Mechanical and thermal behavior of a recycle Polypropylene using fillers as an additives

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Abstract— **It has been investigated that the mechanical and thermal properties of recycled polypropylene (RPP) has less properties around 9% less when compared to virgin polypropylene. There is need to improve RPP properties by using a filler materials. With the addition of silica into RPP as a filler material, the significant growth in the mechanical properties were observed, but silica is having poor thermal conductivity. In order to improve thermal conductivity, the graphite is added as a filler material to the above RPP+Si composite. An experimentally determined value for the RPP+Si+C composites was calculated. Due to the presence of silica there is increase in the hardness, tensile modulus and thermal behavior but decrease in elongation because of graphite and makes material more brittle.**

Index Terms—: PP (Polypropylene), RPP (Recycle polypropylene), Si (silica), C (graphite), TGA (Thermo gravimetric analysis)

I. INTRODUCTION

With growing production and consumption, in plastics worldwide is currently resulting in a significant contribution to the municipal solid waste. Over recent years polypropylene (PP) has had a steadily growing role in enabling automotive designers and engineers to improve vehicle technology. Light weight, optimal balance of mechanical properties and excellent surface finish allow it to replace metal at a lower cost in an expanding range of exterior, interior and under the bonnet applications. At 15-20% lighter than other plastics, polypropylene offers the potential to bring higher weight savings to auto manufacturing [1]. The polypropylene is low in cost and has outstanding mechanical properties and moldability. This project deals with the usage of polypropylene obtained from the industrial waste which is then recycled for the application in automobiles. During the recycling process the material undergoes various operations that bring out several modifications in the molecular structure. As a matter of fact, the mechanical properties of the recycled products and their structural organization are quite different compared to those composed of virgin material [2]. Also, particular attention is attached to the relationship and several consequent changes in the mechanical properties. Two kind of plastics include of virgin and recycled polypropylene (VPP, RPP) and virgin and recycled polyethylene (VPE, RPE) was selected. Result indicated that the mechanical properties of composites containing PP are significantly higher than those of PE. Also, the tensile strength and modulus of composites decreased with the increase of recycled plastic loading. However, the impact strength of composites increased with increase of plastic content [3]. In this work the recycled polypropylene (RPP) is reinforced with the filler materials such as silica and graphite to improve the thermal conductivity and mechanical properties. The content of graphite filler affected structural integrity and mechanical properties of composites. Graphite can be added to the polymers up to 30-50 wt. % to increase the elastic modulus and density. With increasing the amount of the graphite addition to the PP results in a decrease in elongation at break values. XRD investigations showed that the crystallization ratio changes in the PP composites.

II. EXPERIMENTAL PROCEDURE

The fabrication of RPP with Si and Graphite as a filler and the effect of RPP composites were investigated. The 90gms of RPP with 5gms of silica and 5gms of graphite is weighed and were prepared. These composite materials were melted and injected through injection molding machine with a molding temperature of 300^0c and with a cooling time of 5mins as listed in the below table. The formulation of the composites are shown in Table 1.

Table 1.composite molding data

Material	Concentration	Mould temp^{0}c	Molding time/job	Mould pr.	Cooling time
RPP+Si+C	90%/5%/5	300	300	2200	5min

Manuscript received Sep, 2014.

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ISSN: 2278 – 7798

III .RESULTS AND DISCUSSIONS

MECHANICAL PROPERTIES

The mechanical properties of composites plays a vital role in most of the load bearing applications. The demand for composite materials is increased in aeronautical, civil, automobile and structural application. The mechanical properties of RPP/Si/C composites were discussed under 3 headings, tensile, flexural, compression, hardness and TGA.

TENSILE STRENGTH: (ASTM D 638)

The measured tensile properties of RPP +Si+C composites are presented in Table 2.

Sl No	strain at Peak (%)	Load at peak (Mpa)	stress at peak (Mpa)	strain at Break (%)	Load at Break (kN)	Stress at break (Mpa)	Young's Modulus (Mpa)
1	3.889	1.462	25.072	4.063	1.445	24.785	3302.155
2	3.319	1.186	20.337	3.380	1.183	20.30	2997.217
Mean	3.604	1.324	22.705	3.722	1.314	22.542	3149.686

Table 2: Tensile properties of RPP+Si+C composites

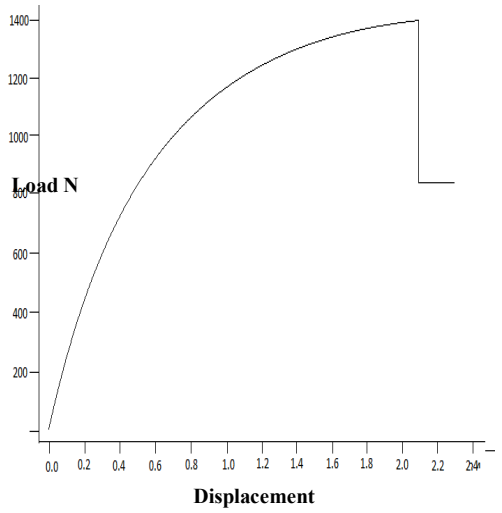


Fig.1. Stress Strain graph Load v/s Displacement of RPP+Si+C composites.

