ISSN : 0974 - 7486 Volume 14 Issue 12

Materials Science

An Indian Journal

Full Paper

MSAIJ, 14(12), 2016 [509-513]

Tearing strength of hydroentangled non-woven fabrics

Mbwana Suleiman Ndaro[1,2], Josphat Igadwa Mwasiagi[2,3]*, Lodrick Makokha Wangatia[2,4]
[1]TIRDO, Dar-es-salaam, (TANZANIA)
[2]School of Textiles, Donghua University, Shanghai, (CHINA)
[3]School of Engineering, Moi University, Eldoret, (KENYA)
[4]School of Material Science and Engineering, JIT, Jimma University, (JIMMA ETHIOPIA)
E-mail: mbwanasul@yahoo.co.uk; igadwa@gmail.com; lodricksw@yahoo.com

ABSTRACT

The manufacture of non-woven structures using the hydroentanglement technique is popular for the production of non-woven fabrics which need to have soft handle and high level of drapability. In this research paper the study of the tearing strength for hydroentangled fabrics made from bicomponent fibers was undertaken. The results obtained indicated that the tearing strength of the hydroentangled fabrics was affected by the density of the fiber webs, water jet inclination angle and the type of bicomponent structure.

KEYWORDS

Hydroentanglement;
Tearing strength;
Bicomponent fibers;
Inclination angle;
Non-woven fabrics.

INTRODUCTION

The properties of non-woven structures is affected by several factors which include the technique of production and the type of fiber. Hydroentangled non-woven fabrics have found application in areas where soft handle and drapability are important. The factors which have been reported to affect the properties of hydroentangled structures include the fiber properties, technology of web formation, water jets nozzles geometry, water jet pressure and water circulation[1-4]. Many research works have been conducted to investigate the mechanical properties of hydroentangled fabrics treated with perpendicular water jets during hydroentangling process, [3-9] but very few studies have reported the use of inclined water jets. Several research works[10-12] have reported the effects of inclined water jets on the tensile and bursting strength of hydroentangled fabrics made from PA6/PET and PET/COPET bicomponent fibers. The aforementioned reports indicated that bursting strength of the non-woven structures showed a correlation with fiber structure, water jet inclination, and the density of the fiber web.

The hydroentangled nonwoven fabrics made from splittable bicomponent fibers such as PA6/PET and PET/COPET have been considered to be suitable for the production of ultra high filtration media, artificial leather backing, swimming suits and specialty wipes just to mention a few. The tearing strength is one of the main mechanical properties in the mentioned products, therefore it is useful to investigate the role of inclined water jets on the tearing strength of splittable bicomponent hydroentangled nonwoven fabrics. The aim of this paper was to describe the tearing strength of islands in the sea (PET/COPET) fabrics compared to pie segmented (PA6/PET) fabrics when using inclined water jets in hydroentanglement process.

EXPERIMENTAL

Materials

Two types of fibers were used in this research work; (i) island-in-the-sea fiber (70%PET/30%COPET) with 37 PET islands, and (ii) pie segmented fibers (70%PA6/30%PET), with 8 segments. A carding machine, was use to prepare webs of basis weights of 60 g/m^2 and 100 g/m^2. A modified hydroentangled machine, with adjustable inclined water jets was used to manufacture the samples. The water jets were set at pressure levels of 3 and 7 bars, while the angle of inclination was set at 0^0 and 20^0. Other important machine setting included; web velocity (0.72 m/min), jet density (3jets/cm) and nozzle orifice diameter (0.3mm). The length between nozzle orifice exit and fiber web (standoff distance) was fixed at 20mm.

Physical measurement

The force required either to start or to continue or propagate a tear in a fabric under specified conditions is known as tearing strength. The Universal Tensile Testing Machine (WDW-20) was used and the experiment was conducted as per directives of ASTM D 5735-95. The sample of 200 mm (length) by 75mm (width) was cut at the center of shorter edge to form a two-tongue specimen and the cutting slit was 75mm in length. One tongue of the specimen was gripped in the upper jaw and the other tongue was gripped in the lower jaw of a tensile testing machine. The specimen was torn as the moving jaw moved away from the fixed ones due to the force applied to propagate the tear. During this process, the force developed was recorded; therefore the maximum force to continue the tear was obtained from autographic chart recorders. Five samples in the machine direction and five samples in the cross direction were tested for each sample and the average value results were recorded.

