Development of menstrual panties within the framework of sustainability and creation of a start-up

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Abstract: *Direct At the Technical University of Liberec, Faculty of Textiles, there was a cooperation between this state university and a small private company. The cooperation was created for the development of sustainable aids for menstrual periods. All development took place at the university, including the search for local production partners, and the private company financed the development. The output is a utility model owned by the university and the private company, and in addition the private company pays the license fee. The article describes in more detail this cooperation, as well as the development and the developed product, up to its actual commercialization.*
Keywords*: SUSTAINABILITY, START-UP,layer,*

1. Introduction

Menstrual panties are another alternative for women during their periods which aims at increasing the women's feeling of comfort. Another advantage is their sustainability, as it is an aid that can be used repeatedly, unlike the still widespread tampons and pads. Their advantage is the possibility of being washed and reused. In his article, Parent focuses on hygiene aids, including menstrual panties, and the public awareness about them in France. The reason for this study was that no work had been done on this topic so far. In conclusion, the author points out that there is a growing interest in these products among the French public [1]. Medina-Perucha deals with menstrual aids in her work, both disposable and multi-use ones. Respondents were more in favour of the re-usable products. Her work also points out common problems with menstrual cups [2]. The author de Belleville points out common problems with menstrual aids in India and compares India with France. In France, a woman has several types of protection to choose from, whereas in India, only 12% of women have access to protective equipment during their menstruation. Other women use rags and other textile waste [3]. The Stockburger MD describes menstruation and the possibilities of its suppression, but also describes the aids available for menstruation, including menstrual panties. He mentions that all devices have their advantages and disadvantages [4]. Marcelis has dealt with various menstrual aids, including menstrual panties, and a system for evaluating the effects of excreted substances on the skin of the body [5].

The research shows that there are already several manufacturers that manufacture and sell menstrual panties and those are perceived as a positive protection alternative during a woman's period. At the same time, thanks to the possibility of repeated use they seem to be very important for developing countries, where classic disposable aids are just not available.

The development of menstrual panties took place from the very beginning with the emerging start-up, which did not yet have any legal form of business. All development took place at the Technical University of Liberec and the start-up (natural persons) paid for the individual stages of the development. After the successful completion of the first prototype, SaYu s.r.o. (legal entity) was created. The SaYu company, in cooperation with the Technical University of Liberec, arranged production by Czech manufacturers and suppliers. After the completion of this stage a common utility model was created, which is owned by SaYu and the Technical University of Liberec. It is this connection between a university and a company and the creation of a successful product which represents a typical example of a successful transfer.

2. Materials Development of menstrual panties

At the time when the development of menstrual panties began at the Technical University of Liberec, these products already existed, but unfortunately, they had great limitations, especially in terms of their thermo-physiological comfort properties. These were mainly hydrostatic resistance (water column height), vapor permeability and low absorbency. Therefore, the development was focused mainly on finding suitable layers for menstrual panties. Menstrual panties consist of four basic layers. Figure 1 shows a diagram of menstrual panties and their functional layers. Menstrual panties as developed at the Technical University of Liberec have the task to perfectly remove any moisture from the skin, to transfer excess moisture into the absorbent layer and at the same time there is another layer - a nanofiber membrane. The task of the nanofiber membrane is not to let through excess moisture, but at the same time the membrane must be very vapour-permeable.

