

**A STUDY ON PROPERTIES OF AIR-JET
TEXTURED YARNS AND
COMPRESSIONAL PROPERTIES OF
THEIR FABRICS**

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AND
COMPRESSIONAL PROPERTIES OF THEIR FABRICS**

by

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Submitted

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to the**



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Certificate

This is to certify that the thesis entitled “**A study on air-jet textured yarns properties and compressional properties of their fabrics**” being submitted by **Mr. Rajat Kumar Baldua**, to the **Indian Institute of Technology Delhi**, for the award of the degree of **Doctor of Philosophy** in the Department of Textile Technology is a record of bonafide research work carried out by him. Mr. Rajat has worked under our guidance and supervision and fulfilled the requirements for the submission of the thesis.

The results contained in the thesis have not been submitted, in part or full, to any other University or Institute for the award of any degree or diploma.

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Abstract

Flat synthetic multi-filament yarn can be modified by the process of texturing to impart openness and voluminosity. Among the several techniques available for texturing, air-jet texturing is the most versatile in terms of processing of various types of constituent feed filament yarns with different process variables during texturing. Air-jet textured yarn imitates the spun yarn and its properties, and it can be considered as substitute material to produce fabrics with improved fabric handle and thermo-physiological comfort. Many attempts have been made by several researchers over the years to explore various aspects of the air-jet texturing process. They have focused on the feed filament characteristics, air-jet nozzle design, and air-jet texturing process parameters on textured yarn properties. However, limited studies have been carried out to study the effect of aforementioned parameters on fabric properties. Hence, this current research is aimed to study the effect of some of the important feed filament characteristics and air-jet texturing variables on textured yarn properties and their effect on fabric compression and recovery behaviour. Further, comparative assessment of fabrics made from air-jet textured yarn, parent yarn and equivalent ring spun yarn have been done for compression and recovery behaviour.

Air-jet textured yarn properties such as physical bulk, instability and loss in tenacity have been studied at different levels of linear density per filament, overfeed, air pressure, and texturing speed. The potential contribution of each of the variables to explain the properties of air-jet textured yarn is evaluated on the basis of normalized regression coefficients and analysis of variance obtained with the help of multiple regression model. Air-jet textured yarn properties are most influenced by overfeed percentage. The second most influencing factor to explain variability in the textured yarn properties is linear density per filament for physical bulk and yarn instability; and

air-pressure in the case of loss in tenacity.

Artificial neural network (ANN) model has been designed to predict the air-jet textured yarn properties, and the performance of ANN model has been compared with a statistical regression model. ANN model predicts the air-jet textured yarn properties more effectively as compared to regression model with a low level of errors. The validation data set shows a lower level of mean error percent in the case of ANN than the regression model.

Effect of feed yarn parameters such as filament fineness, filament shape, and total linear density on physical bulk, instability and loss in tenacity of air-jet textured yarns have been studied. The textured yarns were produced with optimum process parameters of texturing. It is found that an increase in linear density (dtex) of filament results in lower physical bulk and loss in tenacity, while instability is high in the resultant textured yarns. The textured yarn made from trilobal polyester filament leads to highest physical bulk and loss in tenacity; and lowest yarn instability. Circular cross-section filament yarn exhibited intermediate values of physical bulk and loss in tenacity and higher instability as compared to trilobal and rice cross-section filament yarns. An increase in total yarn linear density (dtex) leads to higher physical bulk and instability; while, lower loss in tenacity.

Fabrics have been woven from 167 dtex twisted multifilament polyester yarn as warp and experimental parent and textured yarns as weft to evaluate the fabric properties. Fabric compressional properties were measured by modified digital thickness tester. Further, this fabric compression and recovery behaviour were defined by an empirical model involving initial thickness, compression parameter (α) and recovery parameter (β).

Effect of linear density of feed filament and texturing process parameters on

compression and recovery behaviour of textured yarn fabrics have been reported. Overfeed percentage is the most dominating factor to explain the air-jet textured yarn fabric compressional properties, while linear density per filament is a most dominating factor to affect fabric resiliency. Texturing speed is the second most influencing variable to affect the compression and recovery behaviour of textured yarn fabrics.

