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STUDY ON LONG FIBRE REINFORCED THERMOPLASTIC AND CHARACTERIZATION DURING DIRECT EXTRUSION PROCESS

[1]Bommanna K, [2]Dr. K V Mahendra, [3]Dr A Hareesh [4]Dr Yuvaraj Naik, [5]Dr Radha H R

[1]Ph.D Research Scholar, [2]Professor, [3]Associate Professor, [4]Associate Professor, [5] Professor & Research Scientist

[1234]Department of Mechanical Engineering, [5]Department of Chemistry

[123]R R Institute of Technology, Bangalore, Karnataka, India

[4]Presidency University, Bangalore, Karnataka, India

[5]Sarojaayudh Innovation cell, Bangalore, Karnataka, India

Abstract: The present work involves manufacturing of long fibre reinforced thermoplastic composites by single stage using polypropylene as matrix material and continuous sisal fibre roving as reinforcement and Maleic Anhydride Polypropylene (MAPP) as a coupling agent. The continuous Sisal fibre roving were obtained from external source and Physical properties were studied. Chemical treatment of fibre has been done using NaoH and Nacl solution to remove lignin content results in better adhesion observed between matrix and fibre. Extrusion process has carried out by introducing compounding element and screw configuration by that fibre attrition has been reduced. Special type of screw elements was used to convey the fibres into the extruder. Test plates were obtained for different screw speeds with different volume fraction. Microscopic tests and Solvent test were also conducted in order to do fibre length analysis, obtained Test plates were tested as per ASTM standards. Improved Mechanical properties were obtained and the result values were correlated and validated with the fibre length and screw speed.

***Index Terms* - Long natural fibre, Fibre attrition, Screw speed, Compounding Element, Twin screw extruder**

I. Introduction

The long fibre reinforced thermoplastic parts are currently manufactured in two stages. Initially the well-known process is pultrusion and second stage is injection or compression moulding. In Pultrusion process the strands are produced using extruder with a crosshead die to impregnate and wet-out of the continuous sisal fibre roving with the thermoplastic and then cooled followed by granulated to pellets from 12.5 mm to maximum 25 mm length. These pellets of long fibre reinforced thermoplastic parts are produced either with compression or injection moulding in the second stage. These two stages involve high labour cost, high capital investment and limited options to quick change to end user’s new requirements. In these two stages process the polymer undergoes two heating history and because of this there is a chance of deterioration of the properties of long fibre reinforced thermoplastic parts and as a result reduction of overall performance. In order to overcome the inconvenience of two stage process, the state-of-the art of single stage process called Direct processing of long fibre reinforced thermoplastic is developed. Major advantages are improved dimensional accuracy of the product, lesser maintenance, cost reduction, improved initial and long-term properties.

EXPERIMENTAL

Materials

The sisal fibre rovings are selected as reinforcing fibre and these fibres are in continuous form. Polypropylene (REPOL H 110 MA) is selected as matrix material, Maleic Anhydride Polypropylene (MAPP) (5% OPTIM P-410) is selected as coupling agent. The sisal fibres were extracted from sisal plant leaves using fibre extraction tools. These fibres were chemically treated with 5% NaoH and 5% Nacl solutions in order to remove lignin content and other impurities, results in improved adhesion between fibres and matrix.

PROCESS SETUP

The present work is concentrated on Direct processing of long fibre reinforced thermoplastic with in-line compounding system integrated with press moulding (LFRTP-D-ILC). In the current process twin screw extruders and a hydraulic press is used to deliver homogeneous long sisal fibre reinforced compound extrudate in the form of rectangular shape from the film die. The polypropylene in granules form, coupling agent and colourants are delivered by the gravimetric feeders into the twin screw extruder either by individual feeder or premixed form. The twin screw extruder acts as compounding unit, which is a co-rotating, closely intermeshing, self-wiping with degassing barrel assisted with vaccum or atmospheric pressure and provision for the continuous sisal fibre roving feeding. The screw configuration incorporated with the twin screw extruder to obtain long fibre i.e, >5 mm to 50 mm. The molten extrudate is conveyed to the press by manually or robotic handling and the deposition of the material press is closed.

