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Effect of Nozzle Design and Processing Parameter on Characteristics of Glass/Polypropylene Hybrid Yarns

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ABSTRACT
Among the various methods commingling process is comparatively better alternative to produce hybrid yarns. The required properties of hybrid yarns can be obtained by controlling main processing parameters such as air pressure, overfeed and take-up speed along with proper selection of nozzle (jet) design. The commingling machine has been fabricated to study the commingling parameters. The nozzle is the most important element of the commingling machine. The design specification of commingling jet along with the processing parameters decides the final characteristics of yarn. In the present study two different types of jets have been selected to investigate commingling characteristics of glass/polypropylene hybrid yarn.
Keywords – *Commingling, Hybrid yarn, Nozzle, Nip Frequency, Nip stability*

I. INTRODUCTION

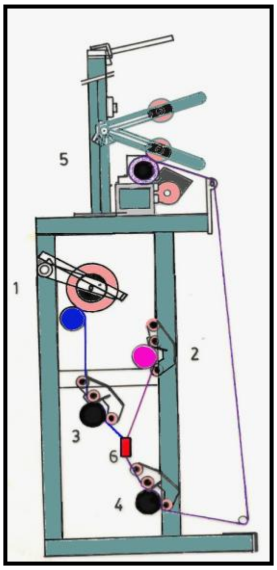
Recently thermoplastic polymer composites are increasingly used as alternative to natural material. Owing to the high melt viscosities of thermoplastic polymers, the matrix has to be combined with the fibre at the preform stage in such a way that the polymer does not have to flow long distances to achieve fibre wetting during consolidation. Probably the greatest potential for further shortening of impregnation time lay in the advancement of combination techniques. One of the outstanding advantages of commingled yarns lies in their potential of intimate blending of reinforcement material like glass, carbon etc with matrix fibers like Polypropylene, Polyester etc by simultaneously retaining the flexibility of the original fibre tow [6]. The commingled yarns are mainly characterized by having regular nips which have been act as a binding point between open portions. In the present study, the hybrid yarns were manufactured from glass/ polypropylene using different type of nozzles with constant take up speed and different level of air pressure and overfeed.

II. MATERIAL AND METHODS

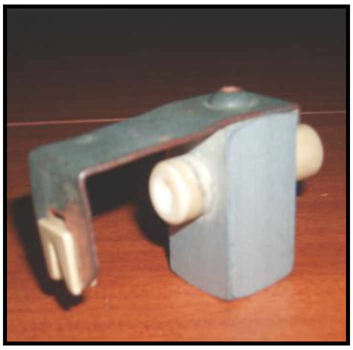
The various hybrid yarns have been prepared using commingling machine as shown in Fig.1 using glass and polypropylene filament yarns. The various hybrid yarns have been prepared to study the effect of nozzle design and processing parameter on commingling behavior of hybrid yarn.

The various hybrid yarns have been made at 50 m/min constant Take up speed and three level of Air pressure 5bar, 6 bar, 7bar and overfeed value 0%,1%,2% combination. The Fig.1 Nozzle I is ceramic jet with circular cross section having 2 inlet hole with 15^0 inclination, 1,5mm diameter of inlet hole, 40mm channel length and 2.5mm channel diameter. Fig.1 Nozzle II is the metallic jet with semi circular cross section (Nozzle 2) having 2 inlet hole with 15^0 inclination, 1,0mm diameter of inlet hole, 20mm channel length and 1.5mm channel diameter respectively.