Fabric images

The photos of the samples before and after hydroentanglement were taken using JSM-5600LV Scanning Electron Microscope (SEM) of resolution 3.5-4.5 nm and range of magnification 18-300000. Based on the photos the splitting behaviors of splittable bicomponent fibers were investigated.

RESULTS AND DISCUSSION

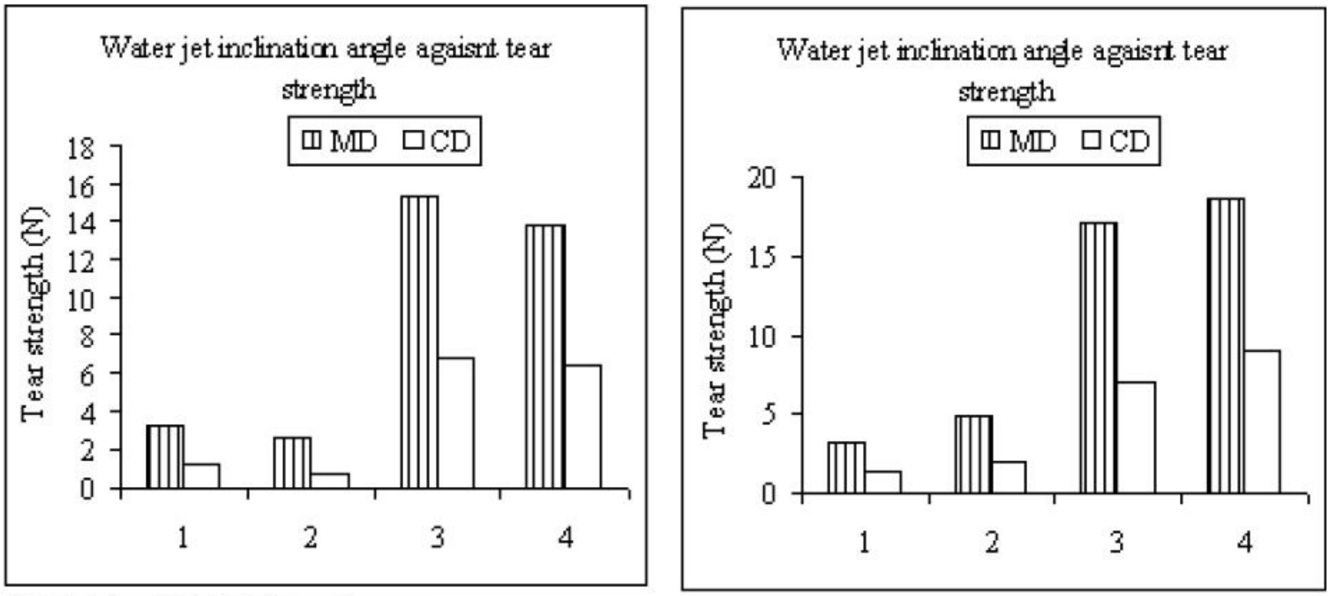
Figures 1 and 2 shows the influence of water jets inclination angle on tear strength of pie segmented and islands-in-the-sea splittable bicomponent fibers. The values of machine directions (MD) and cross-wise directions (CD) for tear strengths are also shown.

From Figures 1 and 2 it is clear that water jet pressure affects the tearing strength of the samples. For the increase of water jets pressure from 3 bars to 7 bars in the same inclination angle, the tear strength of the samples increased. This can be due to the fact that increases of water jets pressure means increase of impact force and drag forces which caused many fiber to be displaced, bend, twisted and knotted or entangled with one another to form strong network structures of higher fiber bonding strength.

