CHAPTER 6

COMMINGLING PARAMETERS

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Effect of Nozzle Design and Process Parameters on Commingling Behaviour of Glass/Polypropylene Hybrid Yarn

6.1 INTRODUCTION

The commingling process is comparatively easy simple alternative to produce hybrid yarns. The required properties of hybrid yarns can be obtained by controlling main processing parameters viz. air pressure, overfeed and take-up speed along with proper selection of the type of nozzle (jet).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 processing parameters decides the final characteristics of yarn. In the present study two different types of jets are selected to study the commingling behaviour of glass/polypropylene hybrid yarn. The effect of glass and polypropylene proportion on commingling characteristics of hybrid yarn has also been investigated.

6.2 EXPERIMENTAL PROCEDURE

In the present study, the hybrid yarns are manufactured from glass/ polypropylene on commingling machine. The machine set up, specifications of raw material and sample preparation methodology has been discussed in following section. Samples are mainly prepared by using different types of nozzle and the different glass/polypropylene content.

6.2.1 Raw Material

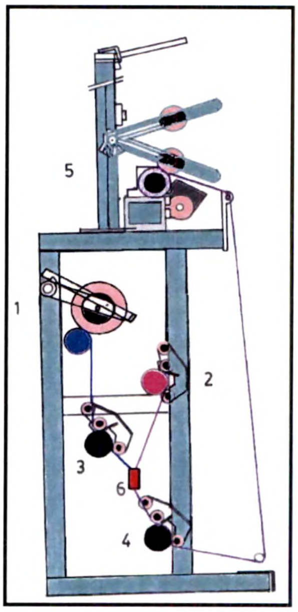
The various hybrid yarns have been prepared using glass filament and polypropylene filament yarns. The specifications of the parent yarns used are given in Table 6.1. The various hybrid yarns are prepared to study the effect of nozzle design, proportion of individual component in hybrid yarns and processing parameters on commingling behaviour of hybrid yarn.

Table 6.1 Specifications of Parent Yarns Used for Hybrid Yarn

Sr. No.	Type of yarn	Code	Linear density (denier)	Number of filament	Tenacity (cN /tex)	Extension (%)	Friction co-efficient (M)
1	Glass	G_1	1395	3600	44.01	2.20	0.567
		G_2	2700	3600	25.2	1.03	0.594
2	Polypropylene	PP_1	840	144	26.55	26.55	0.743
		PP_2	1000	144	47.34	47.34	0.743

6.2.2 Preparation of Yarn Sample

The passage of yarn through machine during preparation of yarn is shown in Fig. 6.1. The different types of nozzle are used for the experiment to investigate the effect of nozzle design. The Table 6.2 shows various commingled glass/polypropylene hybrid yarns made using two-nozzle type viz. ceramic circular nozzle and fiberguide inter jet 100 with semi circular cross section. To investigate the effect of the type of nozzle on commingled behaviour of glass/polypropylene hybrid yarns are produced at constant take-up speed with different combinations of air pressure and overfeed. All yarns are produced using glass filament of 2700 denier(G_2) and polypropylene filament of 840 denier (PP_1).



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

Fig. 6.1 Passage of yarn through commingling machine

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Table 6.2 Processing Parameters Used for Various Commingled Hybrid Yarns

Sr.No.	Air pressure (bar)	Overfeed (%)	Take-up speed (m/min)	Sample code
Commingled yarn produced using ceramic jet (Nozzle I)				
1	5	0	50	NI_1
2	6	0	50	NI_2
3	7	0	50	NI_3
4	5	1	50	NI_4
5	6	1	50	NI_5
6	7	1	50	NI_6
7	5	2	50	NI_7
8	6	2	50	NI_8
9	7	2	50	NI_9
Commingled yarn produced using metallic jet (Nozzle II)				
1	5	0	50	NII_1
2	6	0	50	NII_2
3	7	0	50	NII_3
4	5	1	50	NII_4
5	6	1	50	NII_5
6	7	1	50	NII_6
7	5	2	50	NII_7
8	6	2	50	NII_8
9	7	2	50	NII_9

Table 6.3 Various Mingled Hybrid Yarns Made Using Different Proportions of Glass and Polypropylene

Sr. No.	Component yarn	Mass proportion Glass:Polypropylene	Sample Code
1	PP_1	100%	H_1
2	G_2	100%	H_2
3	G_1+PP_1	60:40	H_3
4	G_2+PP_1	75:25	H_4
5	G_1+PP_1+PP_1	40:60	H_5
6	G_1+ G_2+PP_1	80:20	H_6

Similarly, the Glass filament of different linear density and number of filament by changing the supply package of polypropylene are commingled using commingling machine. The all yarn processed at constant processing parameter of 6 bar air pressure with 1% overfeed and 50 m/min take-up speed. Table 6.3 shows various hybrid yarns with different glass: polypropylene content produced by commingling process.

6.2.3 Nozzle Specifications

The various hybrid yarns produced using two type of mingling jet to study the effect of nozzle design and processing parameters on glass/polypropylene commingled hybrid yarns. The Fig. 6.2 and Fig. 6.3 shows the pictures of ceramic jet and metallic jet respectively. The jet specifications are as under

a) Ceramic jet(Himson)