With the addition of silica the tensile modulus of RPP/Si/C composites was increased drastically from 3149 MPa when compare to virgin PP 1657 MPa, but percentage elongation reduced drastically from 12.33 to 3.722 % when compared with Virgin PP over RPP because the graphite has more carbon content and makes the material more brittle. Hence reduce in the % elongation.

FLEXURAL STRENGTH: (ASTM D 790)

The measured Flexural properties of RPP +Si+C composites are presented in Table 3.

Table 3: Tensile properties of RPP+Si+C composites

SI NO	Load at yield (KN)	Stress at Yield (Mpa)	Strain at yield (mm\mm)	Young's Modulus (Mpa)
1	0.177	50.220	0.063	1968.346
2	0.122	52.346	0.061	1967.679
3	0.087	49.428	0.049	2539.403
Mean	0.109	50.665	0.058	2158.476

FLEXURETEST GRAPH

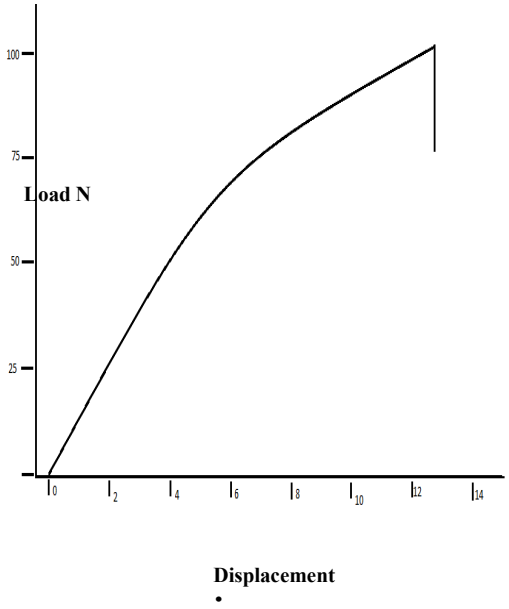


Fig.2. The Load v/s Deflection curves of RPP+Si+C composites

Flexural strength of RPP/Si/C composites showed improvement over virgin PP from 1650 Mpa to 2539.403 Mpa. The improvement in the flexural is because of addition of silica.

COMPRESSIVE STRENGTH: (ASTM E 1131)

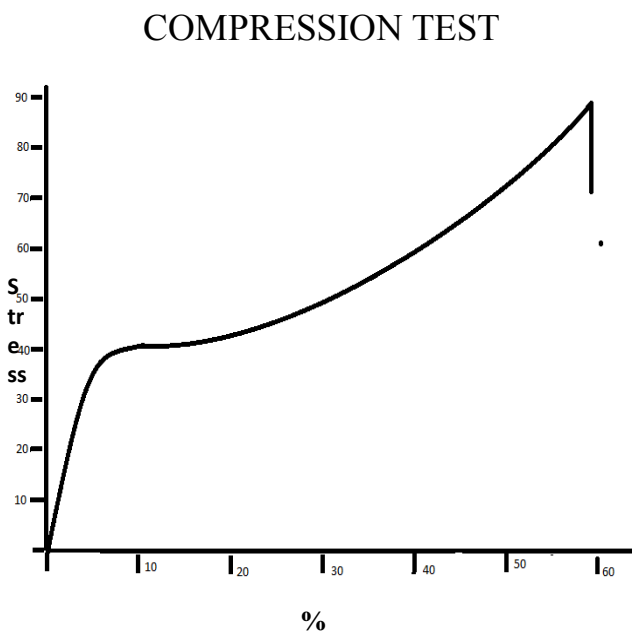
The measured compression properties of RPP+Si+C composites are presented in Table 3.