In order to study the qualitative and quantitative effect of the type of nozzle on the commingling hybrid yarns, various samples of hybrid yarns have been made from glass/polypropylene filaments to study the mechanical properties such as tenacity, extension at break. The mingling characteristics have been evaluated in terms of nip frequency, nip stability



1. Feed roller 1
2. Feed roller 2
3. Over feed roller
4. Output roller
5. Winding unit
6. Mingling nozzle



Nozzle I **Nozzle II**

Fig. 1 Passage of yarn through Commingling Machine and Commingling jets

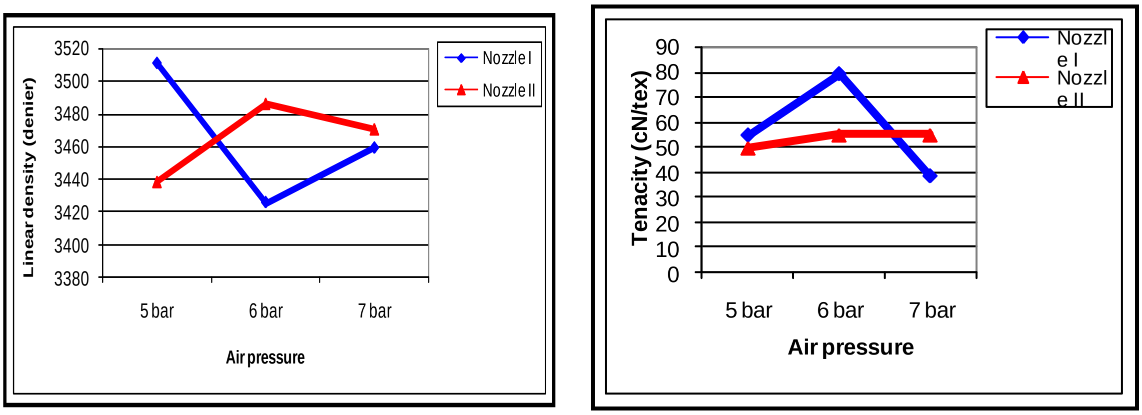
III. RESULTS AND DISCUSSION

The effect of the two types of nozzles on linear density, tenacity and homogeneity of hybrid yarn has been studied; where glass of 2700 denier and polypropylene of 840 denier were mingled at different air pressure and overfeed with constant take-up speed.

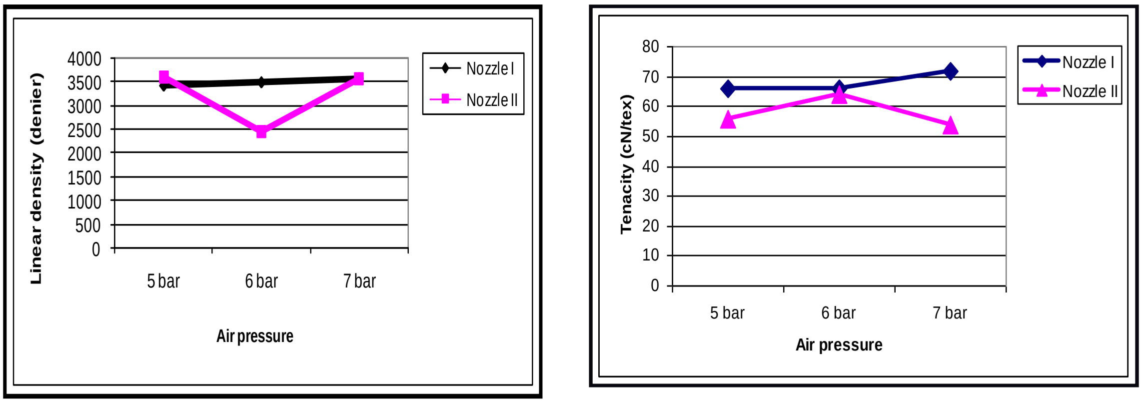
3.1 Effect on Physical Properties of Hybrid yarn

The linear density of commingled hybrid yarns are mainly affected by parent yarn denier and number of filaments, bending properties of filament and processing parameters viz. air pressure and overfeed percentage. Fig. 2 (a), (b) and (c) shows the effect of air pressures on linear density and Tenacity of hybrid yarn at 0%, 1% and 2% overfeed.