- Type of Nozzle: Ceramic jet
- Cross sectional shape: Circular

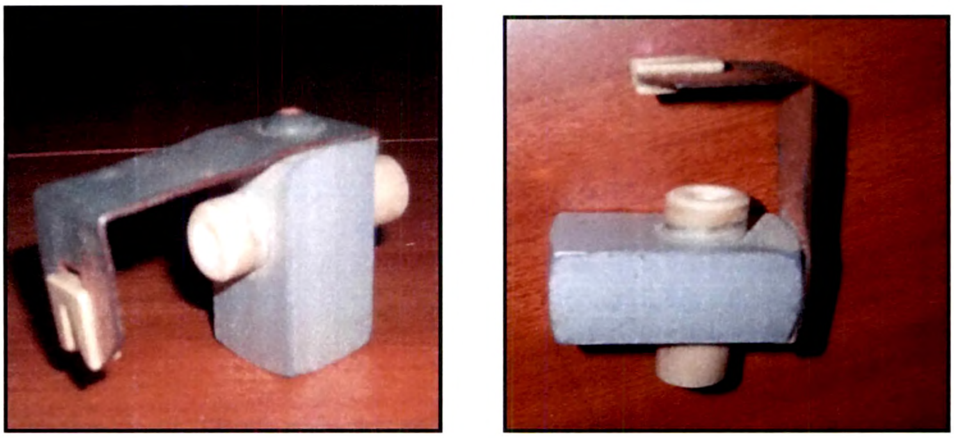

Fig.6.2 Ceramic jet with circular cross section from Himson

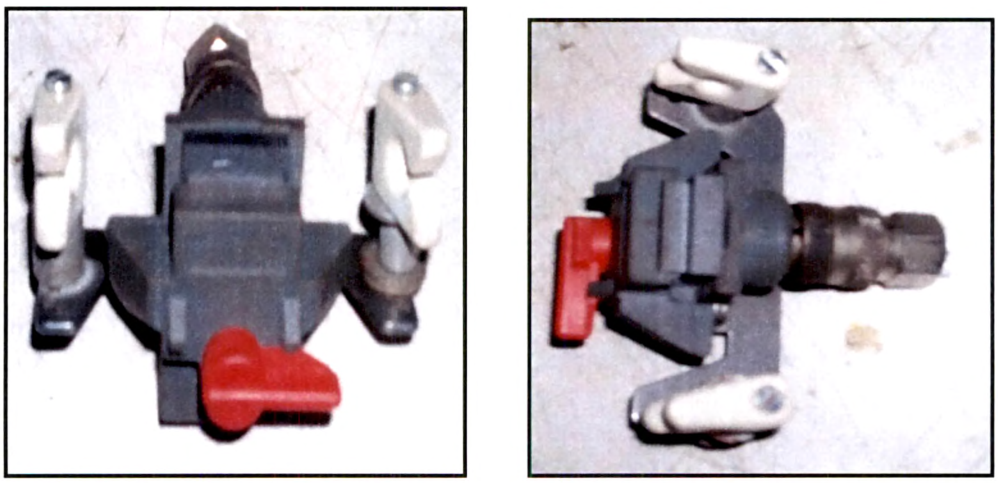

Fig.6.3 Metallic jet with semi circular cross section from Fiberguide

- Number of inlet hole: 2
- Inclination of inlet hole: 15 degree
- Diameter of inlet hole: 1.5 mm
- Length of yarn channel: 40 mm
- Diameter of yarn channel: 2.5 mm

b) Metallic jet(Fiberguide)

- Type of Nozzle: Metallic jet, intel 100
- Cross sectional shape: Semi circular
- Number of inlet hole:2
- Inclination of inlet hole: 15 degree
- Diameter of inlet hole: 1.0 mm
- Length of yarn channel: 20 mm
- Diameter of yarn channel: 1.5 mm

6.2.4 Test Methods of Commingled Hybrid Yarn

In order to study the qualitative and quantitative effect of the type of nozzle on properties of the commingling hybrid yarns, various samples of hybrid yarns are made from glass/polypropylene filaments. The various mechanical properties have been studied such as tenacity, extension at break. The mingling characteristics have been evaluated in terms of nip frequency, nip stability and nip regularity. The methods of measurement of these properties are same as described in Chapter 5.

6.3 RESULTS AND DISCUSSION

6.3.1 Effect of Nozzle Type on Properties of Commingled Hybrid Yarn

The various characteristics of glass/polypropylene hybrid yarn properties produced using two different nozzles are given in Table 6.4. The effect of the two types of nozzles on mechanical properties viz. tenacity, extension and commingling characteristics viz. nip frequency, nip stability, nip regularity of hybrid yarn has been studied; where glass of 2700 denier and polypropylene of 840 denier are mingled at different air pressure and overfeed with constant take-up speed.

Table 6.4 Effect of nozzle type on characteristics of commingled hybrid yarn

Sample code	Linear density(denier)	Tenacity (cN/tex)	Extension (%)	Nip frequency (nips/meter)	Nip stability (Cycle)	Nip regularity (cm)
Nozzle I						
NI_1	3510	54.9	2.1	34.5	7.3	2.6
NI_2	3425	79.2	1.8	17.4	8.0	2.0
NI_3	3458	38.7	2.1	41.8	6.8	2.8
NI_4	3436	65.7	2.6	38.5	7.2	1.9
NI_5	3507	65.7	2.8	39.4	9.6	2.6
NI_6	3592	72.0	2.6	60.4	12.7	1.8
NI_7	3575	55.8	2.0	13.8	10.2	1.9
NI_8	3522	70.2	2.7	17.9	11.1	2.1
NI_9	3470	97.2	2.7	39.6	7.1	2.9
Nozzle II						
NII_1	3438	49.5	2.3	25.4	14.4	1.5
NII_2	3485	54.9	2.2	11.3	12.2	1.9
NII_3	3470	54.9	2.6	14.5	12.2	1.7
NII_4	3605	55.8	2.5	20.1	9.2	2.0
NII_5	2469	63.9	2.7	23.5	10.5	1.8
NII_6	3556	54.0	2.5	24.6	11.0	2.1
NII_7	3500	55.6	2.5	13.2	10.0	1.3
NII_8	3536	50.5	2.1	15.0	13.4	1.6
NII_9	3526	55.1	2.3	14.8	12.1	1.9

a) Linear density

The linear density of commingled hybrid yarn is mainly affected by processing parameters viz. air pressure and overfeed percentage. Fig. 6.4(a), Fig. 6.4(b) and Fig. 6.4(c) shows the effect of various air pressures used during the mingling of linear density at 0%, 1% and 2% overfeed of parent yarn.

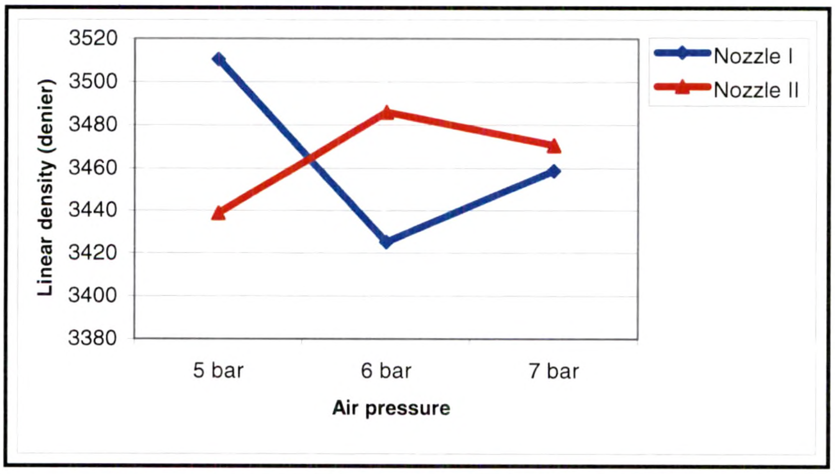

Fig. 6.4 (a) Effect of air pressure on hybrid yarn linear density at 0% overfeed

Fig. 6.4 (b) Effect of air pressure on hybrid yarn linear density at 1% overfeed

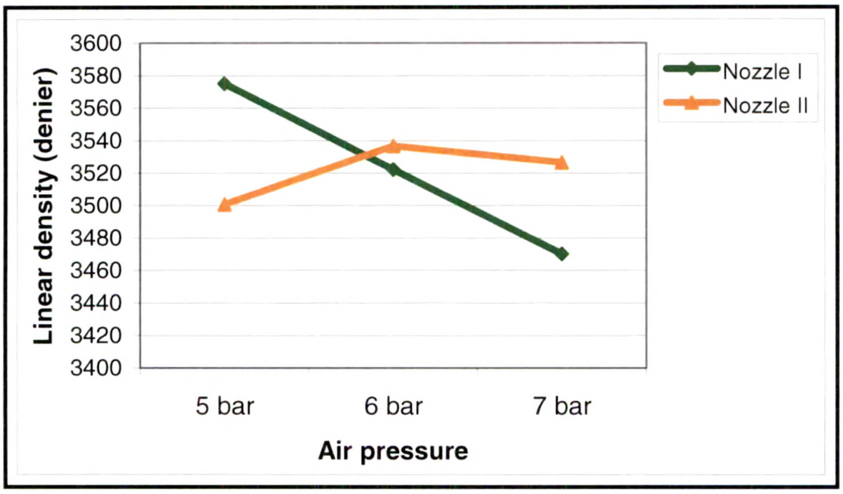

Fig. 6.4(c) Effect of air pressure on hybrid yarn linear density at 2% overfeed

glass/polypropylene yarn processed by using ceramic jet(Nozzle I) shows that at 0% and 2% overfeeds value there is 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. In Nozzle II similar performances observed at 2% overfeed.

