Structural Analysis of Commingled Yarns

Vinayak Ogale and Ramasamy Alagirusamy
Department of textile technology, Indian Institute of Technology,
Delhi110016, India

ABSTRACT

The commingled yarns are mainly characterized by having nips at very regular intervals in the longitudinal direction. Nips act as the binding points between open portions. In this paper nips of different class are classified into different categories based on their structure. The causes for occurrence and their effect on commingled yarn properties are identified. The degree of interlacing also studied in relation to the process parameters. The results show that commingling process parameters as well as the type of matrix forming fibers significantly affects the structure and properties of commingled yarns.

Keywords: commingled yarns, nip structure, thermoplastic prepregs,

INTRODUCTION

Thermoplastic composites offer new opportunities for fast, efficient processing technology. However, along with their advantages, thermoplastic composites also have introduced new problems into processing. Commingling of the matrix forming fibers and high performance fibers has the potential to achieve high levels of composite properties. However, it is reported that commingled towpregs tend to de-mingle due to non-uniform stretching of commingled yarns during textile and other preform making processes [1]. This would lead migration of the stiffer reinforcing fibers from matrix forming fibers.

Furthermore this will result in non-uniform distribution of fibers in final composite part and lead insufficient impregnation. Consequently, insufficient impregnation affects the mechanical properties of composites [2]. Hence, in order to obtain best composite properties with less severe consolidation conditions, there is a clear requirement for detailed study on the commingling behavior of the fiberglass filaments, which have high modulus and strength, with other matrix forming filaments which will have only moderate modulus and strength.

The structure of nips in commingled yarn is of prime importance because variations in mingled yarn properties are reported mainly due to variations in yarn structure. Structure and properties of commingled yarns mainly depend on type of supply yarn material, mingling process parameters and jet design [3-5]. Although high levels of composite properties are attained with this technique, there is no work repï commingled yarns. Hence, there is a clear requirement for detailed study on the structure of commingled yarns with the high performance filaments like glass, which has high modulus and strength with low modulus matrix forming filaments like polypropylene, nylon and polyester. In the present work, an attempt has been made to study the effect of air pressure on structure of GF/Nylon, GF/PP and GF/PET commingled yarns.

EXPERIMENTAL

Design of Commingling Nozzle

The structure of the flow inside the yarn chamber depends on the number of jets, relative location of the jets from each other and from the both open ends of the chamber, angle at which air enters in the chamber and the pressure of the air at entry to the yarn chamber. Since it is very difficult to change these parameters practically, therefore to choose the best commingling configuration CFD analysis of configurations has been done. The commercial CFD package FLUENT 6.1 is used for this study.

Development of commingled yarn samples

A laboratory model of commingling equipment has been developed for the present study. The Glass and matrix forming multifilament yarns from separate packages are combined and fed to a pair of feed roller. After passing the yarn through supporting guides and an air nozzle, the commingled yarn is wound onto a package. Wide range of feed ratios, take up speeds and air pressures could be selected to produce commingled yarns at different processing conditions. The ratio of glass and other matrix forming filaments in commingled yarn is adjusted to get different volume fractions. Total 9 commingled yarn samples from GF/PP, GF/PET and GF/Nylon are developed at air following air pressures: 6, 7 and 8 bar. All other process parameters are kept constant.

TEST PLAN

Nip structure and degree of interlacing

The prepared yarn samples are visually examined form each commingled yarn sample ten specimens of length one meter were selected form different parts of package. The nips have been classified into five different groups according to their structure, namely, braid, entanglement, combination of braid & entanglement, wrap and others (consisting of core, braided core and side by side). The degree of interlacing is also obtained.

