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Effects of Ferrochromium on High Density Polyethylene (HDPE) and Polypropylene (PP) Melt Flow Indexes and Densities

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ABSTRACT: *In the present study, variations in the density and melt flow indexes of high density polyethylene (HDPE) and polypropylene (PP) based on the ferrochromium content were investigated. The ferrochromium was mixed with 10%, 20% and 30% thermoplastic by weight separately. The high density polyethylene matrix mixture obtained with the above mixtures was tested at 190 ° C and under a weight effect of 2.16 kg, while the polypropylene matrix mixtures were tested at 230 ° C and under a weight effect of 2.16 kg. The findings are presented with graphs and the effects of ferrochrome on both high density polyethylene and polypropylene fluidity and density were determined.*
KEYWORDS - *High density polyethylene (HDPE), polypropylene (PP), recycling, melt flow index, density.*

I. INTRODUCTION

Polymers are macro-composites that are formed by continuous succession of small, simple molecules. Today, polymers are used in several areas. Polymers are used almost everywhere including the PVC window frames and Teflon kitchen utensils. The most important group of polymers include thermoplastics. Thermoplastics are solid at room temperature and become soft and viscous when heated. It is possible to heat and cool thermoplastics several times without any deformation. An important group of thermoplastics include poly-olefins. Olefins are hydrocarbons that contain one or more dual bonds. Polyethylene and polypropylene are the most basic poly-olefins [8-15].

Polyethylene could be divided into three groups of low density, high density and low density linear polyethylene. High Density Polyethylene (HDPE) is a high density polyethylene material obtained from petroleum. Compared to other polyethylenes, it is stiffer, stronger and it is heavier but harder when compared to LDPE (low density polyethylene). This denomination is generally used in industrial and manufacturing sectors. 1 kg. HDPE raw material is obtained from approximately 1.75 kg oil. HDPE is lighter than water. It could be produced by casting technology or by extrusion method, could be processed with machine tools and could be combined using special welding methods. It is rather difficult to combine it using adhesives [2-5, 8-12].

HDPE is similar to LDPE in appearance but it is much harder with a molecular mass of around 150000-400000. It has good resistance to water and chemicals. It is not durable under light and outdoor conditions unlike LDPE, however its resistance could be increased with special additives (carbon black). Its mechanical properties are very good, especially impact and tensile strengths are high. These properties could be further improved with certain fillers. Normally the tensile strength is around 225-350 kgf / cm^2. The temperature resistance is over 100 ° C. HDPE is used in a wide variety of industries including the production of pressure pipes, gas distribution pipes, bottles, drums, barrels, domestic appliances and machine parts, insulators, toys, electrical and electronic goods [10-16].

Polypropylene is a natural white material obtained by polymerization (the process of obtaining larger molecules by butting the molecules) of propylene molecules obtained from "Naphtha", a crude oil derivative. As a result of a series of complex chemical treatments, the physical properties such as hardness, flexibility, heat resistance and brittleness of polypropylene raw materials could be improved on by adding ethylene molecules to polypropylene molecules to render the material suitable for diverse areas of use. For example, positions of the propylene molecules in the 1-7% ethylene molecule obtained with the reaction between propylene and ethylene gases in a reactor under very special conditions would determine the physical properties of the obtained material. Thus, raw material that can withstand very high pressures and very high temperatures is obtained. Today, containers made of propylene could be used in baking ovens at 120 ° C temperatures [8-16].

Ferrochrome is an alloy containing 50% - 70% chromium and 30 - 50% iron. The alloy is the molten of iron magnesium chromium oxide melted in an electric arc furnace. The steel industry is the largest consumer of this alloy utilizing more than 80% of the world's ferrochrome production in stainless steel production. The 18% average chromium content in stainless steel provides its characteristic appearance and corrosion resistance. The high carbon ferrochrome, which is produced with high grade chrome, is used in special applications. In these special applications, although the Cr / Fe ratio is important, the other elements are at optimum levels as well [14-15].

Figure 1: Ferrochrome

II. EXPERIMENTAL

The MFI (JPT Equipment, XRL-400A) is a measure of the ease of flow of the melt of a thermoplastic polymer. It is defined as the mass of polymer (in grams), flowing in 10 min through a capillary of a specific diameter and length by a pressure applied via prescribed alternative gravimetric weights for alternative prescribed temperatures [1, 7, 17].

Table 1 below demonstrated the temperature and pressure values required for melt flow index (MFI) measurements for the thermoplastic matrix material used in the studies. Filling material is ferrochrome.

Table 1: Temperature and weight values for MFI in certain thermoplastics.

