Flexural Properties of Injection Moulded PP/MoS_2 Polymer Matrix Composites

KolekarAniket.B.
PG Student
Department of Metallurgy & Materials Science
College of Engineering Pune,411005,India
kolekar_9860@rediffmail.com

Kulthe.M.G.
Assistant Professor
Department of Metallurgy & Materials Science ,
College of Engineering Pune, 411005,India

Abstract **-Molybdenum disulphide (MoS_2) filled polypropylene (PP) composites were prepared using the horizontal ball milling machine followed by injection moulding. The content of MoS_2 was varied from 0 to 7.12 vol.%. Experimental density of the composites prepared by horizontal ball milling was close to the theoretical density. Flexural modulus increased by 21% up to 4.28 vol.% MoS_2,then it shows detrimental effect on flexural modulus. Flexural strength also increased from 13 MPa to 28 MPa at 4.28 vol.% MoS_2.The percentage deflection at break of the pure PP sample prepared by injection moulding was higher, as compared to other composites. % deflection at break decreases by 34.95%.**

Keywords: ***Polymer matrix composite (PMC), Polypropylene (PP), Molybdenum disulphide (MoS_2), Injection Moulding, Flexural properties***

I. INTRODUCTION

A. Polymer Matrix Composite

Polymer matrix composites are comprised of a variety of short or continuous fibres bound together by an organic polymer matrix in which the strong reinforcing dispersed phase provides high strength and stiffness. They were designed so that the mechanical loads to which the structure is subjected in service are supported by the reinforcement. The function of the matrix is to bond the fibres together and to transfer loads between them. Polymer Matrix Composites are very popular due to their low cost and simple fabrication methods. Use of non-reinforced polymers as structure materials is limited by low level of their mechanical properties, in addition to relatively low strength; polymer materials possess low impact resistance.

Due to the favourable combination of easy process ability and attractive mechanical properties, the use of polymer materials in structural applications has assumed large proportions over the last decades. To ensure proper operation under heavy-duty conditions, these applications have to meet specific requirements regarding quality, safety, and mechanical performance (e.g. stiffness, strength and impact resistance). Mechanical performance is generally optimized by trial and error until the functional demands of the design are satisfied. Chief among the advantages of PMC s is their light weight coupled with high stiffness and strength along the direction of the Reinforcement. This combination is the basis of their usefulness in aircraft, automobiles, and other moving structures. Other desirable properties include superior corrosion and fatigue resistance compared to metals [1].

Reinforcement of polymers by strong fibrous network permits fabrication of Polymer Matrix Composite (PMC) characterized by the following properties High tensile strength, Good rupture resistance, High stiffness, Good corrosion resistance, High Fracture Toughness, Low cost, Good abrasion resistance&Good impact resistance.

The main disadvantages of Polymer Matrix Composites (PMC)

- Low thermal resistance
- High coefficient of thermal expansion.

B. Polypropylene Polymer (PP)

Polypropylene is a plastic polymer of the chemical designation C_3H_6. Polypropylene resins are a general class of thermoplastic produced from propylene gas. Propylene gas is derived from the cracking of natural gas feedstock’s or petroleum by-products. Under broad ranges of pressures and temperatures, propylene generally polymerises to form very long polymer chains. However, to make Polypropylene resins with controlled configurations of molecules at reasonably acceptable commercial rates, special catalysts are required [3].

Table 1: Properties of PP

Properties	Units	Homopolymer (H110)
Density	Kg/m^3	905
Tensile Strength	MPa	15-35
Tensile Modulus	GPa	1.4
Elongation at Break	%	150
Hardness	“ R” scale	90
Notched Izod Impact	kJ / m	0.07
Heat Distortion Temp.	MPa / ◦C	105
Limiting Oxygen Index	%	18

C. Molybdenum Disulfide (MoS_2)

Molybdenum disulfide is a dark gray to black powder (the colour depending on its particle size). Generally molybdenum disulfide in its naturally occurring hexagonal form is chemically very inert. It is insoluble in both oil and water. Molybdenum disulfide is uncreative with most acids, however it is not resistant to attract of hot concentrated sulphuric and nitric acids. Also, molybdenum disulfide dissolved in strong oxidizing agents such as aqua regia. Molybdenum disulfide exists in two crystalline forms, hexagonal and rhombohedral. The hexagonal form is by far the most common and being the only type found in commercial ores. Also, the hexagonal form has been found in synthetic MoS_2.The rhombohedral was first identified in a synthetic material and subsequently found in several natural sources [4].