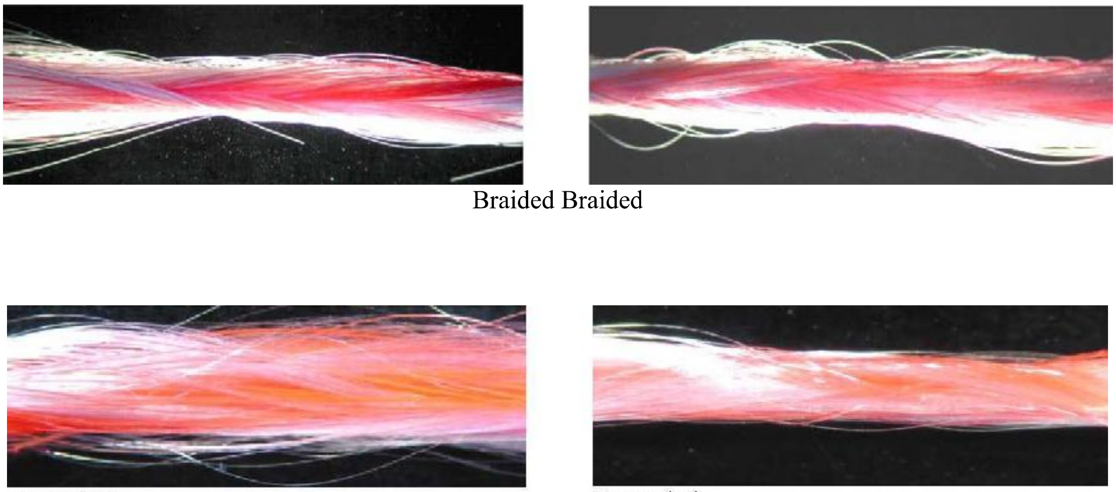
$$\text{The degree of interlacing (\%)} = \frac{\text{Total length of nips in the yarn}}{\text{Length of yarn specimen}} \times 100$$

RESULTS AN D DISCUSSION

Structure of nips in commingled yarns

From the microscopic observations nips found in commingled yarns can be classified as braids, entanglements, entangled braids, wraps and others which are shown in *Figure 1.* The occurrence of particular type of nip in a jet depends on the condition of filaments when they are acted upon by the jet.

Braided nips are composed of intertwined filament bundles of glass and matrix forming fibers. It has been observed that, glass filaments split into three or more groups and braiding with matrix forming filaments.



Braided Braided

Entangled Entangled

Figure 1.Diffrent type of nips formed in commingled yarns

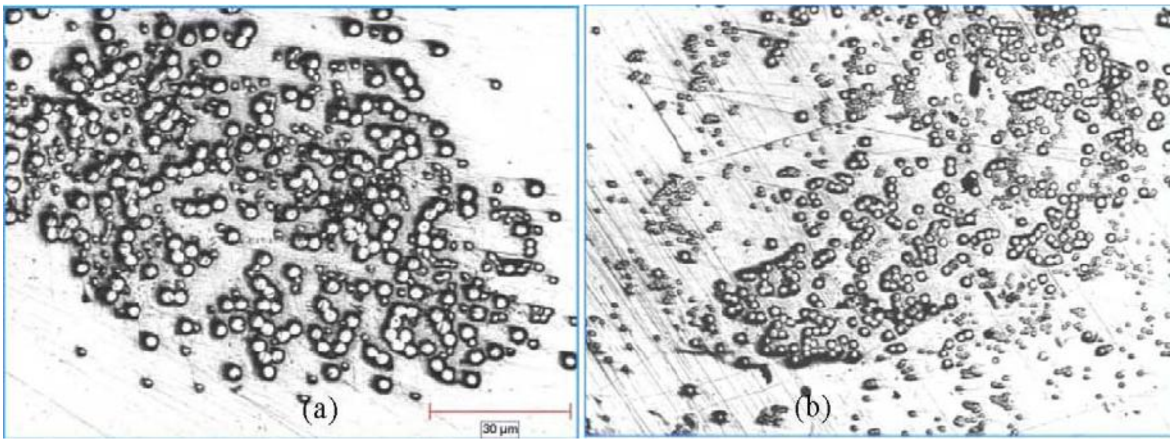


Figure 2 Micrographs of GF/PET and GF/Nylon commingled yarns.

Entanglement nips are formed due to initial opening of matrix forming fibers and Glass fibers; initial opening of filaments would disorganize the filament spatial positions. Further action of air jet would enhance the possibility of random intermingling of the small groups of opened bundles of Glass and matrix forming filaments together. Entangled braid type of nips are similar to braided nips, however sudden change in the direction of strong jets acting on filaments of the small and disorganized bundles of matrix forming filaments and glass filaments which are already built into partial braids would get entangled each other.