b) Tensile properties of hybrid yarn

Fig. 6.5(a), Fig. 6.5(b) and Fig. 6.5(c) shows effect of air pressure on hybrid yarn tenacity at different overfeed percentage. The tensile and extension of hybrid yarn 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 increases of hybrid yarn produced by

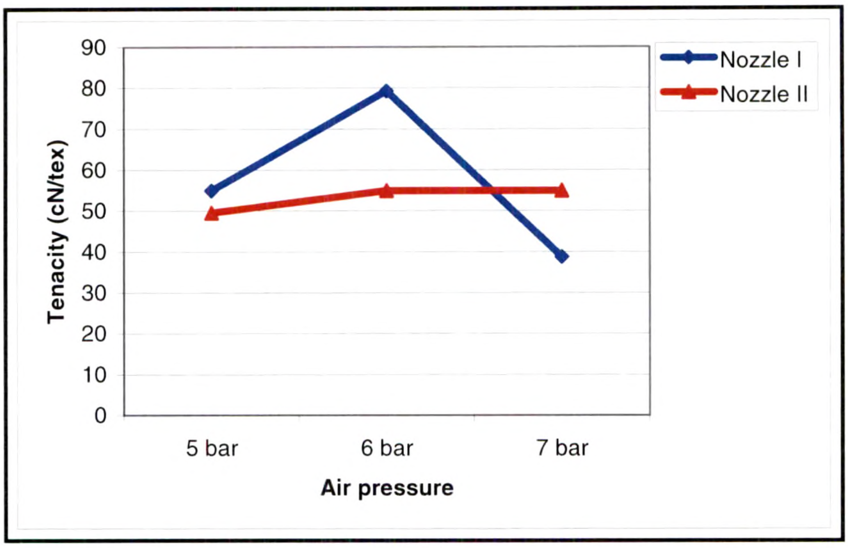

Fig. 6.5(a) Effect of air pressure on hybrid yarn tenacity at 0% overfeed

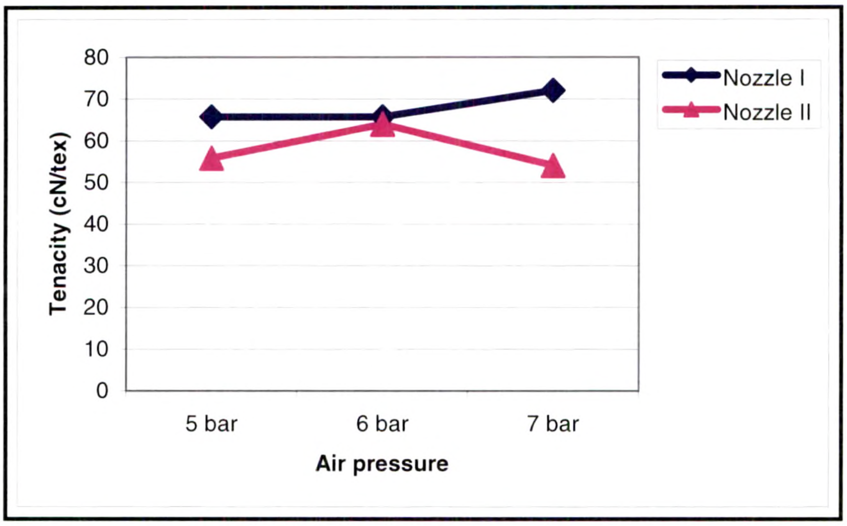

Fig. 6.5(b) Effect of air pressure on hybrid yarn tenacity at 1% overfeed

Nozzle1 and at 1% overfeed there is no significant change in tenacity of hybrid yarn produced by Nozzle I as well as Nozzle II.

Fig. 6.6(a), Fig. 6.6(b) and Fig. 6.6(c) shows effect of air pressure on hybrid yarn extension at different overfeed percentages. Individually the polypropylene filament shows high extension while glass filament shows low extension; but the final hybrid yarn shows lower extension close to glass filament due to proper mingling of glass with polypropylene. The extension of commingled yarn is more if there are more loose nips or due to improper mingling of two filaments in hybrid yarn. The change in extension percentage

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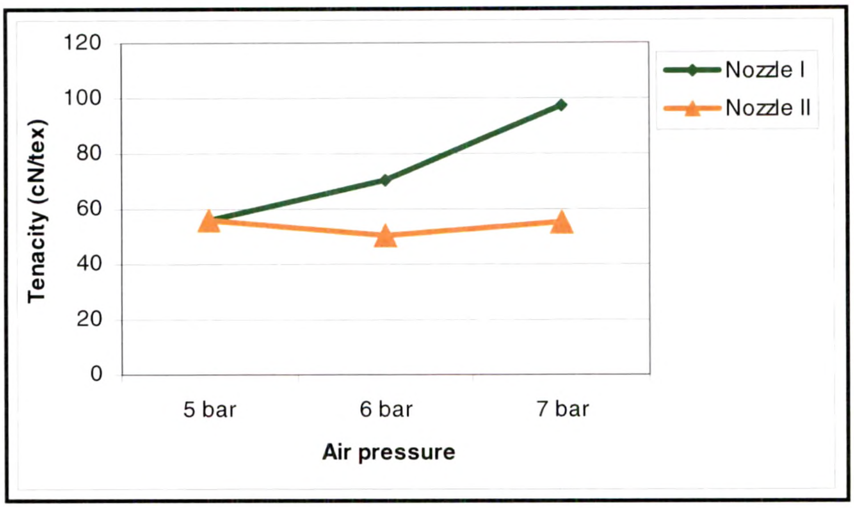