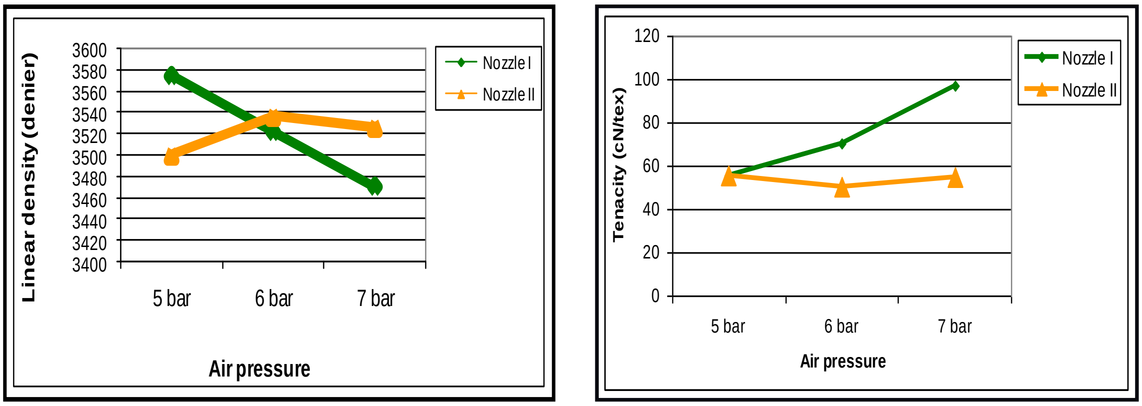
The glass/polypropylene yarn processed by using Nozzle I give no change in linear density at 1% overfeed but at 0% and 2% overfeeds value shows drop in linear density at high pressure due to more breakage of filaments. But at 1% overfeed there is no significant change has been noted as shown in Fig 2 (a). (b),(C). The tensile and extension of hybrid yarns are depends on tensile properties of the component yarn and linear density of hybrid yarn. Hence due to drop in linear density at 0% and 2% overfeed at high pressure the tenacity should increases but at 0% sudden drop in tenacity due high tension in yarn generated due to high pressure at 0% overfeed and 1% overfeed there is no significant change in tenacity of hybrid yarn produced by Nozzle I.