From Figures 1 and 2, it is also evident that the angle of inclination of water jets increased from 0^0 (perpendicular water jets) to inclined jets of 20^0 the tear strength was increased for all 100 grams per square meter (gsm) hydroentangled fabrics processed at the same pressure levels. The increase of tear strength may be due to the following reasons:

(1) It can be assumed that during hydroentanglement in inclined mode of impact the turbulence effect of water jets of 20^0 was higher compared to that of perpendicular water jets (0^0). Therefore as the inclined water jets of 20^0 strikes the fiber web support they tend to contribute more effect of reflected water jets which caused more fibers to be entangled forming more bonding points than perpendicular water jets of 0^0.

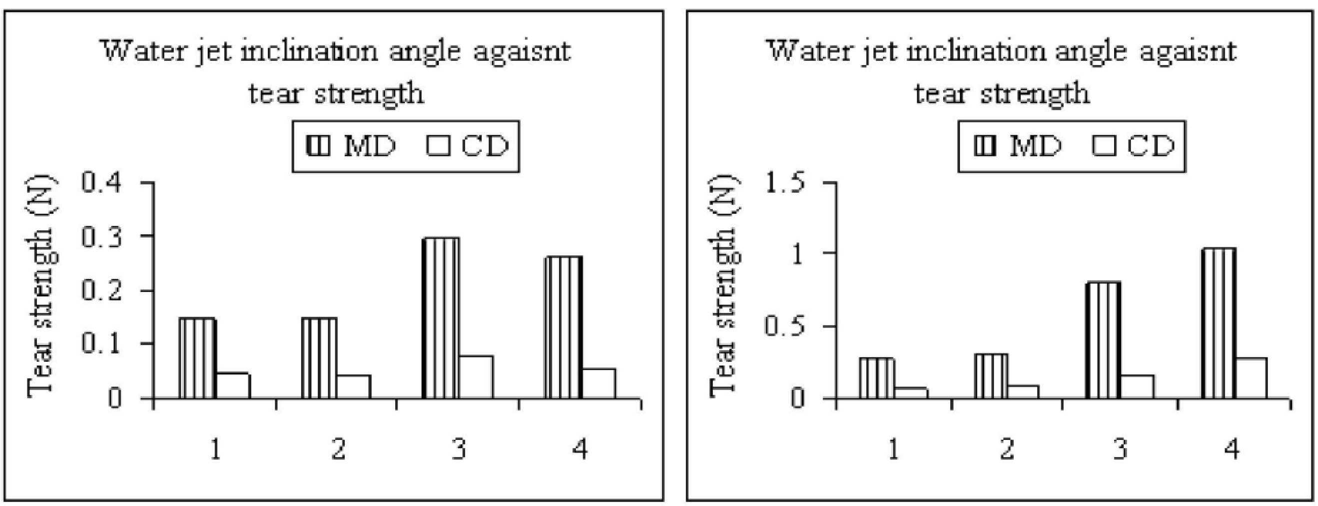
(2) In inclined water jets of 20^0 the water jets have the long path distance through the fiber webs compared to perpendicular water jets (0^0), which tends to displace, twist, rotating and knotting many fibers to form many entangled points which caused stronger network structure.



(a) Fabrics (PA6/PET), 60 gsm (b) Fabrics (PA6/PET), 100gsm

On horizontal axis: 1-at 3 bars with 0°, 2- at 3 bars with 20°, 3-at 7 bars with 0°, 4- at 7 bars with 20°

Figure 1 : The effect of water jets inclination angle on tear strength for PA6/PET fabrics



(a) Fabrics (PET/COPET), 60 gsm (b) Fabrics (PET/COPET), 100 gsm

On horizontal axis: 1-at 3 bars with 0°, 2- at 3 bars with 20°, 3-at 7 bars with 0°, 4- at 7 bars with 20°

Figure 2 : The effect of water jets inclination angle on tear strength for PET/COPET fabrics

Further from Figures 1 and 2 it can be noticed that the tear strengths of all fabrics in Machine Direction (MD) were higher than in Crosswise Direction (CD), this can be due to the fact that in the Machine Direction (MD) more fibers were entangled to form more strong bonding points while for Crosswise Direction (CD) in some places there were few entanglement which caused some of the fibers to slide easily from each other causing low tearing strength.