II. EXPERIMENTAL WORK

High purity commercial grade polypropylene granules (REPOL-110 Homo-polymer) were purchased from Reliance Industries Limited and were grinded to fine powder by liquid nitrogen grinding.

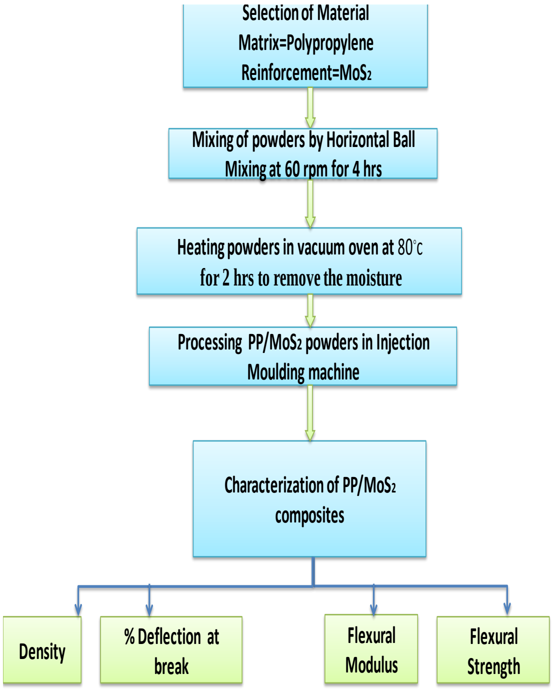

Figure 2: Flowchart of experimental work

Commercial Molybdenum di-sulphide powder with density 5.06 g/cm3and particle size 3µm was purchased from sigma aldrich. It was used without treatment. The experimental works was carried out by varying content of MoS2 (0.93-7.12vol.%) in Polypropylene (PP) matrix. Experimental procedure is as below,

III. FLEXURAL TEST

These test methods cover the determination of flexural properties of unreinforced and reinforced plastics, including high modulus composites and electrical insulating materials in the form of rectangular bars moulded directly or cut from sheets, plates, or moulded shapes. These test methods are generally applicable to both rigid and semi-rigid materials. However, flexural strength cannot be determined for those materials that do not break or that do not break or that do not fail in the outer surface of the test specimen within the 5.0% strain limit of these test methods. These test methods utilize a three point loading system applied to a simply supported beam [2].

Figure 3: Position of test specimen for flexural test

Flexural properties as determined by these test methods are especially useful for quality control and specification purposes. Flexural properties may vary with specimen depth, temperature, atmospheric conditions, and the difference in rate of straining.

IV. RESULTS & DISCUSSION

Flexural test was carried out on a polymer UTM according to ASTM standard D790. The load now applied to the sample is displayed on the upper display and the length travelled by the movable jaw is displayed on the lower display. When the sample breaks and the load drops below the cut off percent of the peak load, the motor is stopped and the movable jaw stops. The cut off percent of the peak load is noted.

Table 2: Flexural properties of PP/MoS_2 composite

Composition	Flexural Strength (MPa)	Flexural Modulus (GPa)	% Deflection at break
Pure PP	13	1.55	43.33
PP-0.93vol.% MoS_2	14	1.65	40.30
PP-1.95vol.% MoS_2	17	1.72	38.40
PP-3.06vol.% MoS_2	27	1.80	36.40
PP-4.28vol.% MoS_2	28	1.89	34.40
PP-5.63vol.% MoS_2	21	1.70	31.40
PP-7.12vol.% MoS_2	18	1.64	28.50

Flexural strength of PP/MoS2 composite increases as the percentage of MoS2 increases in pure PP matrix up to 4.28 vol.%, then it decreases as shown in Figure 4. % Defection at break for pure PP is very high as to other composites as shown in table 2, this is due to pure PP having more ductile in nature. As the % of MoS2 increases, ductility of the composites decreases & due to addition of MoS2 composite become somewhat brittle in nature. It appears that addition of MoS2 leads to an improvement in the flexural modulus as shown in figure 6 as well as strength of PP/MoS2 composites up to 4.28 vol.% MoS2,then it decreases gradually. Flexural properties depend upon the placement of reinforcement within the thickness of the sample whereas, for tensile properties, position is independent of thickness.