a) 0% Overfeed



b) 1% Overfeed



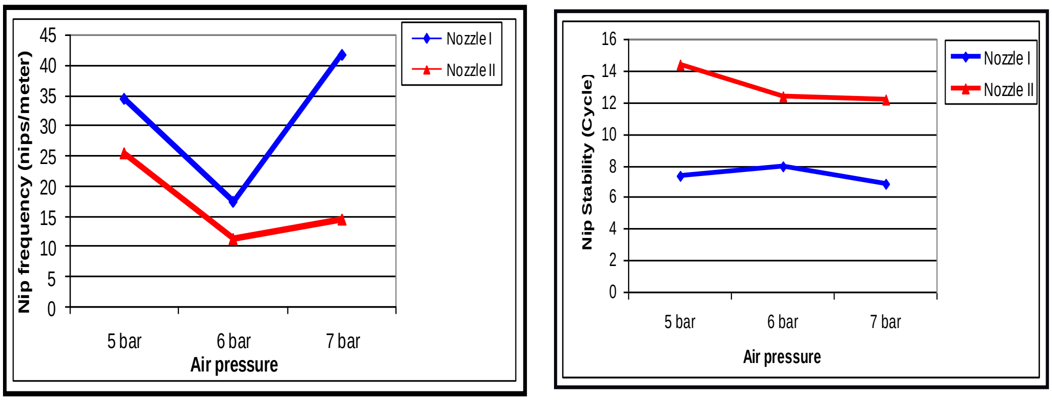
C) 2% Overfeed

Fig. 2 Effect of air pressure on linear density and tenacity

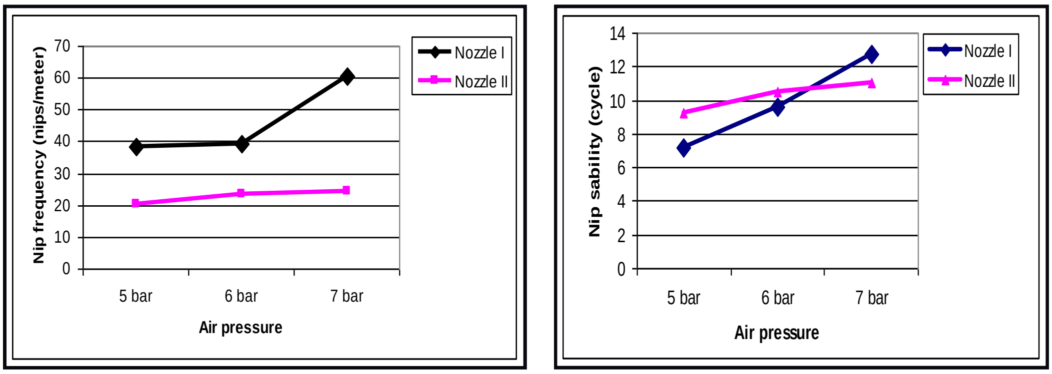
Similarly The glass/polypropylene yarn processed by using Nozzle II shows decreasing trend at 6 bar due to tension change and breakage of filament and then increasing in linear density at 1% overfeed and accordingly tenacity value shows inverse trend. At 0% and 2% overfeed value shows little increase in linear density at high pressure that may be due to better commingling effect at high pressure. The constant values of take-up speed gives increase in tenacity with high value of overfeed and air pressure due to high number of nips.

3.2 Effect on Commingling Properties of Hybrid yarn

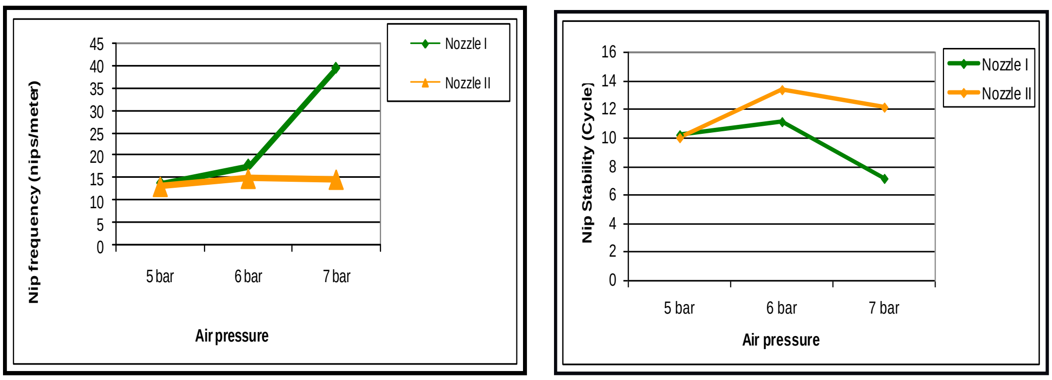
The effect of processing parameters on commingling properties of hybrid yarn, it has been clearly indicate that as the air pressure increases the nip frequency also increases in case of Nozzle I. At 0% overfeed the 6 bar air pressure; there was sudden drop in nip frequency, which may be due to higher breakage of filaments as indicates drop in linear density explained earlier. The Nozzle I show better performance compared to Nozzle II. In case of yarns produced using Nozzle II there was not much change found in nip frequency with change in air pressure or overfeed as shown in Fig 3(a) (b), (c).



a) **0% Overfeed**



b) **1% Overfeed**

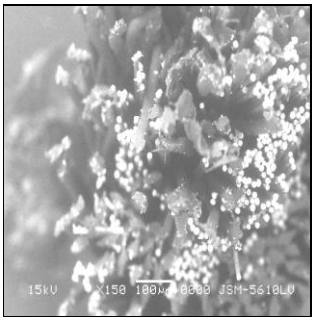


c) 2% Overfeed

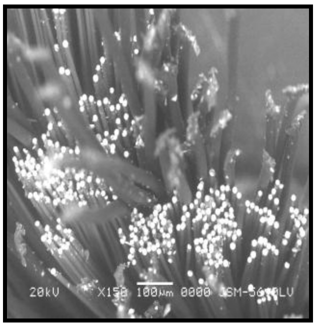
Fig. 3 Effect of air pressure on Nip frequency and Nip Stability

3.3 Effect of Different Types of Nozzle on Homogeneity of Hybrid Yarns

The SEM analysis of glass/polypropylene hybrid yarn produced using two different types of nozzles and same Processing parameters has been studied. Fig. 4 (a), (b) shows the hybrid yarn produced using Nozzle I and Nozzle II produced at 6 bar air pressure, 1% overfeed and 50m/min take-up speed.