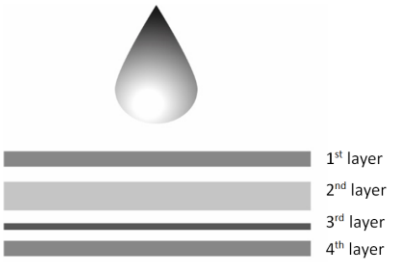

Fig. 1 *Functional layers of menstrual panties*

1st layer – transport layer (transports fluids as fast as possible into the next layer)

2nd layer – absorbent layer (highly absorbent and also spreading moisture along the absorbent core)

3rd layer – protective layer (membrane – provides high hydrostatic resistance and at the same time excellent vapour permeability)

4th layer – visible aesthetic layer (the same material as is used for the other parts of the complete final product)

Fabric liquid moisture transport properties in multi-dimensions, called moisture management properties influence the human perception of moisture sensations significantly. Some standards and test methods can be employed to evaluate the fabric's simple absorbency and wicking properties, and the liquid strike-through time of nonwovens also can be tested according to ISO 9073-8. However, the existing standards cannot measure the behavior of fluid transfer of the clothing materials dynamically [6].

The MMT measures textiles' dynamic liquid transport properties, such as knitting and woven fabrics. A series of indexes are defined and calculated to characterize the liquid moisture management performance of the test specimen [7].

3. Results and discussion

Transport layer

In this layer, rapid transport of fluid from the wearer's skin to the absorbent core is particularly desirable. Functional knits based on shaped fibres such as PES, POP or WO are particularly suitable for this purpose. In the case of the development of menstrual panties, a knit of 100% merino wool with areal weight of 105 g / m2 was chosen. The moisture transport rate is best expressed by measuring the absorbency value of the sample [% $.s^{-1}$] on an MMT instrument (Moisture Management Tester). The devise MMT measure according to the standard AATTC 195 - Moisture Management Tester

At the same time, however, this material is not suitable for the second absorbent layer, precisely because of the low moisture distribution in the area. Table 1 shows the measurement results for the transport layer and Figure 2 shows the spread of moisture over time.

Table 1: *The measurement results for the transport layer.*

WASHED SAMPLES		Sample No. 3 Double-face
Wetting time [s]	Top side	7.7
	Bottom side	45.4
Absorbency [%/s]	Top side	210.7
	Bottom side	10.8
Maximum wetting radius [mm]	Top side	5
	Bottom side	8.3
Solution-spread rate through the fabric [mm/s]	Top side	0.67
	Bottom side	0.65

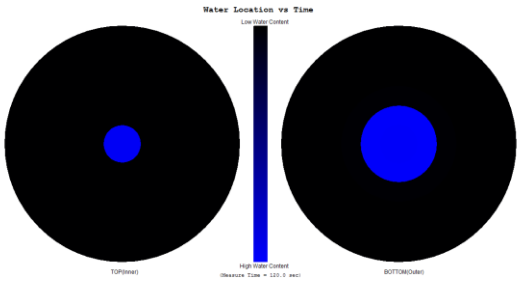

Fig. 2 *Moisture spreading in time for the transport layer.*

Absorbent layer

For the first layer - the tactile one - the rapid transport of fluid from the wearer's skin towards the absorbent core is most desirable. However, for the second layer – the absorbent one - the level of moisture distribution is very important. 100% cotton was selected for this layer, which has these desired properties. Because it is only the second layer, which is not in contact with the wearer's skin, it can be just knitted fabrics like cotton with a real weight of 165 g / m^2. Table 2 and Figure 3 show the specific results.

WASHED SAMPLES		Sample No. 4 Double-face
Wetting time [s]	Top side	4.5
	Bottom side	5.3
Absorbency [%/s]	Top side	45.6
	Bottom side	51.4
Maximum wetting radius [mm]	Top side	20
	Bottom side	20
Solution-spread rate through the fabric [mm/s]	Top side	3.69
	Bottom side	2.93