Effect of feed filament characteristics such as linear density of feed filament (dtex), cross-sectional shape and total yarn linear density (dtex) on compressional properties of textured yarn fabrics have been investigated and compared with their corresponding parent yarn fabrics. Further, fabrics were woven with two weave structures namely plain and twill weave to assess the effect fabric structure on compression and recovery behaviour of the fabrics. It has been observed that textured yarn fabrics made from coarser filament feed yarn have higher initial thickness and compression parameter; while, lower recovery and resiliency compared to those fabrics made from finer filament feed yarn. Fabrics made from trilobal cross-sectional shaped filament yarn have exhibited high initial thickness and compression parameter whereas lower recovery parameter and resiliency as compared to circular filament yarn fabrics. Further, the fabrics made from coarser yarn (larger total yarn dtex) have higher initial thickness and compression parameter while lower recovery parameter and resiliency as compared to fabrics made from finer yarn. Parent yarn fabrics exhibited a low value of all compressional properties irrespective of change in any feed yarn characteristics as compared to their equivalent textured yarn fabrics. Twill woven fabrics exhibited a higher value of all compressional parameters compared to their equivalent plain woven fabrics.

Equivalent ring spun yarns have been produced as that of experimental air-jet textured yarns. Fabrics were woven with these ring spun yarns as weft and 167 dtex

twisted multifilament polyester yarn as warp. Fabric compression and recovery behaviour have been evaluated for ring spun yarns fabrics and these results are compared with their equivalent textured yarn fabrics. Textured yarn fabrics possess higher initial thickness and compression parameter; while, lower recovery parameter and resiliency as compared to ring spun yarn fabrics irrespective of change in feed filament characteristics.

सारांश

प्लैट कृत्रिम बहुरेशिये धागे को खुलापन प्रदान करने के लिए टेक्सचर की प्रक्रिया द्वारा उसे संशोधित किया जाता है कृत्रिम धागे को टेक्सटूरिंग के लिए उपलब्ध कई तकनीकों में से ,एअर जेट टेक्सचरिंग तकनीक सबसे बहुमुखी है क्योंकि यह तकनीक विभिन्न प्रकार के घटक फ्रीड फिलामेंट धागे को विभिन्न प्रक्रिया चर के साथ प्रसंस्करण करने की सुविधा प्रदान करती है। एअर-जेट धागे की बनावट (संरचना), रिंग स्पन धागे और उसके गुणों का अनुकरण करती है, और इसे बेहतर कपड़े संभाल और थर्मो-फिजियोलॉजिकल आराम से युक्त कपड़े बनाने के लिए वैकल्पिक सामग्री के रूप में माना जा सकता है। शोधकर्ताओं ने एअर जेट टेक्सचरिंग प्रक्रिया के विभिन्न पहलुओं का पता लगाने के लिए वर्षों से कई प्रयास किये हैं शोधकर्ताओं ने अपना ध्यान विशेष रूप से फ्रीड फिलामेंट के विभिन्न गुणों, एअर-जेट नोजल डिजाइन एवं एअर-जेट तकनीक के प्रक्रिया चरों का, एअर- जेट टेक्सचर की धागे बनावट (संरचना) एवं उसके गुणों के प्रभाव पर केंद्रित किया है। हालांकि, टेक्सचर धागे से बने कपड़ों के गुणों पर उपर्युक्त मापदंडों के प्रभाव का अध्ययन करने के लिए सीमित शोध प्रयास किए गए हैं। इसलिए, वर्तमान शोध का उद्देश्य कुछ जरूरी फ्रीड फिलामेंट विशेषताओं और महत्वपूर्ण एअर-जेट तकनीकी चरों का, एअर-जेट टेक्सचर धागे की बनावट पर एवं इस धागे के गुणों के प्रभाव और एअर-जेट धागे से बने कपड़े के सम्पीडन और वसूली व्यवहार पर प्रभाव पर केंद्रित हैं। इसके अलावा, एअर-जेट धागे , पैरेंट धागे और समकक्ष रिंग स्पन धागे से बने कपड़ों का सम्पीडन और वसूली व्यवहार का तुलनात्मक मूल्यांकन किया गया है।

