STUDY THE EFFECT OF COMMINGLING PARAMETERS ON GLASS / POLYPROPYLENE HYBRID YARNS PROPERTIES

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Abstract:

The objective of this paper is to discuss effect of commingling parameter on characteristics of Glass/Polypropylene commingled hybrid yarns to get homogenous mix of matrix and reinforcement elements in the final yarn. A commingling machine developed to produce hybrid yarn using two techniques viz. mingling technique and hollow spindle wrapping technique using single machine is highlighted .The machine can run at speed upto 800 meters/min and for hybrid yarn it can go up to 200 meters/min. To study the effect of parameter three variable namely Air pressure, Overfeed and Take-up speed are take in to consideration and the Box-Behanken design is used for experimental setup. The hybrid yarn samples have been evaluated to investigate the influence of process variables the commingling characteristics of hybrid yarn viz. nip frequency; nip stability and nip regularity have also been studied. 'MINITAB' software is used for the analysis of test results. It was observed that effects of individual parameter as well as interaction effects are equally important in deciding final yarn quality. The structural analysis of hybrid yarn is done using SEM (Scanning electron microscope). To study the mixing behaviour of glass/polypropylene hybrid yarn three different methods have been used to prepare hybrid yarn viz. Friction spinning, hollow spindle wrapping, commingling. Its was clearly observed that commingled process gives better homogenous mixing of glass and polypropylene filaments compare to other two method. This yarn is used to make final laminate sample using hot press.

Key words:

Commingling, Hybrid yarn, Response Surface, Thermoplastic Composite, Matrix, Reinforcement, Nip frequency.

Introduction

A textile composite is generally made by consolidation of certain matrix materials and textile reinforcement in form of various fibrous structures in form of fibre, yarn or fabric. Various thermoplastic polymeric resins are generally used as the matrix. The fibrous structures providing reinforcement are called textile preform which can be prepared using either staple or continuous filament fibres. The glass filament fibre-reinforced composites have become very popular in recent years in providing the extremely strong and lightweight structures in aerospace, automotive and such industrial applications.

The hybrid yarns consisting of polypropylene filament as matrix material and glass filament as reinforced material can give economical solution for thermoplastic composite. Some suitable methods may be used for preparation of hybrid filament yarns, which can be converted in to preform. In a subsequent heating and consolidation process, the thermoplastic fiber melts and become the matrix material in the formed fiber composite in a single process. The homogeneity of reinforcing and matrix elements is important for the performance of textile composites. The present paper highlights a research study mainly emphasising the development of a new method to produce hybrid yarn using two techniques viz. mingling technique and hollow spindle wrapping technique on one machine. The effect of processing parameter on characteristics of commingled yarn has been studied to get homogenous mix of matrix and reinforcement elements in the final yarn.

Objectives

The major problem with thermoplastic resin is its high viscosity. It is very difficult to inject the highly viscose thermoplastic melt uniformly into the textile preforms during manufacturing of composites. The existing conventional spinning machines in general are not suitable to produce commingled yarn, due to lack of positive and precise control. Hollow spindle wrap spinning method gives hybrid yarn having core/sheath structure, with poor homogeneity.

The existing machine set up has been modified to produce commingled hybrid yarn using two different methods on one machine. The aim of the research is to study the effect of processing parameters on commingling behaviour and properties of various hybrid yarns for thermoplastic composite. The main object of the study is to produce various types of hybrid yarns incorporating polypropylene matrix filaments with reinforced filaments (glass) using commingling process.

Modification in machine

Based on the preliminary study, the commingling machine is modified to produce hybrid yarn. The various changes are incorporated while fabricating the machine to have following features:

- Single machine to make yarn with two different processes.
- Simple threading arrangement to minimize fiber damage and Positive feeding arrangement.

- Feed roller with overfeed adjustment upto 4%.
- Polished rubber cover roller surface with ceramic guides.
- Machine speed upto 800m/min depending on yarn types, and Inverter drive for commingling unit and Individual drive for hollow spindle unit.

Figure 1. Commingling Machine.

The commingling machine has been fabricated incorporating two processes viz. commingling unit and hollow spindle wrapping unit for production of hybrid yarns, using each technique separately. The machine houses the supply package creel, spinning zone, yarn guides and tension rollers, and a winding unit as shown in Figure1.