Fig. 6.5(c) Effect of air pressure on hybrid yarn tenacity at 2% overfeed

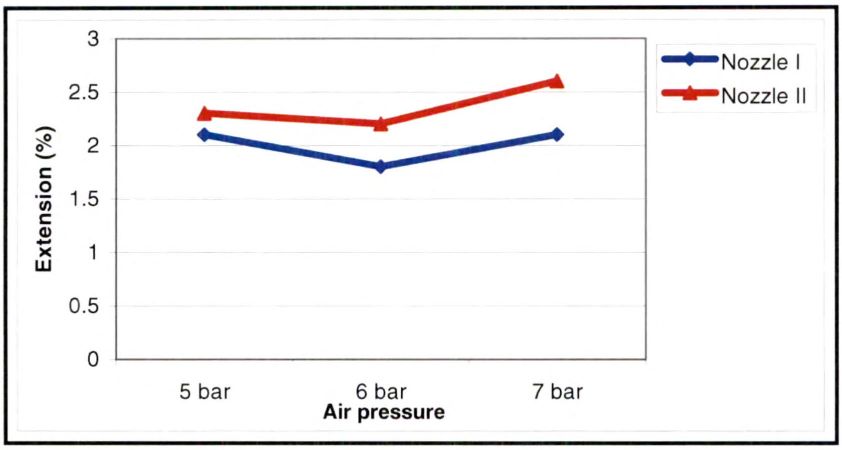

Fig. 6.6(a) Effect of air pressure on hybrid yarn extension at 0% overfeed

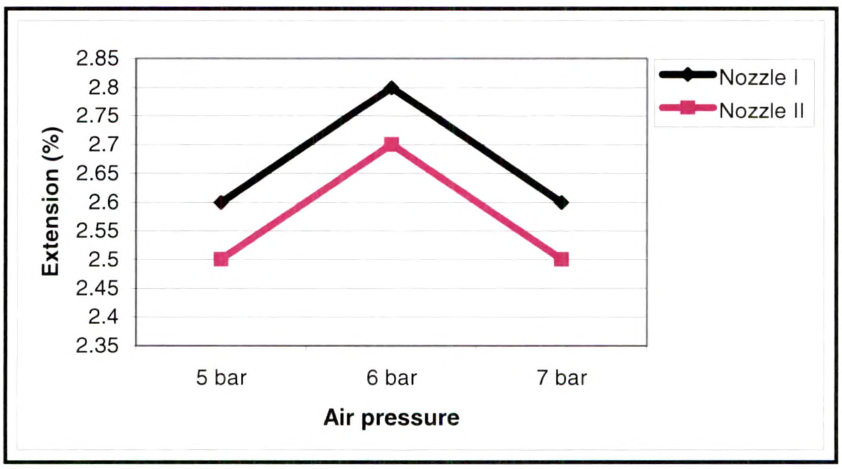

Fig. 6.6(b) Effect of air pressure on hybrid yarn extension at 1% overfeed

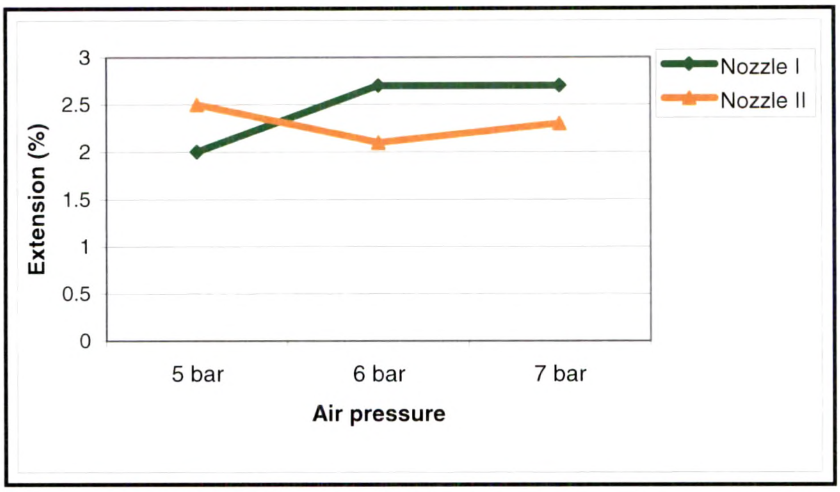

Fig. 6.6(c) Effect of air pressure on hybrid yarn extension at 2% overfeed

is almost negligible at different values of air pressure and overfeeds. Even the difference in percentage extension of hybrid yarn produced using Nozzle I and Nozzle II are not significant.

c) Commingling characteristics of hybrid yarn

The commingling characteristics viz. nip frequency, nip stability; nip regularity of hybrid yarn depends on processing parameter and type of nozzle used for process.

1) Nip Frequency

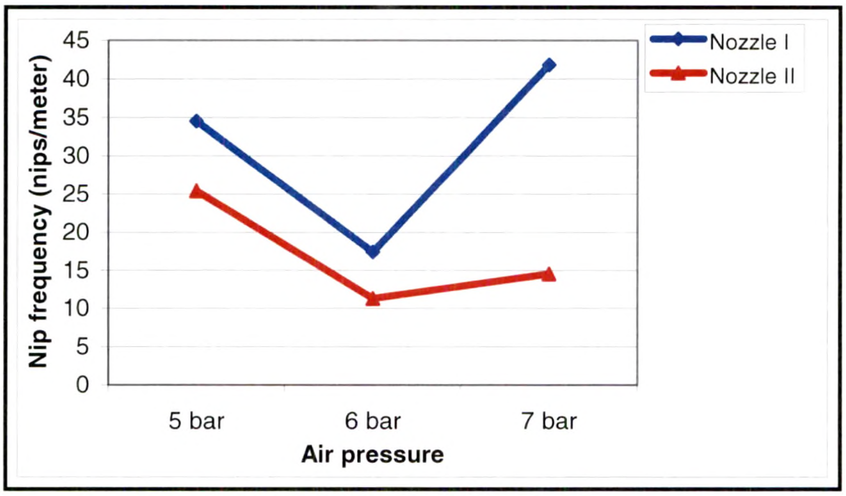

Fig. 6.7(a) Effect of air pressure on nip frequency of hybrid yarn at 0% overfeed

The Fig. 6.7(a), Fig. 6.7(b) and Fig. 6.7(c) shows the effect of processing parameters on nip frequency of hybrid yarn. It is clearly seen 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 is sudden drop in nip frequency which may be due to higher breakage of filaments which also indicates drop in linear density as explained earlier. The Nozzle I shows better performance compared to Nozzle II. In case of yarns produced using Nozzle II there is not much change found in nip frequency with change in air pressure or overfeed.

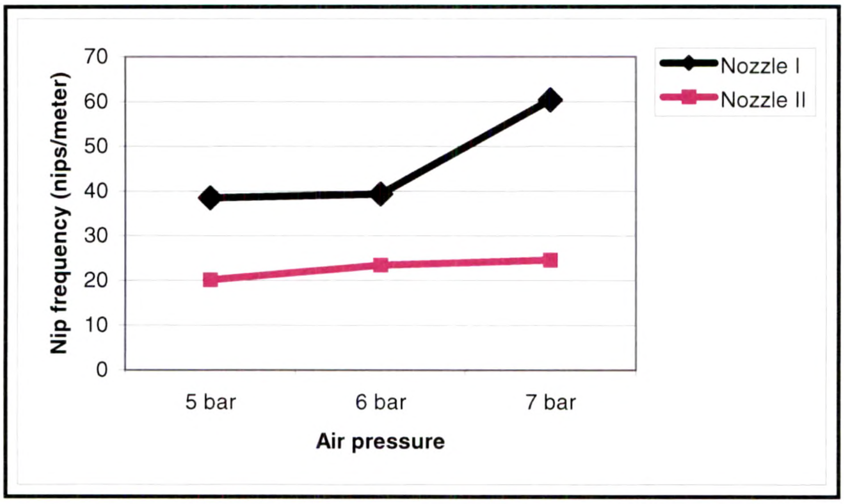

Fig. 6.7(b) Effect of air pressure on nip frequency of hybrid yarn at 1% overfeed