Table 2: *The measurement results for the transport layer.*

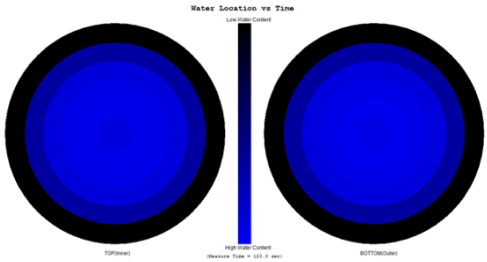

Fig. 3 *Moisture spreading in time for the transport layer.*

Protective layer

A nanofiber membrane was used as the protective layer. Laboratory production of nanofiber membranes was performed on the Nanospider machine. A polymer solution was added to a basin with a rotating roller. This solution was exposed to an electro field of U = 76.1 kV voltage. A collector was placed above the basin at the distance of 175 mm for the first sample and at the distance of 130 mm for the second sample. The speed at which the base material was moving was set at v = 0.1 m/min. The relative humidity in the spinning chamber was regulated at 21%. The humidity sensor was not placed directly in the spinning chamber, but in the tube bringing the air to the chamber to ensure proper sealing. The turning of the roller (driven by a rotor) in the basin created a thin polymer solution layer on its surface from which in turn nanofibers were formed due to the high voltage and collected on the support-material. The mass per unit area of the created nanofiber layer was 5 g/m^2.

Subsequently, a two-layer laminate was created because a simple nanofiber layer would be easily damaged. For the 2 -layer laminate a warp knitted fabric was used (warp knit with a real weight of 29 g / m2, to affect the thermo-physiological comfort of the nanofiber membrane as little as possible) with lamination points and a nanofiber layer, which was still on the base material. When laminating the top material and the nanofiber layer, the size of both materials was 50x50 cm. A nanofiber layer was put on the top material from the side with the lamination points. The resulting structure was placed on the lower part of the body of the Kannegiesser gluing machine and the required pressure of 3 bar was applied on the upper part of the body for 15 seconds at a temperature of 120 ° C. Thanks to these parameters, the polymer dots on the top fabric melted and a solid 2-layer laminate was formed, which can be seen in Fig. 4 taken by a scanning microscope. The base material is later pulled off.

Table 3: *The measurement results for the transport layer.*

WASHED SAMPLES	Sample No. 5 2-layer laminate
Steam permeability Ret[Pa.m^2.W^{-1}]	2.4
Air permeability [l/m^2/s]	1.865
Hydrostatic resistance [mm]	10 340
Number of washing cycles before delamination	95
Joint strength [N]	36.7

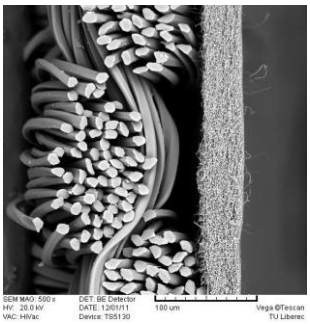

Fig. 4 *Two-layer laminate cross-section.*

The results show that the nanofiber membrane resp. laminate with a nanofiber membrane achieves very good values of thermo-physiological comfort.

3. Conclusion

The results show that the task was to develop menstrual panties with maximum emphasis on their thermo-physiological comfort during periods, meaning that all layers should be as vapour-permeable as possible to make women feel as comfortable as possible while wearing them. At the same time, the development took into account that women should not feel anything during menstruation which means that the first layer has the task of removing moisture from the woman's body as quickly as possible, the second layer has the task of absorbing the excess moisture, so a knitted cotton fabric was chosen. The next layer is a two-layer laminate so that there is no unwanted leakage. However, unlike other commercial panties, a nanofiber membrane was used. Other manufacturers most often use simple coating which has very poor vapour-permeability and lower hydrostatic resistance, properties essential for enabling active movement during a period. Thanks to the development of this product, unique cooperation between the Technical University of Liberec and the SaYu company was created, which at its beginning was a typical start-up, but a successful one. Thanks to this cooperation, joint intellectual property was created in the form of a utility model, where SaYu pays regular license fees for each piece sold. The Technical University of Liberec does not cooperate with anyone else in this field, and SaYu thus has exclusivity in the further development of menstrual panties. This created a model example of cooperation between a state university and a private company. This article wants to show that it is possible not only to start, but above all maintain a long-term cooperation between a state university and a private company.

4. References

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