Wrap nips in commingled yarns are formed due to improper opening of glass filaments and therefore matrix forming filaments just wrap around un-opened bundles of glass filaments. This type of nip occurs when the formation of nip happens at a location in the nozzle where the air forces are weak. *Figure 2* shows micrograph of GF/PET and GF/Nylon commingled yarns.

Figure 3 shows that with increase in air pressure degree of interlacing increases continuously. With increase in air pressure average nip length increases therefore with increase in air pressure degree of interlacing increases irrespective of nip frequency. At higher air pressures, as velocity of filament rotation inside the nozzle increases, the momentum of the filament movement also increases. This causes the nip length to increase as the air pressure is increased. This trend has been observed for all type of nip structures. Although longer lengths of entangled nips where two types of fibers are intimately mixed are preferable, increase in nip length of other types of nip structures should also result in better resin distribution in the resultant composites. and nip formation.

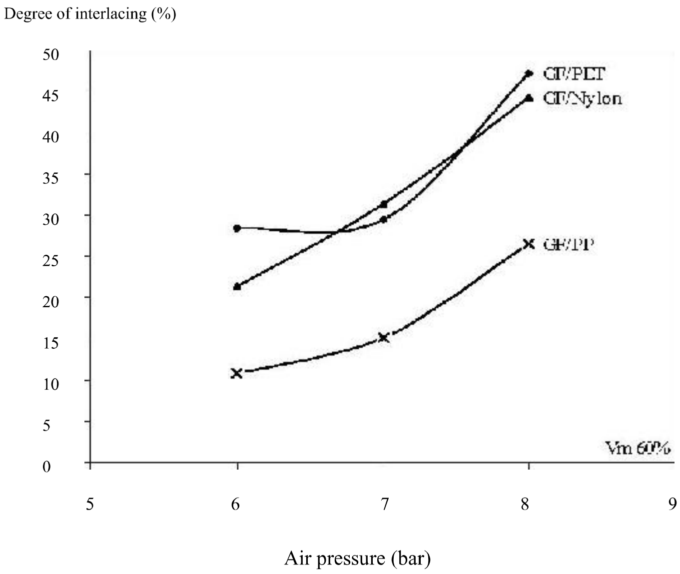


Figure 3 Effect of air pressure on degree of interlacing

Longer nips also provide better stability to commingled yarn structure. GF/PET and GF/Nylon shows higher degree of interlacing than GF/PP yarns poor the same reason explained for nip frequency. These studies clearly indicate that in the case of polypropylene the filament movement inside the nozzle is not quite conducive for commingling

CONCLUSIONS

The structure of Glass/PP, Glass/Nylon and Glass/PET commingled yarns has been characterized. The nip structures are classified into entanglement, braids, entanglement braids and others. The influence of air pressure on degree of interlacing of nips formed is studied. It has been found that Glass/PP yarns have lowest degree of interlacement and generally increase with increase in air pressure. It has also observed that entanglement type of nip structures preferentially form at higher air pressure where as braid type nips form at lower air pressure.

The present work shows that the matrix forming fibers influences of interlacing of commingled yarns.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the financial support provided by the Council of Scientific and Industrial Research (CSIR), Human Resources Development Group through the sponsored project 22(0359)/02/EMR-II.

REFERENCES

1. Ye, L. Friedrich, K. Kastel, J. and. Mai, Y. M. (1995). Consolidation of unidirectional CF/PEEK composites from commingled yarn prepreg, *Compos sci technol*, 54(4):349-358.
2. Long, A.C. Wilks, C.E. and Rudd, C.D. (1995). Experimental Characterization of Consolidation of Commingled Glass and Polypropylene Composite, *Compos Sci Technol,* 61(11): 1591-1603.
3. Versteeg, H.K. Acar, M. and Bilgin, S (1999). Effect of Geometry on the Performance of Intermingling Nozzles*, Text Res J*, 69(8): 545-551.
4. Lazauskas, V. Lukosaitis, A. and Matukonis, A. (1987). Effect of the Design Parameters of the Aerodynamic Device on the Tanglelacing Intensity of Filament Yarns, *Tekhnologiya-Tekstil'noi-Promyshlennosti*, 177(3): 27-30.
5. Imeto, Y. and Chono, S., (1987). Study on Interlaced Yarn. III. Air Flow in Yarn Path, Journal of the Textle Machineary Socity of Japan, 40(5): T47-56.