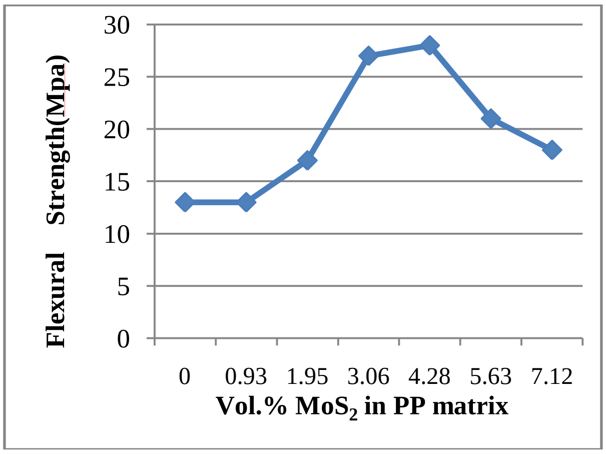

Figure 4: Flexural Strength of PP/MoS2 Composites

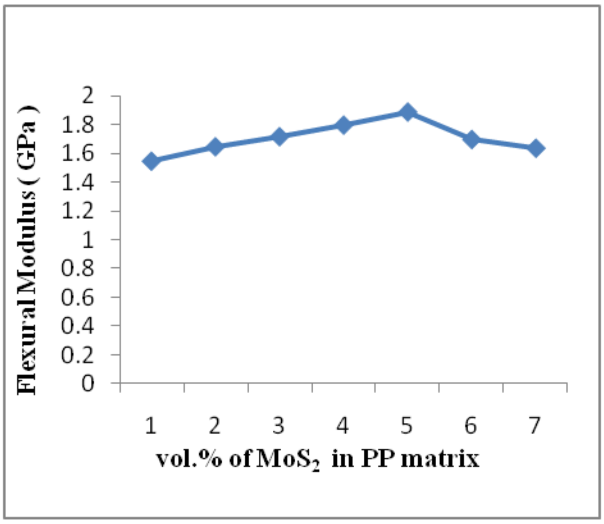

Figure 5: Flexural modulus of PP/MoS_2 Composites

It appears that addition of MoS_2 leads to an improvement in the flexural modulus as shown in figure 6 as well as strength of PP/MoS_2 composites up to 4.28 vol.% MoS_2,then it decreases gradually. Flexural properties depend upon the placement of reinforcement within the thickness of the sample whereas, for tensile properties, position is independent of thickness.

Significant enhancements were also observed for the flexural strength, which increased up to 28 MPa at 4.28 vol.% MoS_2 from 13 MPa pure PP (figure 4). Flexural modulus increased up to 1.89 GPa at 4.28 vol.% MoS_2 from 1.55 GPa for pure PP as shown in figure 5. The improved flexural strength & flexural modulus obtained in this work is ascribed to the very uniform dispersion of the PP/MoS_2 and its high aspect ratio, which results in a larger filler -polymer interfacial area.

V. CONCLUSION

Flexural modulus increased by 21% up to 4.28 vol.% MoS_2,then it shows detrimental effect on flexural modulus. Flexural strength also increased from 13 MPa to 28 MPa at 4.28 vol.% MoS_2.The percentage deflection at break of the pure PP sample prepared by injection moulding was higher, as compared to other composites. % deflection at break decreases by 25.95%.

REFERENCES

[1] Zhen XiuZhangab, Jin Zhangb, Bing-XueLub, Zhen Xiang Xinb, Chang KiKangc, Jin KukKimb, Effect of flame retardants on mechanical properties, flammability and foamability of PP/wood–fibre composites,Composites:Part B,2011 Elsevier Ltd.,150-158.

[2] ASTM International D 790-02, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials,2002,146-154.

[3] Yong Qiana, Ping Weia, PingkaiJianga, JianweiHaob, Jianxin Dub,Preparation of hybrid phosphamide containing polysilsesquioxane and its effecton flame retardancy and mechanical properties of polypropylene

composites,Composites: Part B,2012 Elsevier Ltd.,1541-1547.

[4] Yakov Epshteyn and Thomas J.Risdon, Molybdenum Disulphide in lubricant application, Phoenix, Arizona, USA, 2010, 1-11.

[5] YuxiaYina, YiheZhanga, ZhichaoZhena,c, Paul K.Chub, FengzhuLva, JunhuiJic,Thermal degradation and flame retarding characteristics of polypropylene composite incorporated with boron mud, Composites Science and Technology, 2013 Elsevier Ltd.,131-135.