

**STUDIES ON LIQUID ABSORBENCY BEHAVIOR
OF NONWOVEN AND FIBROUS WEB**

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**STUDIES ON LIQUID ABSORBENCY
BEHAVIOR OF NONWOVEN AND FIBROUS
WEB**

by

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Submitted

In fulfillment of the requirement of the degree of
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Dedicated to “My Family”

CERTIFICATE

This is to certify that the dissertation entitled “**Studies on Liquid Absorbency Behavior of Nonwoven and Fibrous Web**”, being submitted by **Rupali**, Entry No.2017TTZ8351, to the Department of Textile and Fibre Engineering, Indian Institute of Technology Delhi, New Delhi, India, in partial fulfilment of the requirements for the award of the degree of **Doctor of Philosophy**, is a bonafide record of research work carried out by her. She has worked under my guidance and fulfilled the requirements for the submission of the thesis, which has attained the standard required for a Ph.D. degree of this institute.

To the best of my knowledge, the results embodied in this thesis have not been submitted in part or full to other University or Institute for the award of any degree or diploma.

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ABSTRACT

Cellulosic fibres are commonly used in many absorbent products. These products are generally highly porous in nature. Though high porosity leads to better absorbing capacity, however, too porous structures are highly fragile and can easily collapse during absorption process, due to surface tension of the liquid. Deformation also leads to changes in porosity, nature of pores and pore size. A tight structure on the contrary can resist collapse being structurally rigid. The structural rigidity is dependent on fibre fineness, initial modulus, and degree of mechanical bonding between the fibres. The absorbency characteristics of nonwoven fabrics made from very coarse and fine cotton fibres preferred under high and low needle punch densities, have been investigated for two areal densities. It has been seen that the absorption capacity rises phenomenally once the porosity crosses the value of 0.97. The estimated and actual absorption capacities and retention% values have been found to be well correlated. All nonwovens have shown the tendency to collapse laterally during absorption process, leading to lowering of absorption capacity especially loose and nonwovens made of fine fibres (3 micronaire). On an average, the webs made from coarser fibres showed better absorption capacity, rate, and retention than those made from fine fibres, irrespective of process parameters or external pressure. However, the coarse fibre web showed better liquid retention%.

Subsequently, a series of nonwoven webs were prepared using blending technique by super absorbent fibres (SAF): cotton and Kapok: cotton. For SAF: Cotton blended nonwoven, three types of nonwoven structures, viz. mono-component (100 % cotton) and two types of SAF: cotton mixed, bi-component, i.e., one homogeneous mixture (random) and the other layered structure, were prepared. All the nonwoven webs were evaluated for absorption capacity and retention. Surprisingly, the absorption capacity of homogeneously mixed improved marginally compared to mono-component (100 % cotton web). The presence of SAF, however, exceptionally increases the liquid retention% of the blended structure. Amongst all the structures, the retention% in the case of layered structure was found to be superior. The correlation coefficient between absorption capacities estimated based on the rule of the mixture and actual capacity was found to be 0.90. Similarly, the liquid absorption and retention characteristics of Kapok: cotton blended webs were investigated. The morphological characteristics of raw, scoured, and rewetted Kapok fibre was first studied. The Kapok fibre lumen was found to be collapsed after scouring. However, it regained its shape after re-wetting. Absorption capacity, rate and retention were found to be exceptionally

well at 50:50 Kapok: cotton ratios in the nonwoven web. The result also shows that with respect to 100% cotton sample, the capacity, rate, and retention increased by 26.1%, 300%, and 13.5%, respectively, by adding 50% Kapok with cotton.

Other than that, a liquid acquisition-cum-distribution top layer was also developed using spun lace polyester-viscose (30:70) fabric. The one side of the fabric layer is coated with fluorocarbon using the spray coating process to make it hydrophobic. The coating process parameters, spraying distance (distance between spraying nozzle and fabric), finish concentration, and partial coating are varied to determine the optimum combination. The effectiveness of the coating process has been assessed by measuring contact angle, moisture management, and rewet tests. In the end, three incontinence prototypes were developed using: (1) 100% cotton (2) Kapok: cotton, and (3) SAF: cotton, as an absorbent core sandwich between single phased hydrophobic top layer and barrier sheet. Their performance was also evaluated based on rewet test, absorbency test and posture test. It was found the Kapok: cotton incontinence developed product have better absorbency, retention under load and works well under varying condition simulating the real time scenario.