Materials and methodology

Two different types of parents yarn viz. 2700 denier Glass filament yarn and 840 denier polypropylene filament yarns have been used to produce various type hybrid yarns. The hybrid yarns have been prepared on the commingling machine, by varying main process-parameters such as air pressure, overfeed and yarn take up speed. Three levels have been selected in each case i.e. air pressure: 1.5, 2, 2.5 bar, overfeed: 0%, 1%, 2% and take-up speed: 50, 75, 100 m/min. The ceramic jet with circular cross-section is used for mingling of component yarns. The four different hybrid yarns using different technologies have been prepared viz. friction spinning, wrap spinning, mingling technigue and combination of wrap spinning and mingling technique. The yarn structure of each of these hybrid yarns have been studied using SEM technique.

The Box-Behanken design is used to reduce number of experiments for preparations of specimens of hybrid yarn using key processing variables. The fifteen hybrid yarn samples have been evaluated to investigate the influence of process variables on important yarn characteristics such as linear density, tensile strength and elongation at break along. The commingling characteristics of hybrid yarn viz. nip frequency; nip stability and nip regularity have also been studied. 'MINITAB' software is used for the analysis of test results; and the regression equations, contour plots and surface plots are generated to observe the linear and interaction effects of process variables on the hybrid yarn characteristics.