(a) Nozzle I

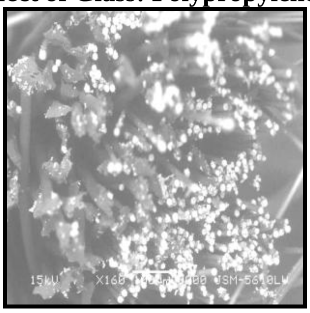


(b) Nozzle II

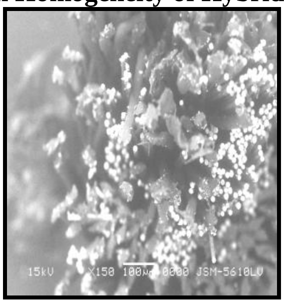
Fig. 4 SEM of Glass/Polypropylene hybrid yarn at two different nozzle (6 bar air pressure, 1% overfeed,)

It has been clearly indicates that Nozzle I gives better homogenous mix compared to Nozzle II. This may be due to higher denier yarn and especially as glass filaments require more space in the jet core to move. As Nozzle I has larger core diameter, it allows filaments to move and form nip. Also circular cross and 15-degree inclination of inlet hole of Nozzle I give better mingling performance than Nozzle II. Hence, for further investigation Nozzle I has been used.

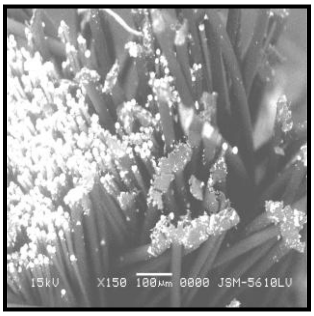
3.4 Effect of Glass: Polypropylene Content on Homogeneity of Hybrid Yarn



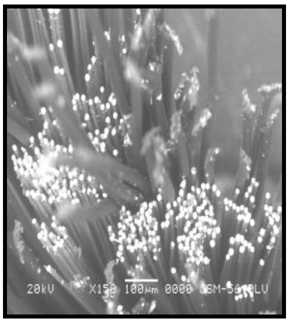
a) (40: 60)



C) (75:25)



b) (60:40)



d) (80:20)

Fig. 8 SEM of hybrid yarn at different Glass: Polypropylene content (6 bar air pressure, 1% overfeed)

The Homogenous mix of glass/PP is critical issue. The balancing between Material, Machine and processing parameter are required for required result. The SEM analysis of hybrid yarns at different Glass: Polypropylene content has been investigated using Nozzle I. It has been clearly indicate during study that 6bar air pressur and 1% overfeed gives best combination for hybrid yarn that 40:60 and 75:25 Glass/Polypropylene hybrid yarn give better mixing compared to 60:40 and 80:20 as shown in Fig 5.

IV. CONCLUSIONS

The study on commingled hybrid yarn with different Nozzle Design and Glass/Polypropylene Proportion conclude that the nozzle geometry plays important role in deciding commingling performance of different hybrid yarn. Hence proper selection of nozzle is required as per the type and linear density of each component yarn. Circular cross sectional shape of main yarn channel in jet is more suitable for glass/polypropylene hybrid yarn compared to semi circular cross sectional shape. Circular ceramic nozzle gives better commingling properties and the effect is more prominent at 1% overfeed and higher air pressure (6 bar and 7 bar).The hybrid yarn with different Glass: Polypropylene content viz. 75:25 gives better commingling properties. The hybrid yarns with Glass: Polypropylene content of 75:25 and 40:60 give homogenous mixing of matrix and reinforced filament within hybrid yarn.

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