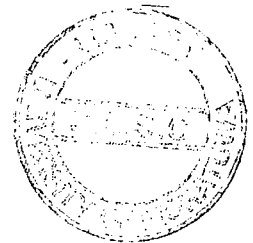


STUDY OF FLOW PROPERTIES OF NYLON 6
RECYCLED MATERIAL IN RECIPROCATING
INJECTION MOLDING MACHINE

by

D. B. Yapa



LIBRARY
UNIVERSITY OF MORATUWA
MORATUWA

**THIS THESIS WAS SUBMITTED TO THE DEPARTMENT OF
CHEMICAL AND PROCESS ENGINEERING OF THE UNIVERSITY
OF MORATUWA IN PARTIAL FULLFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF MSc. IN POLYMER
TECHNOLOGY**

66 "03"
678.675:678.02

Department of Chemical and Process Engineering
University of Moratuwa
Sri Lanka
February, 2003.

78477

78477

University of Moratuwa



78477

ACKNOWLEDGEMENTS

I acknowledge with gratitude the Managing Director and the general Manager of Lanka Fastener Limited in giving me the opportunity to carry out this project in our production facility at Katunayake.

I am grateful to Mr. Mevan Pieris and Dr. Mrs. Olga Gunapala, my supervisor and co-supervisor respectively who very generously spared their precious time and provided necessary guidance and assistance to carryout the research.

I am also extend my gratitude and thanks for the encouragement given by Mr. Subramanium and Dr. Santha Walpolage.

Further, I wish to sincerely thank Mr. Chandana Katugahage of Industrial Technology Institute, Mr. J. M. M. Jayaweera and his subordinates of Lanka Fastener Limited for providing me with all necessary assistance in carrying out this project.



University of Moratuwa, Sri Lanka
Electronic Theses & Dissertations
www.lib.mrt.ac.lk



ABSTRACT

Many of the industries use nylons mainly for engineering applications for several reasons. Basically nylon provide a combination of toughness, rigidity and lubrication free performance of products, which leads to mechanical uses. Some of the initial properties of nylons may change in the process of mechanical and thermal recycling. The flow properties of extrusion grade recycled nylon 6 were observed with a torque measuring mixer and a reciprocating screw injection moulding machine. Low Density Polyethylene and Zinc-stearate were used separately as lubricants. The plasticating behaviour was observed by increasing mixer temperature in a torque measuring mixer and recorded as torque versus time. The resultant stock temperature variation of above process was also recorded graphically. The flow of recycled nylon 6 through reciprocating screw injection moulding machine was discussed. The effect of polyethylene (1% maximum) incorporated recycled nylon 6, to the quality of specific product was compared against the pure recycled nylon 6.



CONTENTS

Acknowledgement	i
Abstract	ii
Contents	iii
List of Figures and Tables	iv
1 Introduction	1
2 Literature Review	
2.1 Nylon Plastics	3
2.2 Polyethylene	13
2.3 Lubrication	15
2.4 The Injection Moulding Machine	19
2.5 Analysis Of Flow In Reciprocating Screw Injection Moulding Machine	29
2.6 The Brabender Measuring Mixer	46
2.7 Productivity	49
2.8 Raw Material Data	50
3 Experimentation	
3.1 Flow Test and Moulding Operation On Injection Molding Machine	52
3.2 Vicat Softening Temperature	56
3.3 Prevailing Torque Test	57
3.4 Flow Test on Extruder Machine	59
3.5 Flow Test On Brabender Measuring Mixer	60
4 Results and Calculation	62
5 Discussion	66
6 Conclusion	77
7 Appendices	79
8 References	81





List of Figures

Figure	Description	Page
2.1	Effect of relative humidity on the equilibrium moisture absorption of the nylon	6
2.2	Chain folding structure of nylon66	8
2.3	Boundary layer lubrication between metal surface and polymer melt	16
2.4	Lubrication effects on torque, head pressure, output	18
2.5	Screw valve closed	19
2.6	screw valve opened	19
2.7	Typical molding cycle for nylon	23
2.8	Injection molding cycle	23
2.9	screw	24
2.10	Single stage screw	25
2.11	Nylon screw	27
2.12	The plastication process	27
2.13	Physical interpretation of Coulomb's law	30
2.14	Friction between two plates	31
2.15	Friction applied on the polymer in a rectangular channel	32
2.16	Friction between two co-axial cylinders	34
2.17	Liquid film formation at the barrel surface	36
2.18	Formation of liquid pocket along the back flight	36
2.19	Variation of the liquid pocket along the solid bed along unwound channel	36
2.20	Diffusion of molten polymer in the pores of the polymer solid bed	37
2.21	Pressure build up along the back flight	38
2.22	Pressure profile along the back flight	39
2.23	Analysis of drag flow	40
2.24	Analysis of pressure flow	41
2.25	Details of screw	42
2.26	Development of screw	43
2.27	Open discharge, blocked discharge	45
2.28	Disassembled view of Measuring Mixer W50EHT	46
2.29	Thermocouple location in the mixer bowl	48
3.1	Temperature settings and band heater arrangement in the screw barrel.	53
3.2	Nylon washer inserted nut	57
3.3	Prevailing torque testing device	58
5.1	Compressed and compacted solid polymer in screw channel	66
5.2	Vectorial representation of solid conveying in the screw channel	67

5.3	Force acting on the solid polymer	67
5.4	Force acting on a section of solid plug across the helical Channel of the feeding zone.	68
5.5	Force acting on a section of solid plug across the helical Channel of the feeding zone.	72
5.6	Rotational and sliding movements of the polymer particles near to the inner barrel wall in the initial stage of the compression zone.	73
A-1	Apparent viscosity Vs. shear rate	79
A-2	Effect of temperature on polymer viscosity	80

List of Tables

Table	Description	Page
2.1	Effect of temperature on polymer viscosity	4
2.2	Operating temperature limits for injection moulding of nylon	4
2.3	Moisture absorption of nylons	7
2.4	Effect of polymer structure on flow properties	14
2.5	Injection moulding sequence of operation	22
2.6	Friction coefficient for various polymers in contact with polished steel surface	30
2.7	Nylon 6 Recycled Material data	50
2.8	Low Density Polyethylene material data	50
3.1	Machine parameters in injection moulding of recycled nylon 6	53
4.1	Prevailing torque test results of sample A	62
4.2	Prevailing torque test results of sample B	62
A-1	Apparent viscosity of polymers	79
A-2	Shear rates of different processes	80
A-3	Heat penetration thickness and thermal diffusivity of polymers	80