Furthermore in comparison of tear strengths of fiber types in Figure 1 and 2, it shows that the tear strength of PA6/PET fabrics in Figure 1 were higher than the tear strength of PET/COPET fabrics in Figure 2, in the same pressure levels and inclination angles. The main reason for higher tearing strengths of PA6/PET hydroentangled fabrics treated by the pressure levels of 3 bars and 7 bars with inclined water jets of 20 degree may be due to the water jets strike the fibers at an angle to their fiber segments that easily break the polymer interfacial bonding so the fiber splitting increased compared to the impact of vertical water jets. The explanations can be supported by Figures 3 and 4, which showed the SEM photos or images of pie segmented (PA6/PET) hydroentangled fabric structures of 60 and 100 g/m^2 processed at pressure levels of 3 and 7 bars and inclination angles of 0^0 and 20^0 which occurred fiber splitting after hydroentanglement even at very low pressure levels.

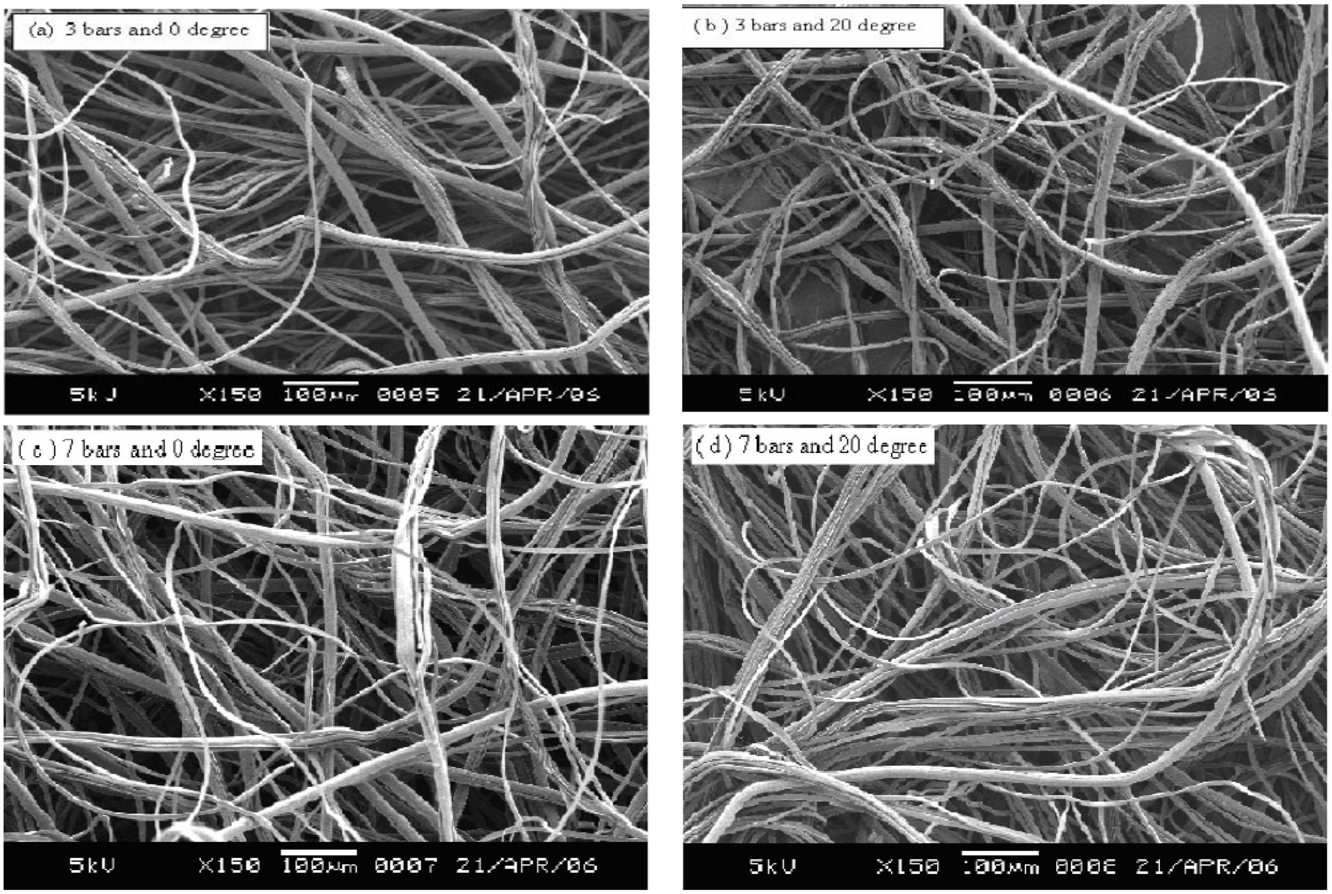


Figure 3 : SEM photos of hydroentangled PA6/PET fabrics of 60 g/m^2

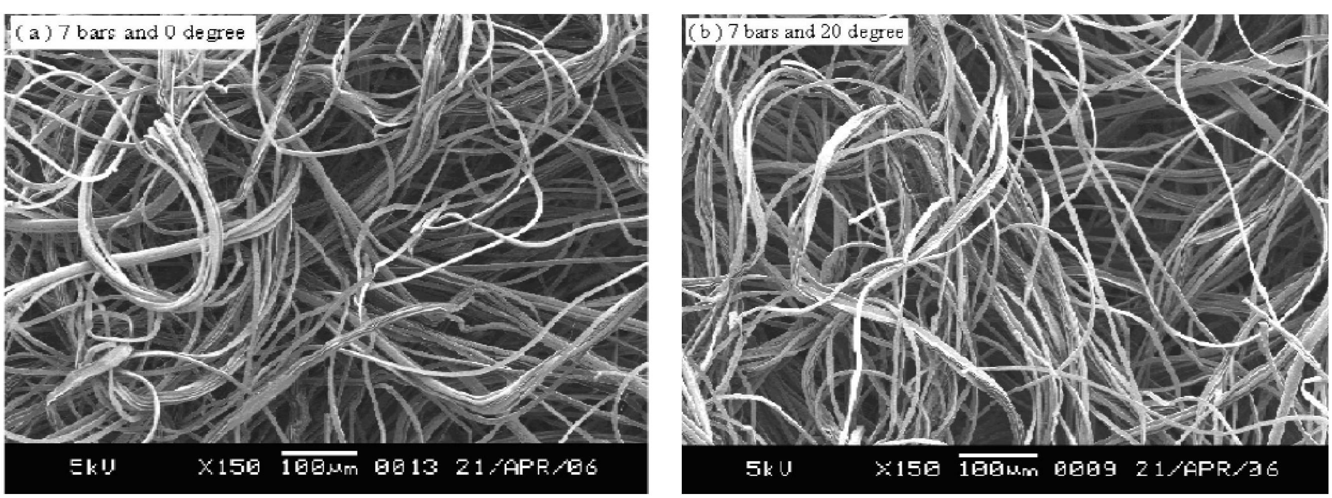


Figure 4 : SEM photos of hydroentangled PA6/PET fabrics of 100 g/m^2

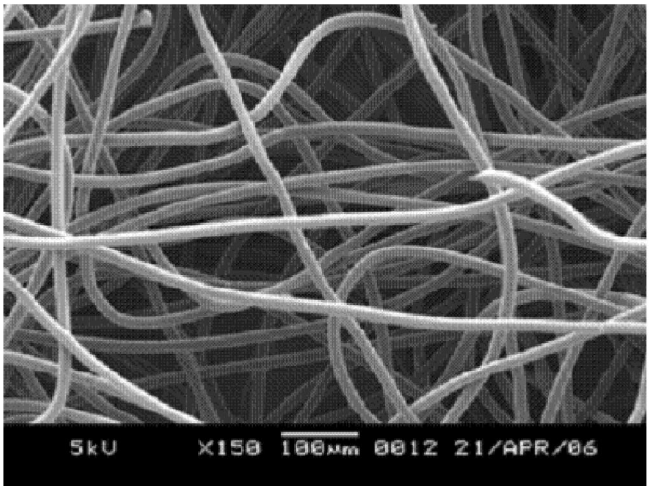


Figure 5 : SEM photos of PET/COPET fabrics of 60 g/ m^2 treated with 7 bars and 20 degree