इस शोध में रेशे का रेखीय घनत्व, अतिरिक्त फ्रीड, वायु दबाव और टेक्सचर गति के विभिन्न स्तरों का जेट टेक्सचर धागे के विभिन्न गुणों जैसे कि भौतिक थोक, अस्थिरता और दृढ़ता में हानि पर पड़ने वाले प्रभावों का अध्ययन किया गया है। प्रत्येक चर द्वारा एअर-जेट टेक्सचर यार्न के गुणों पर पड़ने वाले संभावित योगदान का मूल्यांकन सामान्यीकृत प्रतिगमन विश्लेषण एवं उससे प्राप्त विचलन विश्लेषण के आधार पर किया गया है एअर-जेट धागे की बनावट(संरचना) एवं गुण, फ्रीड पैरेंट धागे की ओवरफ्रीड प्रतिशत से अधिक प्रभावित होती है। टेक्सचर धागा के गुणों में परिवर्तनशीलता की व्याख्या करने के लिए दूसरा

सबसे अधिक महत्वपूर्ण रेशे का रैखिक घनत्व, भौतिक थोक और धागा अस्थिरता के लिए एवं दृढ़ता में नुकसान के मामले में वायु दबाव है।

कृत्रिम तंत्रिका नेटवर्क (एएनएन) मॉडल को एअर-जेट टेक्सट्राइल धागे के गुणों का अनुमान लगाने के लिए डिजाइन किया गया है, साथ ही साथ एएनएन मॉडल एवं सांख्यिकीय प्रतिगमन मॉडल के प्रदर्शन का तुलनात्मक अध्ययन किया गया है। एएनएन मॉडल एअर-जेट धागे के बनावट एवं गुणों का प्रतिगमन मॉडल की तुलना में अधिक प्रभावी रूप से भविष्यवाणी कम स्तर की त्रुटि के साथ करता है। सत्यापन डेटा सेट में प्रतिगमन मॉडल की तुलना में एएनएन के मामले में औसत त्रुटि प्रतिशत की कीमत निचले स्तर पर प्राप्त हुई है।

फीड धागे के कुछ मानदंडों, जैसे कि रेशे का रैखिक घनत्व, रेशे की आकृति, और धागे के कुल रैखिक घनत्व का एअर-जेट टेक्टेचर धागे की भौतिक थोक, अस्थिरता और एअर-जेट टेक्टेचर यार्न की दृढ़ता में हानि पर प्रभाव का अध्ययन किया गया है। टेक्टेचर धागे को उत्पादन के इष्टतम प्रक्रिया मापदंडों के साथ उत्पादित किया गया है। यह पाया गया है कि रेशे का रेखीय घनत्व (डीटीईएक्स) बढ़ने से टेक्सट्राइल धागे का भौतिक थोक एवं दृढ़ता में हानि कम हो जाती है, साथ ही साथ धागे की अस्थिरता उच्च हो जाती है। त्रिकोणीय आकृति वाले पॉलिएस्टर रेशे से बनने वाले टेक्सचरड धागे में भौतिक थोक और दृढ़ता में नुकसान उच्चतम पाया गया है एवं सबसे कम टेक्सट्राइल धागे की अस्थिरता पायी गयी है। परिपत्र आकृति रेशे वाले टेक्सचरड धागे में त्रिकोणीय और चावल आकृति रेशे वाले टेक्सचरड धागे की तुलना में भौतिक थोक और हानि की हानि के मध्यवर्ती मूल्यों और धागे की अस्थिरता का प्रदर्शन किया। धागे के कुल रैखिक घनत्व (डीटीईएक्स) में वृद्धि से भौतिक थोक और धागे अस्थिरता उच्चतम हो जाती है; जबकि, दृढ़ता में हानि निम्नतम पायी गयी है

वस्त्र गुणों का मूल्यांकन करने के लिए कपडा की बुनाई के लिए 167 डीटीईएक्स बहुरेशे वाले पॉलिएस्टर धागे से ताना और प्रायोगिक मूल रेशे और उससे बने टेक्टेचर धागे को बाने में प्रउक्त किया गया हैं कपडे के संपीडन संबंधी गुण मापने के लिए संशोधित डिजिटल मोटाई परीक्षक का उपयोग किया गया है।

इसके अलावा, कपड़े के संपीड़न और वसूली व्यवहार को कपड़े की प्रारंभिक मोटाई, संपीड़न पैरामीटर (α) और पुनर्प्राप्ति पैरामीटर (β) द्वारा एक अनुभवजन्य मॉडल द्वारा परिभाषित किया गया है।

