

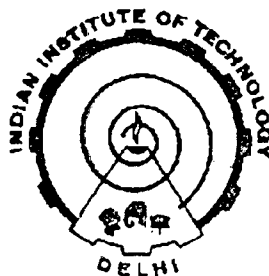
DESIGN AND DEVELOPMENT OF LOAD BEARING COMPONENTS FOR A BICYCLE
FROM GLASS FIBRE REINFORCED NYLONS

BY

ASHOK GUPTA

THESIS SUBMITTED

IN FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY



CENTRE FOR POLYMER SCIENCE AND ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY, DELHI

1994

ACKNOWLEDGEMENTS

My sincere and honest thanks to Prof. Ashok Misra and Prof. R.K. Mittal for their excellent and motivating guidance in carrying out this developmental work. I am very much indebted to them for their generous help and guidance towards the progress, completion and compilation of my work into a valuable thesis.

I owe a great gratitude to Prof. I.K. Verma and Prof. P.N. Rao for being a constant source of inspiration and showing keen interest in my work.

I wish to thank Prof. A.K. Gupta, Assit. Prof. S.N. Maiti, Assit. Prof. Veena Choudhary and Dr. A.K. Ghosh for their ready help and valuable suggestions.

I wish to thank the technical staff/administrative staff of Centre for Polymer Science and Engineering, Applied Mechanics Department, Mechanical Engineering Department, Textile Technology Department and Industrial Design and Development Centre for extending their help throughout my stay at IIT.

I wish to thank Department of Science and Technology, Delhi and TI Cycles of India, Madras for providing funds for the developmental work.

I wish to thank Mr. Darshan Lal and Mr. Jain of M/s Tool Room and Training Centre for providing me assistance and necessary facilities in the fabrication work.

I am thankful to my friends, Mr. Vinay Kumar Karan, Ms. Priti Sharma, Mr. Venkat Prasad, Dr. K. Kannan, Dr. Ranjana, Dr. Mangla Joshi, Dr. Anju, Dr. Renu, Dr. Lalita and other friends at CPSE for their ready help and nice company.

I wish to thank Dr. K. Lal and others at M/s K.V. Microwave Materials for constantly reminding me about my Ph.D. work.

I owe my greatest thanks to Mr. Srikant Srinivasan and Mr. Gurjit Singh and their technical staff in making things possible overnight.

Ashok Gupta

CERTIFICATE

This is to certify that the thesis entitled 'Design and Development of Load Bearing Components for a Bicycle from Glass Fibre Reinforced Nylons' being submitted by Mr. Ashok Gupta to the Indian Institute of Technology, Delhi for the award of degree of Doctor of Philosophy, is a record of bonafide research work carried out by him. Mr. Ashok Gupta has worked under our guidance and supervision and has fulfilled the requirements for the submission of this thesis.

The results contained in this thesis have not been submitted, in part or full, to any other University or Institute for the award of any degree or diploma.



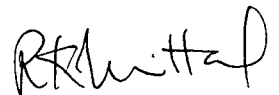
PROF. ASHOK MISRA

Professor and Head

Centre for Polymer Science and Engineering

Indian Institute of Technology, Delhi

Hauz Khas, New Delhi 110 016



PROF. R.K. MITTAL

Professor and Head

Department of Applied Mechanics

Indian Institute of Technology, Delhi

Hauz Khas, New Delhi 110 016

DEDICATED
TO
MY FAMILY
AND
FRIENDS

Abstract

The use of reinforced grades of engineering components have been justified for the design and manufacture of several load bearing engineering components used in ground transport. For bicycles, the introduction of polymeric component started in early eighties with the development of components such as crank, chain wheel and frames. This introduction was primarily to develop light weight components with reduction in manufacturing operations. This study also deals with the design and development of selected bicycle components such as crank chain wheel, and handle bar assembly. The prime objective of this development was to design/develop light weight, single piece injection moulding of these two components in short glass fibre reinforced composites of nylons. An attempt is also made in reducing the number of manufacturing operations for these components.

The effect of processing parameters on the mechanical properties of short glass fibre reinforced thermoplastic composite have been well illustrated in literature (8,9,17), hence, samples of short glass fibre reinforced nylons and acetal resin were developed on a single screw extruder. The compounded material was then used for the fabrication of standard test specimens by varying processing parameters such as mould temperature, injection speed and injection pressure, on a Windsors SP-1 reciprocating screw type injection moulding machine. Tensile, flexural and impact properties were evaluated for these standard test specimens and correlated with the processing conditions. The cryogenically fractured surface of the flexural test specimen were examined for fibre distribution using Scanning Electron Microscope (SEM), while the fibre length distribution was determined by projectina microscope. An attempt was made to correlate these with mechanical properties of the moulded test specimens and optimum processing parameters for each short glass fibre reinforced composite were thus obtained. Parallel to this exercise, conceptual designs for both the components were proposed. In designing both these components, an estimation of rider induced load on these two components were obtained for a commercial 21 inch model of a bicycle (28). Conceptual designs were proposed for both using Uni-graphics (series-9000) HP-work station. For the crank and chain wheel, photoelastic models were prepared and after the stresses were frozen in the models they were partially sliced to separate the crank from the chain wheel. These partially sliced sections were then examined for a maximum shear stress distribution following which maximum shear stress in the crank part of the prototype was estimated. Based on the results and practicability in fabrication, a design was selected, which was then developed into actual operatable component for a bicycle, using HP-work station. A mould was

designed which was subsequently manufactured. The performance of this component was evaluated by putting it on a bicycle based on this evaluation suitable modifications were carried out in the product design. The handle bar design was developed for manufacture using short glass fibre reinforced composite. A mould was also designed for this component.