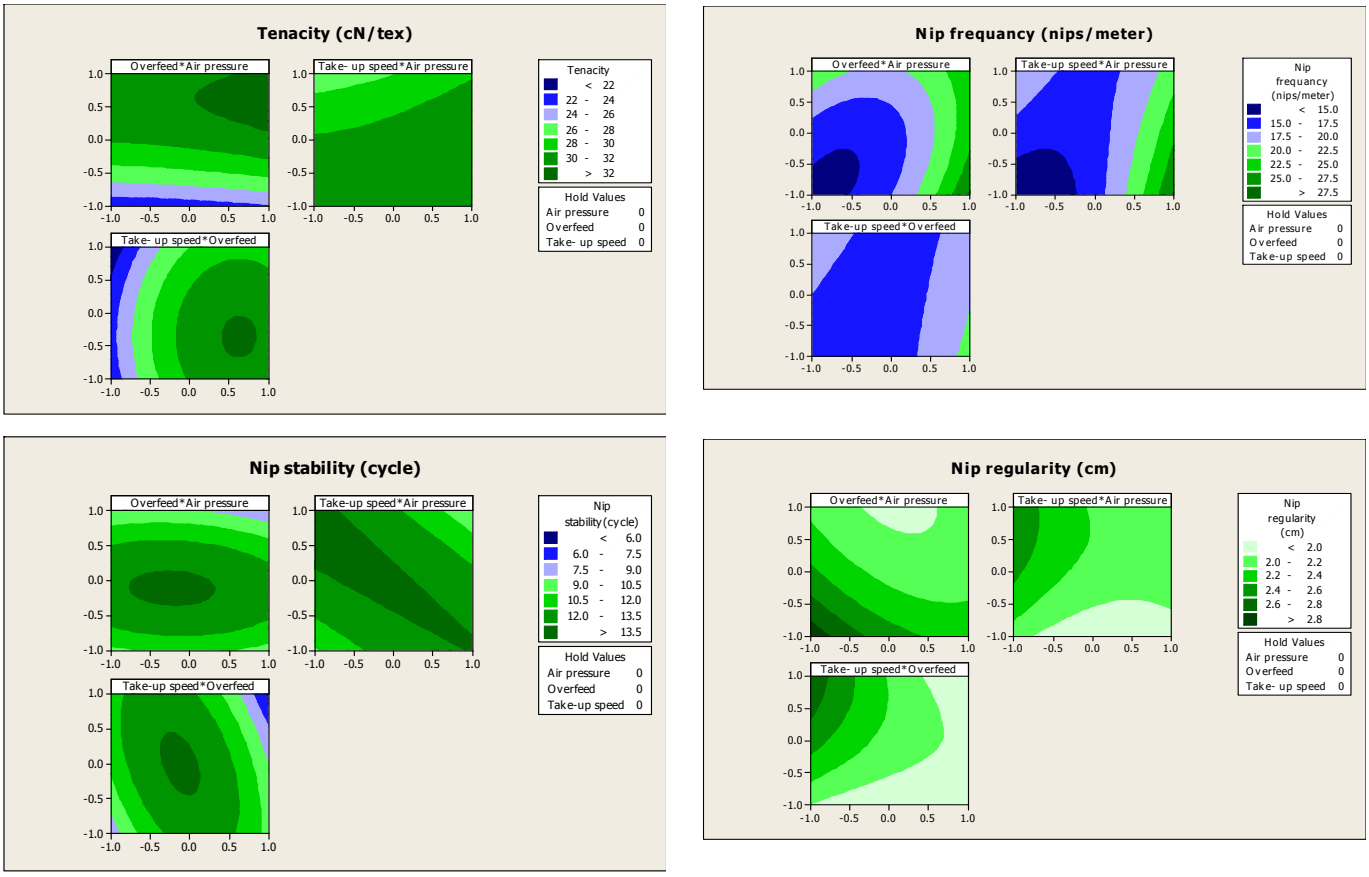

Figure 2. Effect of processing parameter on commingling properties of commingled hybrid yarn.

Figure 3. Hybrid yarn produced using different manufacturing technique.

Results and discussion

The effect of process variables viz. air pressure, overfeed and take-up speed on properties of commingled hybrid yarn produced from glass filament and polypropylene filament has been taken into consideration by using the response surface methodology based on the Box- Behnken design.

It is evident from the results that the yarn denier value is more at higher overfeed and air pressure. Also high pressure with low overfeed gives poor quality of yarn due to higher filament breakage. 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. Similar effect has been observed in Figure 2 for high value of tenacity due to low take-up speed and high pressure; but as take-up speed increases the nip frequency reduces with poor regularity, resulting in poor yarn tenacity. The higher value of overfeed with low take-up speed at constant pressure gives better tenacity due to overfeeding of yarn but in this case nip characteristics are poor at low air pressure, which improve with high pressure. Hence, overfeed is an important factor in deciding the yarn tenacity.

At constant take-up speed, the nip frequency increases with increase in air pressure. Also low take-up speed and high air pressure give higher value of nip frequency. But there is no significant effect of interaction between take-up speed and overfeed on nip frequency. Hence for deciding the nip frequency, air pressure and take-up speed are the important factors. The higher value of take-up speed with lower air pressure gives better nip stability. Similar trend is observed at low take-up speed and high air pressure. The lower overfeed and low pressure gives higher nip frequency but poor nip stability. Similarly, low take-up speed with low overfeed value shows the same trend of poor stability. Thus nip stability is dominated by the interaction effect of all three processing parameters than their individual effect.

The nip regularity is a measure of opening length of nip in commingled hybrid yarn, which can also be measured in terms of degree of opening. The lower value of degree of opening indicates good interlacing properties. Its shows that with increase in air pressure, the open length of nip reduces and this gives higher nip frequency with stable nip due to good interlacement. Similar trend is observed with low take-up speed with 1% over feed value.

Structure of commingled hybrid yarn

The structural analysis of hybrid yarn is done using SEM (Scanning electron microscope). To study the mixing behaviour of glass/polypropylene hybrid yarn. The different methods have been used to prepare hybrid yarn viz. Friction spinning, hollow spindle wrapping, commingling. Figure 3 shows clearly that commingled process gives better homogenous mixing of glass and polypropylene filament. This yarn is used to make final laminate sample using hot press.

Conclusions

The response surface analysis of glass/polypropylene hybrid yarns has been made to study the effect of processing parameters. The three processing parameters of commingling process viz air pressure, overfeed and take-up speed have significant effect on characteristics of hybrid yarn. Commingling behaviour of the yarns during different process conditions and with different methods has been studied. The some of the conclusions drawn are listed below.

1. The effects of individual parameter as well as interaction effects are equally important in deciding final yarn quality.
2. It is evident from result that the final resultant yarn linear density value significantly affected by air pressure and overfeed but give high breakage and poor quality of yarn.
3. The tenacity of hybrid yarn is affected by overfeed value. With higher pressure and increasing overfeed; tenacity improves only at low take-up speed viz. 50 m/min.
4. The main quality parameters of commingled yarn viz. nip frequency, nip stability and nip regularity are mainly affected by interaction value of three processing parameters. It has been observed that high air pressure at 1% overfeed with lower take-up speed gives the best combination in terms of processing glass/polypropylene hybrid yarn.
5. SEM of hybrid yarn cross section shows that commingled yarn give best mixing of glass and polypropylene compare to any other methods of manufacture is achieved with high air pressure and low take-up speed with average overfeed value (1%).

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