who probably hold the patent.

Other medical uses

There are two important medical fields in which nonwovens are not yet used at all, but research will probably be going on to try to penetrate these markets. It is worth considering briefly the reasons why nonwovens have failed up to now.

Bandages. So far no nonwoven has been made that is both strong enough and that at the same time will conform to the shape of the body without creasing and wrinkling.

Internal swabs and supports for surgical operations. In this case, viscose would normally have to be used to give a competitive price, but when this material becomes wet with blood or body fluid it feels slimy, unlike the woven cotton gauze. Additionally, there is a fear that a nonwoven would leave some stray fibres in the body, although the writer believes this to be a surgeons' prejudice, not based on actual facts. In the United Kingdom, all swabs must contain a thread containing about 50% barium sulphate ($BaSO_4$) to permit X-ray detection, and this is an additional disadvantage for nonwovens, because it is easier to insert a thread in wovens than in nonwovens.

Bed and table linen

Sheets and pillowcases

At present, the cost of a disposable sheet is estimated to be about 80% higher than the cost of providing woven sheets and washing them. Even if the cost of labour in laundering were to increase considerably, it is estimated that disposable sheets will still be more expensive in 1978. Hence, the use of sheets is limited to special cases, for example, where sheets are likely to be quickly stained or perhaps if the laundery facilities of the hospital are in sufficient. The situation may be a bit different in the Federal Republic of Germany and Sweden, where labour costs are relatively higher, so that there is a greater incentive to use nonwovens. From the comfort standpoint, disposable sheets are not good; if patients had the choice, which they do not, the use of nonwovens in this area would probably be less.

One use which falls in this area is a small sheet of nonwoven (about 20 x 30 cm) which is used to place over a pillow when a patient lies down for a short time, as for examination or X-ray. Paper is also used, but a nonwoven is used sometimes to give a more textile feel.

The amount of nonwovens used as table linen in hospitals in the United Kingdom is very small, perhaps almost none, but it may be greater in the Federal Republic of Germany and Sweden. Table linen is not used at all in English hospitals; some paper may be used occasionally.

Wipes. Quite a wide variety of fabrics are made in this category, varying from wet-laid and dry-laid disposable ones, to J cloths, which are semi-durable and quite expensive durable fabrics used mainly as floor, window and automobile cloths. Of these, the main fabrics used in hospitals are the disposable ones, which may be used in any situation from sterile to simple wiping. The other fabrics may be used in the kitohens and wards, just as in a normal household.

Clothing. It is interesting to note that the use of nonwoven clothing in Western Europe dropped from 1,000 tons in 1974 to 500 tons in 1975. The use is virtually all in work clothes, overalls and the like, and it is thought that the fall has resulted from the changed economic circumstances caused by the increase in oil prices. However, it must be admitted that it could also be that the consumers did not like the product.

The principal fabrics used are wet- and dry-laid nonwovens, but some spun-bonded fabrics are also used.

Surgeons' and nurses' theatre gowns. These are used by some hospitals but by no means all of them. Including the cost of laundering and sterilizing, the nonwovens may be slightly cheaper and more convenient, but in general the nonwovens do not drape quite as well, and surgeons, unlike patients, can express a preference.

Nurses' ward gowns. These are effectively work aprons, not sterile but work as protective clothing. They are made from wet- or dry-laid nonwovens covered with polyethylene or possibly made from the spunbond Tyvek which is made from polyethylene.

Patients' gowns and pants. These can best be described as modesty garments to wear before an examination or X-ray. They are usually of paper for cheapness.

Theatre masks. Many hospitals still use simple woven cotton, which is really not a very effective filter. Some hospitals are now beginning to use nonwovens designed as a filter with layers of immersion-bonded fabric on the top and bottom surfaces and a spray-bonded filter between them. This type may not be reusable, but it would be more expensive but more efficient than the normal type.

Nurses' ward masks. These may not be as efficient and are normally of paper, for cheapness, rather than of nonwoven.

Nurses' and surgeons' caps. Woven fabric is relatively little used now. For theatre use, nonwovens are most common, but sometimes paper is used in the wards.

Probable future trends

Any opinion of future trends is bound to be subject to considerable error. Two important factors should be taken into consideration. One is the cost of labour or, probably more important, the standard of living. Any increase in this factor would lead to an increased use of non-wovens, particularly of disposables in hospitals. Although labour costs will continue to rise, the real standard of living in Western Europe has probably reached a peak and will probably tend to decline slowly. The second factor is the basic cost of raw materials, which are petroleum, cellulose and cotton. Since petroleum reserves are limited, as is the annual production of cellulose and cotton,an increased demand from the growing world population, together with a demand by the poorer countries for a better standard of living will lead to an increase in the cost of these raw materials. Since materials costs form a much larger percentage of the total costs of disposable nonwovens compared with woven fabrics that are laundered, this will also lead to a reduction in the use of disposables.

It would thus appear that, for both reasons, the use of disposable nonwovens will tend to decline in Western Europe, and this is in line with the current fashion of thinking about ecology. Durable nonwovens will have to justify their use on a cost/efficiency basis, that is,quality and wear life compared with cost.

The same factors will probably apply in Hungary, but the expert is sure that the Hungarian authorities will know better than he to what extent the country's standards of living will rise.

It would seem only fair to add that other experts, particularly American ones, do not agree with this view and predict that the use of disposables in the United States, which is already high, will double during the next five to seven years. While this may be true in that country, it seems unlikely to be so in Western Europe.

Annex VI

QUALITY-CONTROL SCHEME

The following item should be set up and checked at the beginning of each run, but there should be no need for regular checks after that.

Weighing hoppers: mean of at least 3 tests

Fehrer K 12. The batt is quite variable, and one test is not sufficient. There should be four, which is equivalent to 1 m^2.

The level of foam to be checked virtually throughout.

Quality control should be based primarily upon final fabric weight. The standard deviation of 0.25 m^2 samples of VI has been found to be 0.5 g. (The high value is to some extent owing to the long-term variation.) Under these circumstances, in order to control to ±10%, it is necessary to take four samples. (These can be cut near to each other for convenience and to avoid waste.) Warning limits for the sum of the four weights are 28 to 32 g (±2 x 5n), and action limits are 27 to 32 g (±3 x 5 n); that is, 10%. Normally, another sample should be taken soon after the test result falls outside the warning limit, and if the second test result is close to the first one, the machine settings should be altered. A single result falling outside the action limits means that the plant should be altered. A test every two hours is recommended, but this recommendation may be modified by experience.

The foam density should be checked every 2 hours by weighing a litre of it. (Limits to be determined from the standard deviation.)

When an alteration is required, the foam density test should indicate whether the impregnator is responsible. If it is not, the Fehrer batt should be weighed, using again four samples.

It will probably be necessary to modify this scheme in the light of experience.

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