LIST OF CONTENTS

CHAPTER 1 *INTRODUCTION AND LITERATURE SURVEY*

1.1	Introduction	1
1.2	Short Glass Fibre Reinforced Thermoplastics Composites	2
1.2.1	Introduction	2
1.2.2	Processing of Reinforced Thermoplastics	3
1.3	Component Design for Reinforced Thermoplastics Polyamides	4
1.3.1	Force Analysis	4
1.3.2	Material Consideration	4
1.3.3	Component Design	5
1.4	Mould Design and the Moulding Processing	6
1.5	Objective of the Work	7

CHAPTER 2

2.1	Materials and Experimental	8
2.1.1	Materials and Justification of Choices	8
2.1.2	Materials Used	9
2.2	Preparation of Short Glass Fibre Reinforced Composites	11
2.3	Preparation of Test Samples	12
2.4	Testing, Measurement and Analysis	19
2.4.1	Mechanical Properties	19
2.4.1.1	Tensile Properties	19
2.4.1.2	Flexural Properties	20
2.4.1.3	Izod Impact Testing	21
2.4.2	Morphological Studies	21
2.4.3	Fibre Length Distribution	21
2.5	Preparation of Samples for Crank Chain Wheel	22
2.5.1	30% Short Glass Fibre Reinforced pPolyamide 66	22
2.5.2	30% Short Glass Fibre Reinforced Polyamide 6	23

CHAPTER 3 *DESIGN AND DEVELOPMENT OF CRANK AND CHAIN WHEEL FOR A BICYCLE*

3.1	Introduction	24
3.2	Design Considerations	26

3.3	Force Analysis	27
3.4	Design of Crank and Chain Wheel	30
3.4.1	Material Consideration	30
3.4.2	Proposal of Designs	30
3.5	Photoelastic Testing by Stress Freezing Technique	39
3.5.1	Photoelasticity	39
3.5.2	Preparation of Models	43
3.5.3	Fabrication of Test Fixture for Photoelastic Models	43
3.5.4	Testing of Models by Stress Freezing Technique	45
3.5.5	Photoelastic Analysis of Conceptual Designs	46
3.5.5.1	Analysis of the component part-Crank	46
3.5.5.2	Analysis of the chain wheel	62
3.6	Detailed Design of Crank and Chain Wheel	68
3.7	Mould Design for the Crank and Chain Wheel	71

CHAPTER 4 *DESIGN AND DEVELOPMENT OF HANDLE BAR ASSEMBLY FOR A BICYCLE*

4.1	Introduction	78
4.2	Force Analysis	78
4.3	Ergonomics	80
4.4	Design of Handle Bar	82
4.5	Mould Design	83

CHAPTER 5 *INJECTION MOULDING PARAMETERS FOR SELECTED SHORT GLASS FIBRE REINFORCED COMPOSITES*

5.1	Introduction	87
5.2	Results and Discussion	87
5.2.1	Mechanical Properties	88
5.2.1.1	30% Short Glass Fibre Reinforced Polyamide 6	88
5.2.1.2	30% Short Glass Fibre Reinforced Polyamide 66	97
5.2.1.3	40% Short Glass Fibre Reinforced Polyamide 66	105
5.2.1.4	30% Short Glass Fibre Reinforced Acetal Co-polymer	112
5.2.2	Scanning Electron Microscope Studies	119
5.2.2.1	30% Short Glass Fibre Reinforced Polyamide 6	119
5.2.2.2	30% Short Glass Fibre Reinforced Polyamide 66	119
5.2.2.3	40% Short Glass Fibre Reinforced Polyamide 66	120
5.2.2.4	30% Short Glass Fibre Reinforced Acetal Co-polymer	121

5.2.3	Fibre Length Distribution Studies	132
5.2.3.1	30% Short Glass Fibre Reinforced Polyamide 6	132
5.2.3.2	30% Short Glass Fibre Reinforced Polyamide 66	132
5.2.3.3	40% Short Glass Fibre Reinforced Polyamide 66	133
5.2.3.4	30% Short Glass Fibre Reinforced Acetal Co-polymer	133
5.3	Evaluation of Crank and Chain Wheel Samples	136
5.3.1	Processing parameters for	
5.3.1.1	30% Short Glass Fibre Reinforced Polyamide 6	136
5.3.1.2	30% Short Glass Fibre Reinforced Polyamide 66	137
 CHAPTER 6 <i>SUMMARY AND CONCLUSIONS</i>		
6.1	Summary	138
6.2	Conclusions	139
 References		
List of Publications		141
		144