In this process compounding equipments are plays lead role in order to convey the fibres into the extruder. The co-rotating twin screw extruder offers the ability to do these tasks precisely that is setup to deliver the right kind of amount of work at the right place for the right amount of time. The basic process includes three M's- Melt, Mix, Meter. The process involves melting the material ahead of mixing in various ingredients such as colourants, additives and reinforcement. The extruder performs the task of mixing by shearing, stretching, folding and compressing the melt with other constituents. To achieve this it needs feeding, melting, mixing, venting and metering. Proper dispersion of fibres into the matrix has been achieved by using different screw elements which were introduced into the extruder they are names as Screw mixing element (SME), Right kneading block (RKB), Tri-lobed kneading block(3KB). The extrudate was processed by compression moulding by that rectangular shaped composite plates were obtained. The obtained test plates were produced for further analysis.

FIBRE CONTENT TEST

Fibre content of the specimens was determined as per ISO standards. The specimens were cut where different structures were seen. The determination of fibre content of the specimens was done by the calcination method.

FIBRE LENGHT ANALYSIS

Fibre attrition was taken place during compounding process. Fibre length distribution of the specimens were determined by solvent test or burning off test. The polypropylene matrix material was removed from the reinforcing fibres by solvent called xylene. The obtained fibre lengths were analysed using scanning electron microscope.

FIBRE WETTING

The tensile tested specimens were analysed to check the wetting properties for the different process conditions. SEM image analysis were done, proper wetting of fibres has been observed.

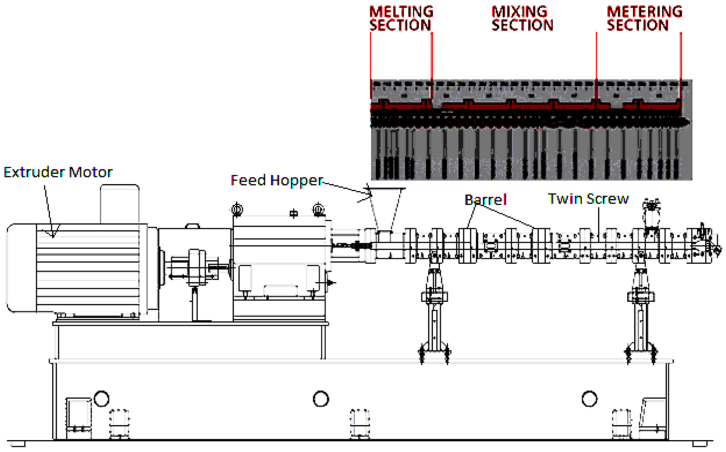


Fig 1: Three M's of compounding Melt, Mix and Melt

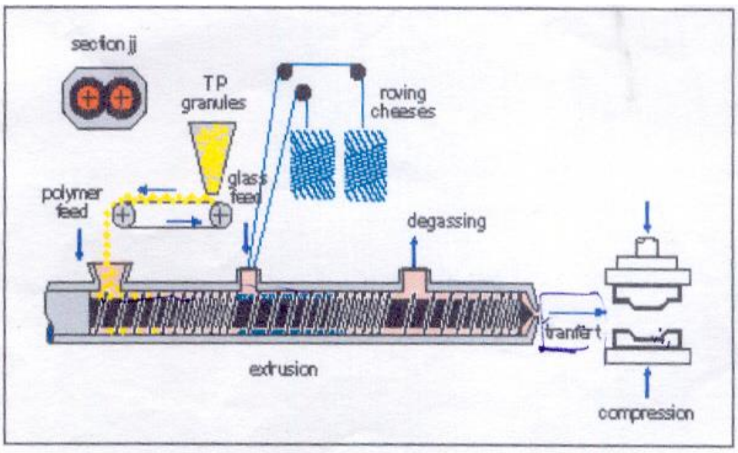
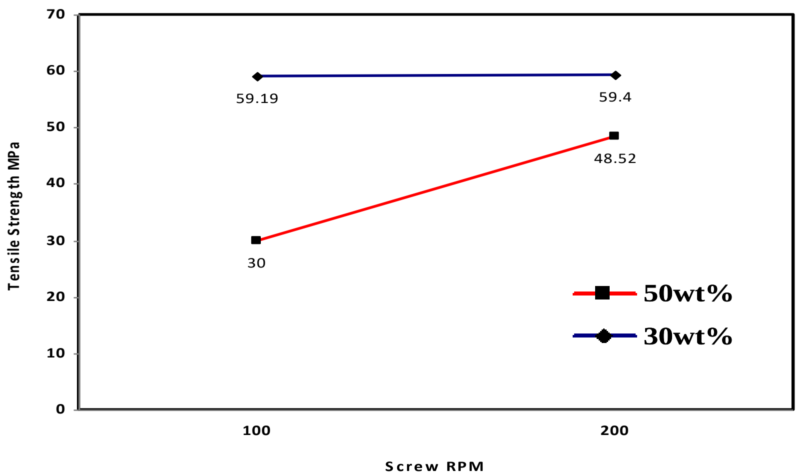