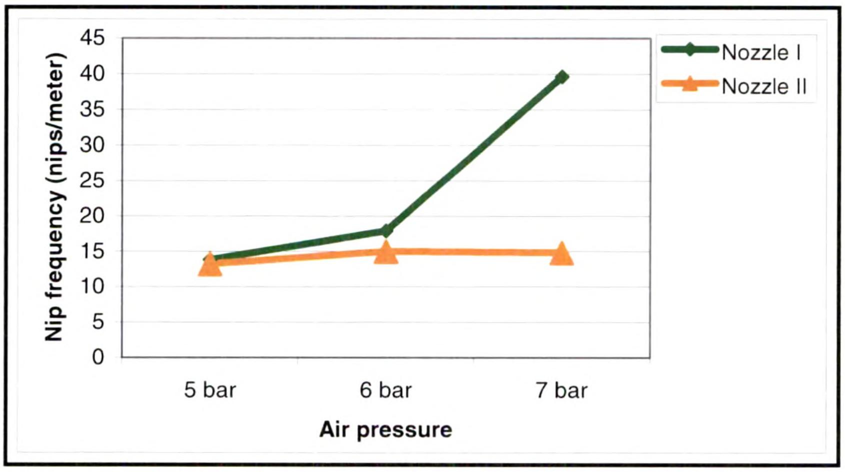

Fig. 6.7(c) Effect of air pressure on nip frequency of hybrid yarn at 2% overfeed

2) Nip stability

The nip frequency alone does not describe the extent of nips in commingled yarn; other parameter like nip stability, is an important quality factor, which is determined the number of cycle required to remove nips. Fig. 6.8(a), Fig. 6.8 (b) and Fig. 6.8(c) shows the effect of processing parameter on nip stability of hybrid yarn. The mingled yarn produced using Nozzle I at 0% and 2% overfeed shows no significant change in the value of nip stability. At 1% overfeed the nip frequency and nip stability increase with increase in air pressure. The Nozzle II shows less nip frequency but higher value of nip stability, there is no significant change with air pressure.

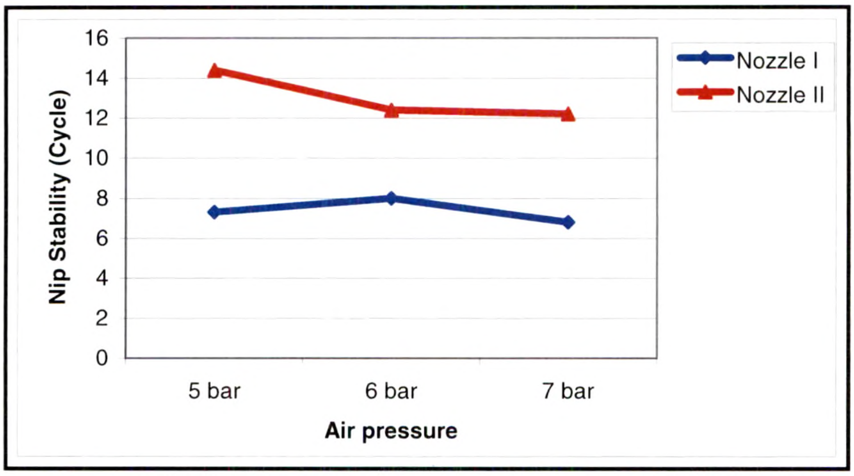

Fig. 6.8(a) Effect of air pressure on nip stability of hybrid yarn at 0% overfeed

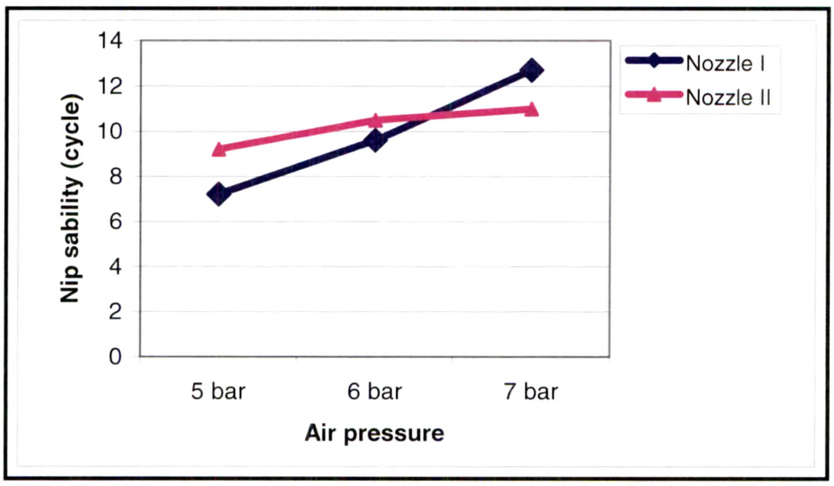

Fig. 6.8(b) Effect of air pressure on nip stability of hybrid yarn at 1% overfeed

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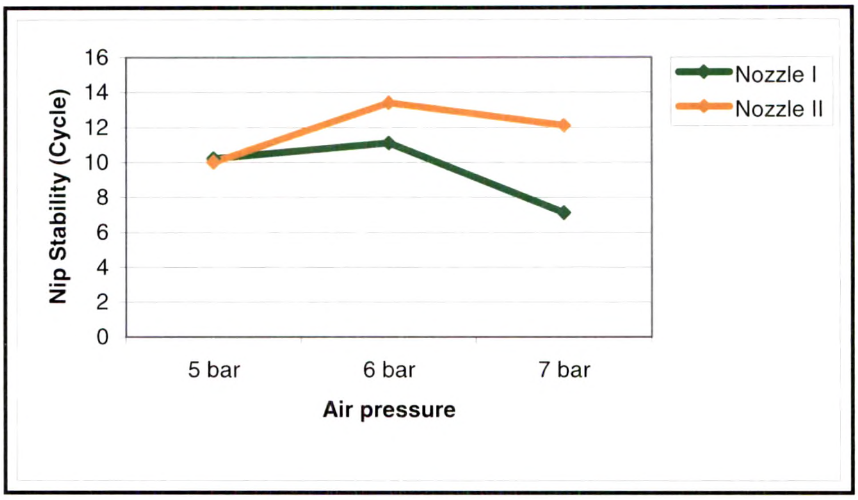


Fig. 6.8(c) Effect of air pressure on nip stability of hybrid yarn at 2% overfeed

3) Nip regularity

Nip regularity is the measure of length of nip between two interlacing points. Higher length of nip gives poor interlacing properties. The change in nip regularity with change in nozzle is not much significant. It is clearly indicated that Nozzle I gives more opening of nip length compared to Nozzle II. Fig. 6.9 (a), Fig. 6.9(b) and Fig. 6.9(c) shows the average value of nip length at different air pressures and overfeeds in two nozzles.

In Nozzle I, at 0% overfeed and 6 bar air pressure, the nip frequency is reduced. It also gives poor interlacing properties and reduced stability of hybrid yarn. At 1% overfeed and 6 bar air pressure nip frequency is less and stability of hybrid yarn is reduced. This may be due to effect of more nip length value but at 7 bar air pressure the commingling properties are significantly improving giving stable yarn. Nozzle II dose not show much variation in value of nip regularity.