From Figures 3 and 4 it was noticed that the increase of water jets inclination angles the fiber splitting of PA6/PET was improved which realized the enhancement of hydroentanglement process and improvement of tear strength compared to PET/COPET fabrics,

From image analysis, all hydroentangled nonwoven fabrics (PET/COPET) of 60 g/m^2 and 100 g/ m^2 showed no fiber splitting; therefore in this paper only one example in Figure 5 is shown. Figure 5 shows no fiber splitting, which confirmed the strong interfacial adhesion of polyester (PET) and co-polyester (COPET) because of their aromatic ring.

CONCLUSION

The preliminary experiment outlined the general results and conclusions summarized as follows:

1. The tearing strength of the non-woven structures made from PA6/PET fibers was higher than that of samples made from PET/COPET fibers.
2. When water jet pressure increased the tearing strength of hydroentangled non-woven fabrics also increased

From this preliminary work it can be concluded that inclined water jets may play a very important role in hydroentanglement process and more work is still needed using much higher water jets pressures and different inclination angles in the commercial industrial hydroentanglement machines to find out the capability and importance of inclined water jets in hydroentanglement process.

ACKNOWLEDGEMENT

We would like to acknowledge the support received from Prof. Yu Chongwen of Donghua University during sample preparation.

REFERENCES

[1] C.Heschmeyer; IFJ, February, 22-23 **(2004)**.

[2] N.Mao, S.J.Russell; Compos.Sci.Technol., **66**, 80-91 **(2006)**.

[3] T.J.Connolly, L.R.Parent; 'Influence of specific energy on the properties of hydroentangled non-woven fabrics', Non-Woven Conference Proceedings, Tappi Press, USA, **(1993)**.

[4] A.Pourmohammadi, S.J.Russell, S.Hoffele; Text.Res.J., **73(6)**, 503-508 **(2003)**.

[5] G.Severine; Combination of hydroentanglement and foam bonding technologies for wood pulp and polyester fibers in wet lay nonwoven fabrics, Master Thesis, NCSU, Raleigh, North Carolina, **(1998)**.

[6] Z.Huabing; The impact of input energy, Fiber properties, and forming wires on the performance of hydroentangled fabrics, PhD.Thesis, NCSU, Raleigh, North Carolina, **(2003)**.

[7] N.B.Timble, T.Gilmore, G.P.Morton; Spunlace fabric performance of unbleached cotton at different specific energy levels of water, International Non-Woven Conference, (INDA-TEC September 11-13) Hyatt Regency Crystal City, Virginia, USA, **(1996)**.

[8] A.Waltz; New concepts for fiber production and spun lace technology for micro denier bicomponent split fibers from polymer to final product, The 8th Shanghai International Nonwovens Conference Papers, Sept 22-23, Shanghai, **(1999)**.

[9] A.Das, R.J.Raghav; *Indian j.fibre* text.Res, **34**, sept, 258-263 **(2009)**.

[10] M.S.Ndaro, J.I.Mwasiagi, C.W.Yu; TLIST, **4(1)**, 35-43 **(2015)**.

[11] M.S.Ndaro, X.Jin, T.Chen, Y.Chongwen; Fiber Polym, **8(4)**, 421-426 **(2007)**.

[12] M.S.Ndaro, Y.Chongwen; Impact of inclined water jets on mechanical performance of pie segmented nonwoven fabrics, Fiber Society 2007 Spring Conference, May 23-25, Greenville, SC, USA, **(2007)**.

[13] M.S.Ndaro, X.Jin, T.Chen, Chong Y.Wen; Journal of Donghua University (Eng.Ed), **24(3)**, 413-418 **(2007)**.