Tensile properties of RPP+Si+C composites

SI NO	Load at yield (KN)	Displacement at yield(mm)	Stress at Yield(Mpa)	Strain at yield (mm)	Load at 50% Strain (KN)	Stress at 50% strain (Mpa)
1	0.177	1.026	50.220	0.063	6.706	69.820
2	0.122	1.075	52.346	0.061	5.802	60.408
3	0.087	1.124	49.428	0.049	6.503	67.715
Mean	0.109	1.075	50.665	0.058	6.337	65.981

ISSN: 2278 – 7798

Fig.3. The Load v/s Deflection curves of RPP+Si+C composites



HARDNESS STRENGTH: (ASTM D 785)

Surface hardness is a measure of resistance to penetration. The measured surface hardness of virgin PP and RPP composites are calculated. The surface hardness of PP is 60 shore D, whereas for RPP composite it is 90shore D. The surface hardness values of composites lies in the range 89 to 91 shore D. The average surface hardness increased significantly with addition of graphite filler. This is because graphite filler and is rigid and harder in nature, which is expected to increase the stiffness of the composites.

THERMAL GRAVIMETRIC ANALYSIS: (ASTM E 1131)

Thermal gravimetric analysis (TGA) is a method of thermal analysis in which changes in physical and chemical properties of materials are measured as a function of increasing temperature (with constant heating rate), or as a function of time (with constant temperature and/or constant mass loss). TGA can provide information about physical phenomena, such as second-order phase transitions, including vaporization, sublimation, absorption, adsorption, and desorption. Likewise, TGA can provide information about chemical phenomena including chemisorption's, desolation (especially dehydration), decomposition, and solid-gas reactions (e.g., oxidation or reduction). TGA is commonly used to determine selected characteristics of materials that exhibit either mass loss or gain due to decomposition, oxidation, or loss of volatiles (such as moisture)

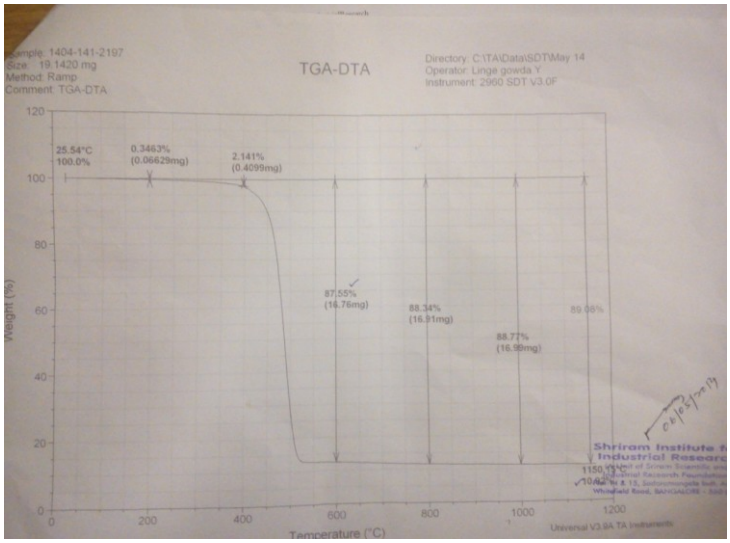


Fig.4. The Weight(%) V/S Temperature(°C).curves of RPP+Si+C composites.

IV. CONCLUSION

In this project we have noticed that the tensile modulus of RPP/Si/C composites was increased drastically from 3149 MPa when compare to virgin PP 1657 MPa, but percentage elongation reduced drastically from 12.33 to 3.722 % when compared with Virgin PP over RPP because the graphite has more carbon content and makes the material more brittle. Hence reduce in the % elongation.

Flexural strength of RPP/Si/C composites showed improvement over virgin PP from 1650 Mpa to 2539.403 Mpa. The improvement in the flexural is because of addition of silica. There is a improvement in hardness from 65 shore D to 95 shore D, because of presence of graphite makes the material harder.

We have noticed that the RPP/Si/C composites has slight decrease in compression value when compare to virgin PP. From TGA data it was observed that the addition of graphite into PP/Si composite has positive effect on thermal stability of composites. The initial degradation was started at 3290c for virgin PP and 4000c for RPP/Si/C composites and maximum degradation was started at 5940c for virgin PP and 11500c for RPP/Si/C composites.

V. ACKNOWLEDGEMENT

We have noticed that there is a slight decrease in tensile and compression values when compared to virgin PP. So in order to increase these properties we can replace graphite with another flame retardant fillers like Decabromo Diphenyl oxide (DCO) or we can incorporate other organic or inorganic fillers like jute, sisal fiber, glass fiber or wood flour to improve the tensile and compression properties.

ISSN: 2278 – 7798

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ISSN: 2278 – 7798