Hence the above study clearly indicates that Nozzle I gives better commingling properties and the effect is more prominent at 1% overfeed and higher air pressure (6 bar and 7 bar). So for further investigation Nozzle 1 with processing parameter viz. 1% overfeed, 6bar pressure,75m/min take-up speed are selected.

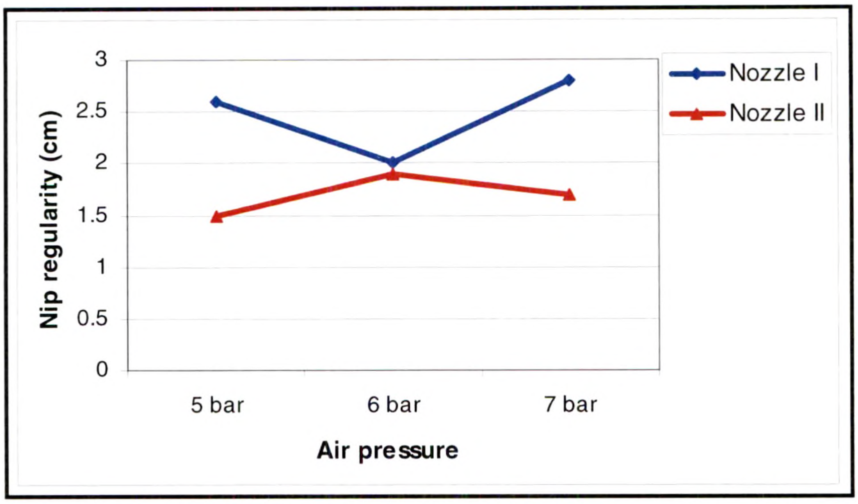


Fig. 6.9 (a) Effect of air pressure on nip regularity of hybrid yarn at 0% overfeed

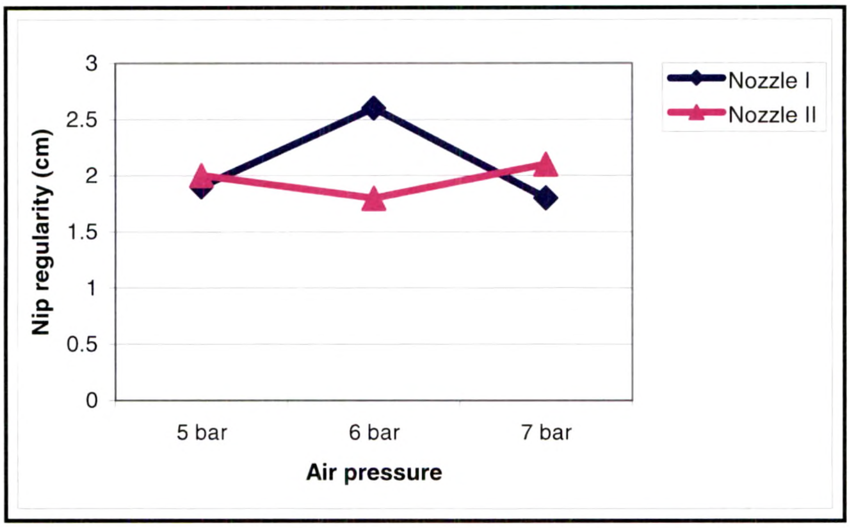


Fig. 6.9(b) Effect of air pressure on nip regularity of hybrid yarn at 1% overfeed

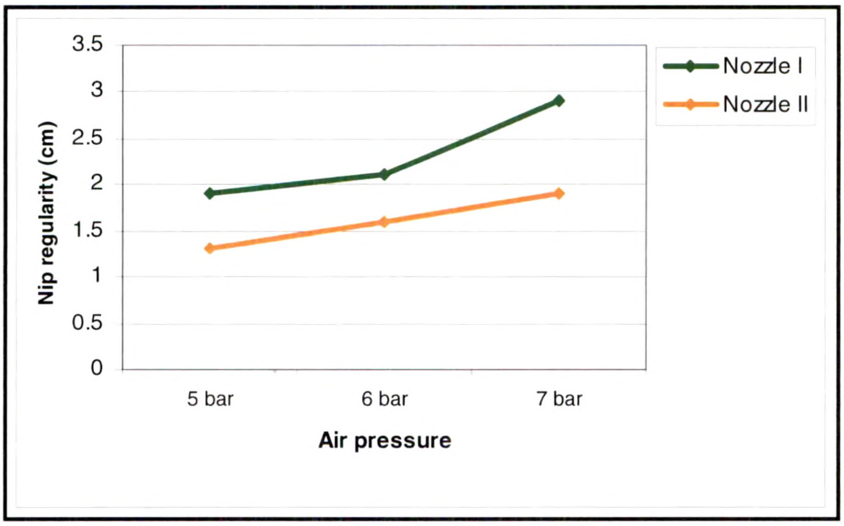


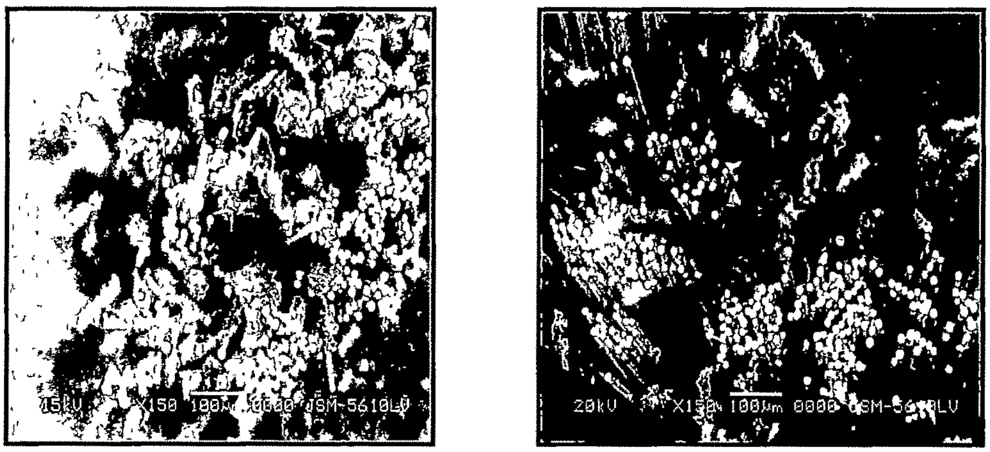
Fig. 6.9(c) Effect of air pressure on nip regularity of hybrid yarn at 2% overfeed

6.3.2 Effect of Different Types of Nozzle on Homogeneity of Hybrid Yarn

The SEM analysis of glass/polypropylene hybrid yarn produced using two different types of nozzles and same processing parameters has been studied. Fig. 6.10(a), Fig. 6.10(b) and Fig. 6.10(c) shows the hybrid yarn produced using Nozzle I and Nozzle II produced at 6 bar air pressure, 1% overfeed and 50 m/min take-up speed. It 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, to form nip. Also circular cross-section and 15-degree inclination of inlet hole of Nozzle I gives better mingling performance than Nozzle II. Hence, for further investigation Nozzle I is used.