सारांश

सेल्युलॉसिक तंतु आमतौर पर कई शोषक उत्पादों में उपयोग किया जाता है। ये उत्पाद आमतौर पर प्रकृति में अत्यधिक झरझरा होते हैं। हालांकि उच्च सरंधता बेहतर अवशोषण क्षमता की ओर ले जाती है, हालांकि, अत्यधिक झरझरा संरचनाएं अत्यधिक नाजुक होती हैं और तरल के पृष्ठ तनाव के कारण अवशोषण प्रक्रिया के दौरान आसानी से ढह सकती हैं। विरूपण से सरंधता, छिद्रों की प्रकृति और छिद्रों के आकार में भी परिवर्तन होता है। इसके विपरीत एक तंग संरचना संरचनात्मक रूप से कठोर होने के पतन का विरोध कर सकती है। संरचनात्मक कठोरता तंतु महीनता, प्रारंभिक मापांक और तंतु के बीच यांत्रिक बंधन की कोटि पर निर्भर है। उच्च और निम्न सुई पंच घनत्व के तहत पसंद किए जाने वाले बहुत मोटे और महीन सूती रेशों से बने अवयनित हुए कपड़ों की शोषक विशेषताओं की जांच दो क्षेत्रीय घनत्वों के लिए की गई है। यह देखा गया है कि जब सरंधता 0.97 के मान को पार कर जाती है तो अवशोषण क्षमता असाधारण रूप से बढ़ जाती है। अनुमानित और वास्तविक अवशोषण क्षमता और प्रतिधारण% मान अच्छी तरह से सहसंबद्ध पाए गए हैं। सभी अवयनित हुए कपड़ों ने अवशोषण प्रक्रिया के दौरान बाद में ढहने की प्रवृत्ति दिखाई है, जिससे अवशोषण क्षमता कम हो जाती है, विशेष रूप से ढीले और महीन रेशों (3 माइक्रोनेयर) से बने अवयनित हुए कपड़े। औसत रूप से मोटे रेशों से बने जालों ने बेहतर अवशोषण क्षमता, दर और प्रतिधारण दिखाया, जो कि प्रक्रिया के मापदंडों या बाहरी दबाव के बावजूद महीन रेशों से बने जाले थे। हालांकि, मोटे तंतु वेब ने बेहतर तरल प्रतिधारण% दिखाया।

इसके बाद, सुपर शोषक तंतु (SAF): कपास और कपोक: कपास द्वारा सम्मिश्रण तकनीक का उपयोग करके अवयनित हुए जाले की एक श्रृंखला तैयार की गई। SAF: कपास सम्मिश्रण अवयनित के लिए, तीन प्रकार के अवयनित संरचनाएं, जैसे, मोनो-घटक (100% कपास) और दो प्रकार के SAF: कपास मिश्रित, द्वि-घटक, यानी एक सजातीय मिश्रण (यादृच्छिक) और अन्य स्तरित संरचना तैयार की गई।

अवशोषण क्षमता और प्रतिधारण के लिए सभी अवयनित हुए जाले का मूल्यांकन किया गया था। आश्चर्यजनक रूप से, मोनो-घटक (100% कपास जाला) की तुलना में समरूप मिश्रित की अवशोषण क्षमता में मामूली सुधार हुआ। SAF की उपस्थिति, हालांकि, मिश्रित संरचना के तरल अवधारण% को असाधारण रूप से बढ़ाती है। सभी संरचनाओं के बीच, स्तरित संरचना के मामले में प्रतिधारण% बेहतर पाया गया। मिश्रण के नियम और वास्तविक क्षमता के आधार पर अनुमानित अवशोषण क्षमता के बीच सहसंबंध गुणांक 0.90 पाया गया। इसी तरह, कपोक: कपास मिश्रित जाले के तरल अवशोषण और प्रतिधारण विशेषताओं की जांच की गई। कच्चे, परिमार्जित, और दुबारा गीला कपोक तंतु की रूपात्मक विशेषताओं का पहले अध्ययन किया गया था। कपोक तंतु अवकाशिका को खंगालने के बाद ढह गया पाया गया। हालांकि, दोबारा गीला करने के बाद यह अपने आकार में आ गया। अवशोषण क्षमता, दर और प्रतिधारण, 50:50 कपोक: कपास के अनुपात में अवयनित हुए वेब में असाधारण रूप से अच्छी तरह से पाए गए। परिणाम यह भी दर्शाता है कि 100% कपास के नमूने के संबंध में, क्षमता, दर और प्रतिधारण क्रमशः 26.1%, 300% और 13.5% की वृद्धि हुई, कपास के साथ 50% कपोक जोड़कर।

इसके अलावा, स्पुनलेस पॉलिएस्टर-विस्कोस (30:70) कपड़े का उपयोग करके एक तरल अधिग्रहण-सह-वितरण शीर्ष परत भी विकसित की गई थी। कपड़े की परत के एक तरफ को हाइड्रोफोबिक बनाने के लिए फुहार लेप प्रक्रिया का उपयोग करके फ्लोरोकार्बन के साथ लेपित किया जाता है। इष्टतम संयोजन निर्धारित करने के लिए लेप प्रक्रिया मापदंडों, छिड़काव दूरी (छिड़काव नोक और कपड़े के बीच की दूरी), परिसज्जा एकाग्रता, और आंशिक लेप विभिन्न हैं। लेप प्रक्रिया की प्रभावशीलता का मूल्यांकन संपर्क कोण, नमी प्रबंधन और पुनः क्लेदन कर्मक परीक्षणों को मापकर किया गया है। अंत में, तीन असंयति प्रतिमान: (1) 100% कपास (2) कपोक: कपास, और (3) SAF: कपास, एकल चरण वाले हाइड्रोफोबिक शीर्ष परत और बाधा शीट के बीच एक शोषक कोर मध्यहित के रूप में उपयोग करके विकसित किया गया। पुनः क्लेदन कर्मक, शोषक परीक्षण और अवस्था परीक्षण के आधार पर उनके प्रदर्शन का भी मूल्यांकन किया गया। यह पाया गया कपोक: कपास असंयति विकसित उत्पाद में

बेहतर अवशोषकता है, भार के तहत अवधारण और वास्तविक समय परिदृश्य को अनुकरण करते हुए
अलग-अलग परिस्थितियों में अच्छी तरह से काम करता है।

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