टेक्स्टाइल धागे के कपड़े के संपीड़न और वसूली व्यवहार पर फीड रेशे के रैखिक घनत्व और टेक्सचरिंग के प्रक्रिया मापदंडों का प्रभाव सूचित किया गया है। पितृ धागे की उत्पादन के दौरान अधिक फीड कपड़े के संपीड़न संबंधी गुणों को समझाते हुए अधिकतम प्रभावशाली कारक है, जबकि रेशे का रैखिक घनत्व फैब्रिक के लचीलापन को प्रभावित करने के लिए एक सबसे प्रभावशाली कारक है। टेक्सचर यार्न कपड़ों के संपीड़न और वसूली व्यवहार को प्रभावित करने के लिए टेक्स्टिंग स्पीड दूसरा सबसे प्रभावशाली कारक है।

फीड धागे की विशेषताओं जैसे कि फीड रेशे के रैखिक घनत्व (डीटीईएक्स), धागे के रेशे की आकृति और धागे के कुल रैखिक घनत्व (डीटीईएक्स) का टेक्सचर यार्न कपड़ों के संपीड़न संबंधी गुणों पर प्रभाव का अध्ययन किया गया है और उनके संबंधित पितृ धागे वाले कपड़ों के साथ उसकी तुलना की गई है। इसके अलावा, कपड़ों के संपीड़न और वसूली व्यवहार पर कपड़े संरचना के प्रभाव का आकलन करने के लिए दो बुनाई संरचनाओं से बने कपड़े का निर्माण हुआ है, जो कि सादे और टवील बुनाई संरचना है। यह पाया गया है कि मोटे रेशे वाले फीड धागे से बनाई गई टेक्टेचर यार्न कपड़ों में प्रारंभिक मोटाई और संपीड़न पैरामीटर उच्च पाए गए हैं; जबकि कम वसूली और लचीलापन उन कपड़ों के मुकाबले बेहतर जो कि पतले रेशे फीड धागे से बना है।

परिपत्र रेशे वाले धागे के कपड़ों की तुलना में त्रिकोणीय आकृति वाले रेशे से बने धागे के कपड़ों का उच्च प्रारंभिक मोटाई और संपीड़न पैरामीटर एवं वसूली वाले पैरामीटर और लचीलापन कम प्रदर्शित करते हैं। पतले धागे से बने कपड़ों की तुलना में मोटे धागे के (बड़ा कुल यार्न डीटीईएक्स) से बने कपड़ों में उच्च प्रारंभिक मोटाई और संपीड़न पैरामीटर पाया गया है जबकि कम वसूली पैरामीटर और प्रदर्शित हुआ है। पितृ धागे से बने कपड़ों ने उनके समतुल्य टेक्सचर्ड धागे से बने कपड़े की तुलना में किसी भी फीड धागे की विशेषताओं में बदलाव के बावजूद सभी संपीड़न संबंधी गुणों का कम मूल्य

प्रदर्शित किया है। टवील बुने हुए कपड़ों ने उनके बराबर सादे बुने हुए कपड़ों के मुकाबले सभी संपीड़न मापदंडों का उच्च मूल्य का प्रदर्शन किया है।

प्रायोगिक एअर-जेट धागे के समतुल्य रिंग काता धागे तैयार किए गए हैं। रिंग काता कपड़े की बुनाई 167 डीटीएक्स बहुरेशे वाले पॉलिएस्टर धागे को ताने एवं रिंग काते धागे को बाने के रूप में प्रउक्त किया गया है। रिंग काते धागे से बने कपड़ों का संपीड़न और वसूली व्यवहार का के लिए मूल्यांकन किया गया है और इन परिणामों की तुलना उनके समतुल्य टेक्सचरड धागे के कपड़े से की गयी है। फीड फिलामेंट विशेषताओं में परिवर्तन के बावजूद टेक्सचरड वाले धागे के कपड़े में रिंग काता यार्न कपड़ों की तुलना उच्च प्रारंभिक मोटाई और संपीड़न पैरामीटर प्रदर्शित करते हैं; जबकि वसूली पैरामीटर और लचीलापन की कम मूल्य को प्रदर्शित किया है

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