6.3.3 Effect of Proportion of Glass: Polypropylene on Characteristics of Commingled Hybrid Yarn

The Glass:Polypropylene content in hybrid yarn depends on the final composite requirements. The Glass:Polypropylene content having significant effect on the commingling behaviour and properties of hybrid yarn. Table 6.5 shows different properties of Glass: Polypropylene content viz. 60:40, 75:25, 40:60, 80:20 produced keeping processing parameters constant (see Table6.2).



(a) Nozzle I (b) Nozzle II

Fig. 6.10 SEM of Glass/Polypropylene hybrid yarn at two different nozzle (6 bar air pressure, 1% overfeed, 50 m/min take-up speed)

The content of Glass:Polypropylene is varied by changing linear density of glass filaments and number of polypropylene yarn strands. The two samples viz H_1 and H_2 are prepared from 100% polypropylene yarn and glass respectively. Fig. 6.10(a)-Fig. 6.10(e) shows various commingled hybrid yarns properties at different Glass: Polypropylene content.

Table 6.5 Properties of Hybrid Yarns With Different Glass/Polypropylene content

Sample code	Linear density		Tenaciy cN/tex	Extension (%)	Young's modulus	Nip frequency (nips/meter)	Nip stability (cycle)	Nip regularity (cm)
	Denier	Tex						
H_1	835	92.8	52.2	22.5	20267.7	12.5	6.5	1.5
H_2	2595.6	288.4	24.6	1.7	49144.1	17.8	4.2	2.5
H_3	2169.1	241.0	25.2	5.5	18957.58	16.0	12.2	1.2
H_4	3696.2	410.7	18.3	1.7	21855.4	22.2	15.2	1.8
H_5	4331.8	481.3	22.7	2.2	21.949.4	16.7	12.1	2.1
H_6	4743.8	527.0	21.7	1.8	14610.7	20.0	10.0	2.3

The physical properties of hybrid yarn vary as per change in linear density of parent yarn or number of strands taken to prepare the hybrid yarn. Fig. 6.11(a) and Fig. 6.11(b) shows linear density and tenacity of hybrid yarn prepared with different Glass:Polypropylene content. The extension values of all hybrid yarns are valued near glass filament extension as shown in Fig. 6.11(c).

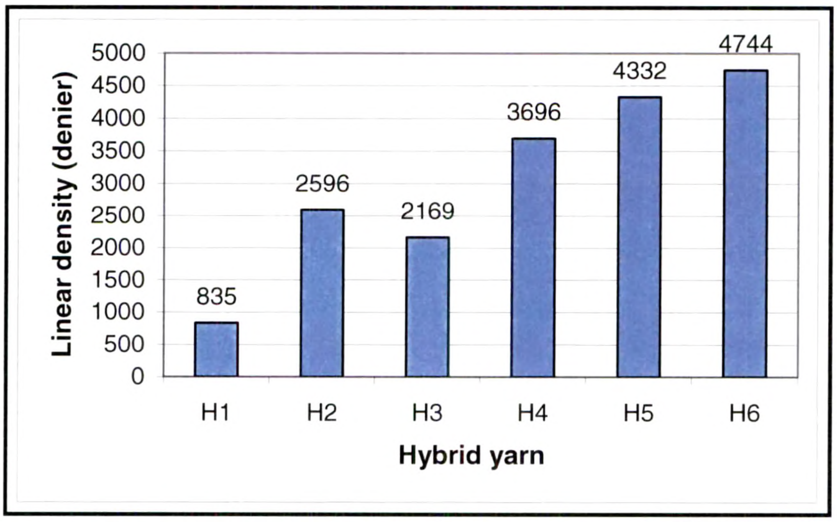


Fig. 6.11(a) Various commingled hybrid yarn linear density with different Glass:Polypropylene content

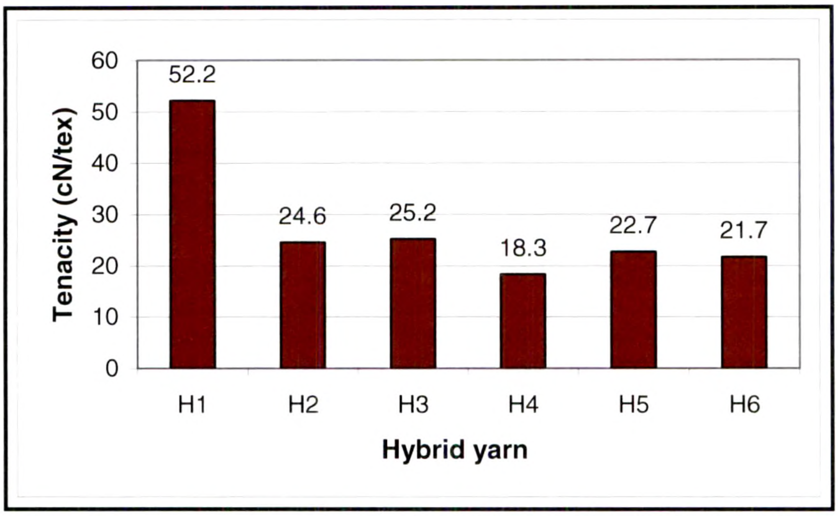


Fig. 6.11(b) Various commingled hybrid yarn tenacity at different Glass:Polypropylene content

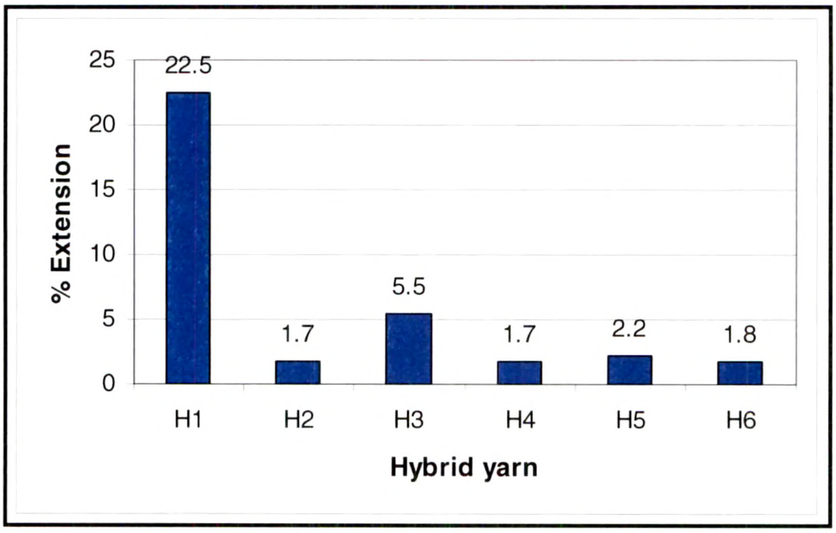


Fig. 6.11 (c) Various commingled hybrid yarn extension at different Glass: Polypropylene content

The extension value of H_3 and H_5 specimen is marginally higher compare to H_4 and H_6 due to more polypropylene content. Similarly for modulus value, polypropylene content dominates and values of all specimen are near to polypropylene value and even glass modulus value is significantly higher as shown in Fig. 6.11(d).