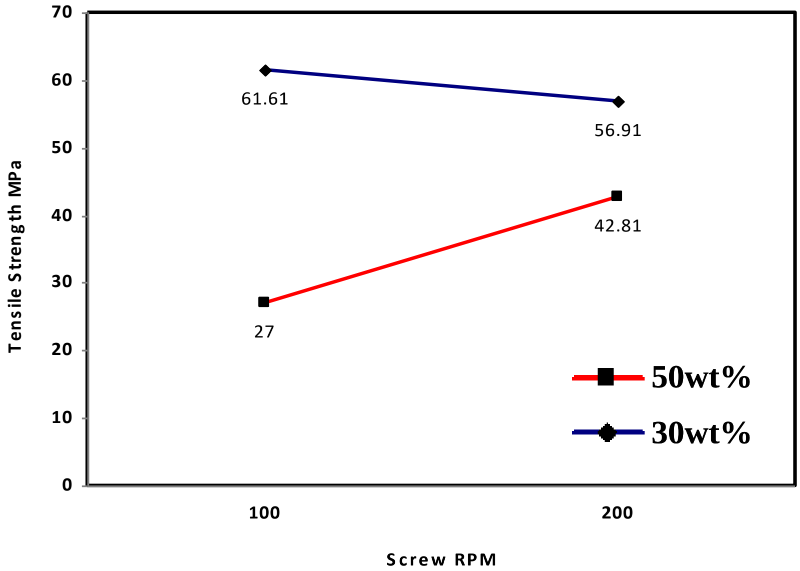
Fig 2: Schematic representation of Proposed Process

RESULTS

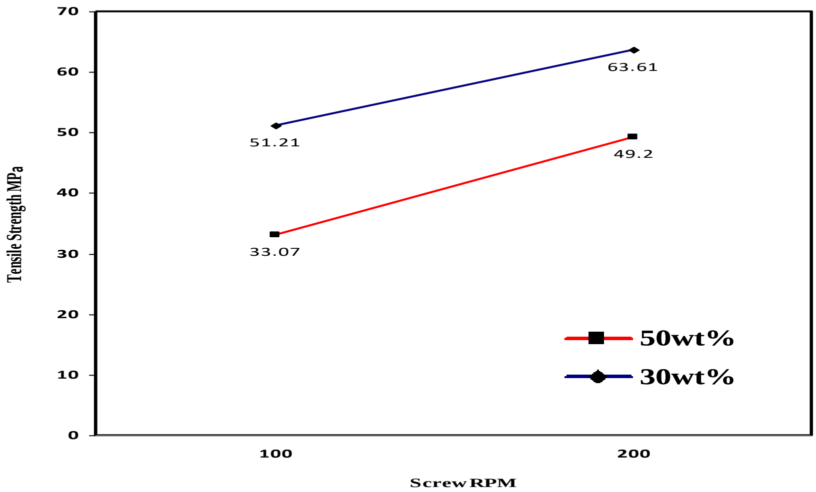
The test specimens were prepared as per ASTM standards. The test plates were obtained by varying the screw speed and volume fraction as a variable parameter.



Graph 1: Effect of screw speed on Tensile strength with SME element



Graph 2: Effect of screw speed on Tensile strength with RKB element



Graph 3: Effect of screw speed on Tensile strength with 3KB element

CONCLUSION

Different screw elements were used to produce long fibre reinforced thermoplastic composite plates. Mechanical tests were conducted according to ASTM standards. The different screw speeds in different volume fraction shows improved mechanical properties. Based on the study it is found that the experimental data that the SME screw configuration shows the reliable values compare with the 3KB and RKB screw configuration.

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