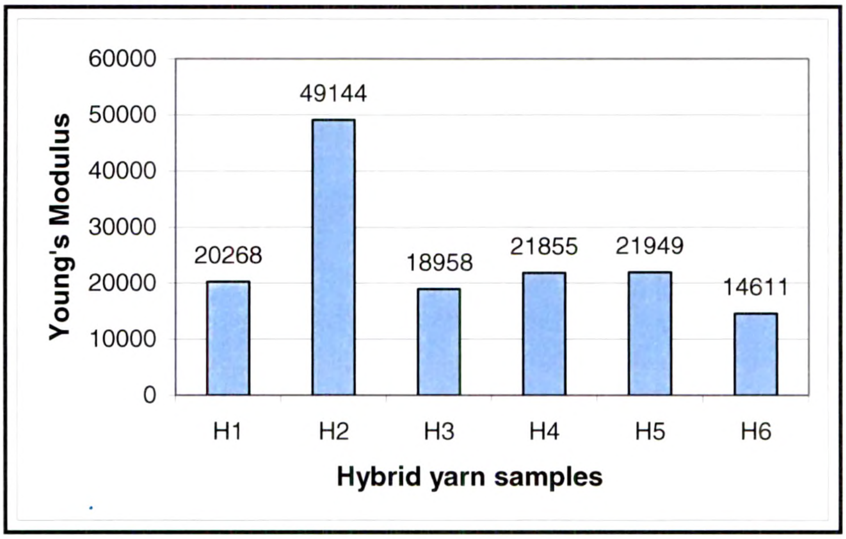


Fig. 6.11(d) Various commingled hybrid yarn modulus at different Glass:Polypropylene content

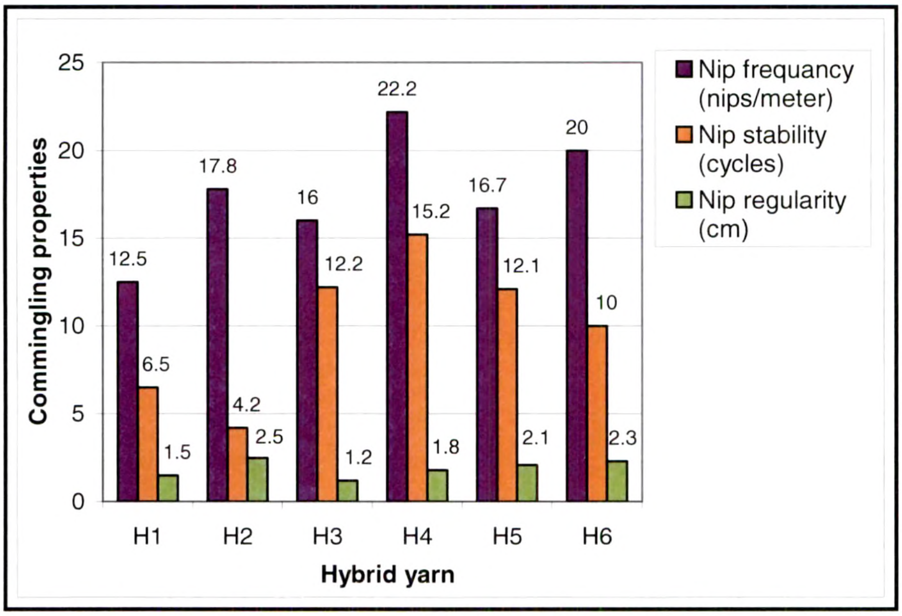
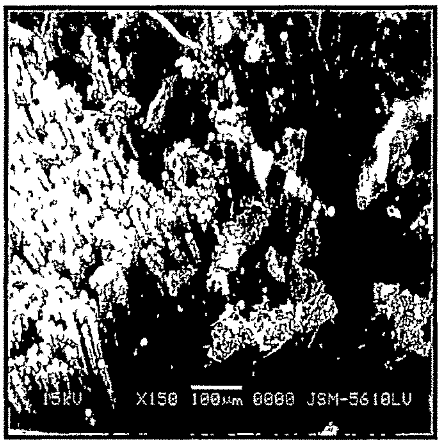


Fig. 6.11(e) Various commingling characteristics at different Glass:Polypropylene content

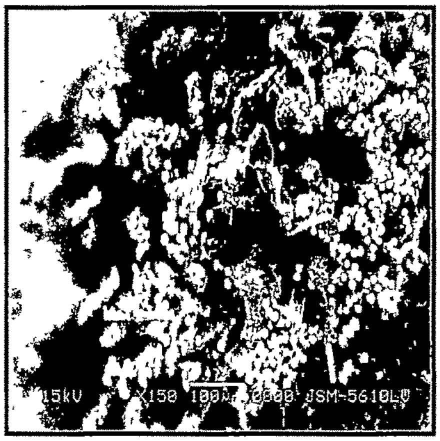
Fig.6.11 (e) shows the commingling characteristics of hybrid yarn. It is observed that 100% polypropylene interlaced yarn give poor interlacing properties and 100% glass give unstable yarn. The hybrid yarns gives better commingling characteristics compared to 100% polypropylene or glass mingled yarn. The specimen H_4 give high frequency yarn with good stability compared to other hybrid yarn. The specimen H3 and H5 shows almost similar characteristics. Hence, to study the effect of processing parameter glass: polypropylene content 75:25 is investigated further.

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

The SEM analysis of hybrid yarn at different Glass:Polypropylene content has been investigated. Fig.6.12(a)- Fig.6.12(d) shows different hybrid yarn with different Glass:Polypropylene content. It is clearly seen that H_4 and H_5 give better mixing compared to H_3 and H_6 Even H_3 and H_6 gives good commingling characteristic.

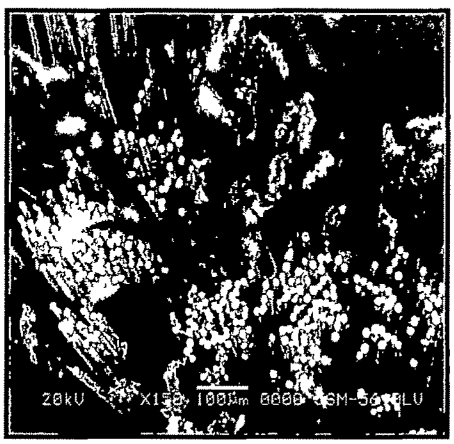


(a) H3 (60:40)



(b) H4 (75:25)

(c) H5 (40: 60)



(d) H6 (80:20)

Fig. 6.12 SEM of hybrid yarn at different Glass: Polypropylene content (6 bar air pressure, 1% overfeed, 50 m/min take-up speed)

6.4 CONCLUSIONS

Following conclusions can be derived from the study on commingled hybrid yarn using different machine and material parameters.

1. The nozzle geometry plays important role in deciding commingling performance of different hybrid yarn. So proper selection of nozzle is required as per the type of component yarn and linear density of each component yarn.
2. 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.
3. 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).
4. Circular ceramic jet give better homogenous mixing of components within yarn as compared to semi-circular metallic jet.
5. The hybrid yarn with different Glass:Polypropylene content viz. 75:25 give better commingling properties.
6. The hybrid yarns with Glass:Polypropylene content of 75:25 and 40:60 give homogenous mixing of matrix and reinforced filament within hybrid yarn.