Termoplastics	Producer Company/ Product Code	Temperature and Pressure for MFI
h Density yethylene (HDPE)	PETKIM I-668	190 ^{o}C / 2,16 kg
Polypropylene (PP)	PETKIM EH-102	230 ^{o}C / 2,16 kg

The ferrochrome was mixed in the rates of 10%, 20% and 30%, respectively, to form 4 to 8 grams thermoplastic mixtures separately as given in Table 1. The experiments were conducted in accordance with ASTM D1238 and TSE1323 standards using the "JPT EQUIPMENT XRL-400A brand and model" instrument in Munzur University Mechanical Engineering Department laboratories shown in Figure 2 for the analysis of mass and volumetric melt flow indices and densities of the mixtures. As shown in Table 1, high density polyethylene (HDPE) weight and temperature values were set at 2,16 kg and 190 ^{o}C, and for polypropylene (PP) these values were set at 2,16 kg and 230 ^{o}C.

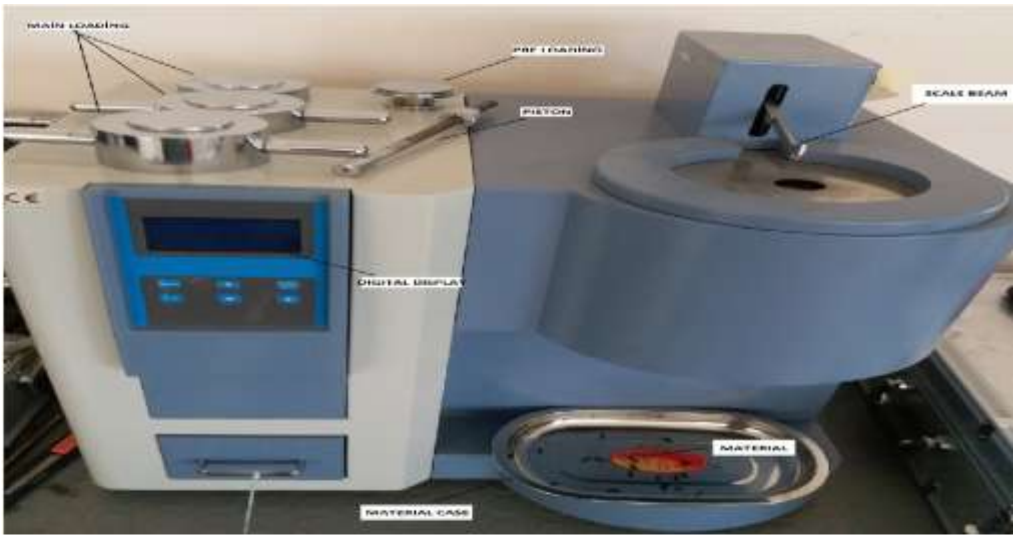

Figure 2: JPT EQUIPMENT brand XRL-400A model" MFI melt flow device.

When the abovementioned device reaches the set measurement temperature, the previously prepared mixtures were poured into the device's reservoir using a funnel and the material in the hot reservoir was compressed by a piston as shown in the figure. After this procedure, preload weights of 0.325 kg were applied on the pistons for both tests. The mixtures were allowed to melt in the heated chamber of the device for a period of about 6-8 minutes. The procedure was conducted at 190 ° C for HDPE, and when the molten material started to flow slowly from the lower part of the reservoir, a further 1.835 kg was added on the piston and the material was allowed to flow under the total weight of 2.16 kg. In polypropylene, 1,835 kg was added for a total of 2.16 kg weight at a temperature of 230 ° C and the molten material was allowed to flow from the bottom of the reservoir. Under these temperature and weight, the flow of the material through the nozzle was observed and the piston under the weight moved in the same direction with the material. Within the expected measurement range, when the lower surface of the weight dropped on the top of the piston came into contact with the scale arm indicated by "Scala Scream" in Figure 2, the sensor kicked in and the device started automatically. The molten material flowing from the tip of the nozzle was automatically cut by a switch next to the nozzle at 30 second intervals as the trigger kicked in. In Figure 2 above, the samples cut from the mixture of polypropylene + 20% ferrochrome are presented. The cut samples were collected in the material reservoir of the instrument and then their average weight was calculated. The average weight was input into the related field on the instrument's digital display, and the melt mass flow indices (MFI) and densities (ρ) of the mixtures were calculated automatically. The variations in obtained findings are presented in the graphs.

III. RESULTS AND DISCUSSION

The viscosity and density analysis for high density polyethylene (HDPE), polypropylene (PP) and ferrochrome mixtures are shown in the following graphs.

Figures 3 and 4 demonstrate the variations in the melt mass flow index (MFI) and density (ρ) of high density polyethylene (HDPE) based on the increase in the amount of ferrochrome. Based on the findings, the calculated MFI value for completely pure High Density Polyethylene (HDPE) with no ferrochrome additive was approximately 5.381 g/10 min, while the same value for high density polyethylene (HDPE) with 30% by weight ferrochrome addition decreased to 2.754 g/10 min.

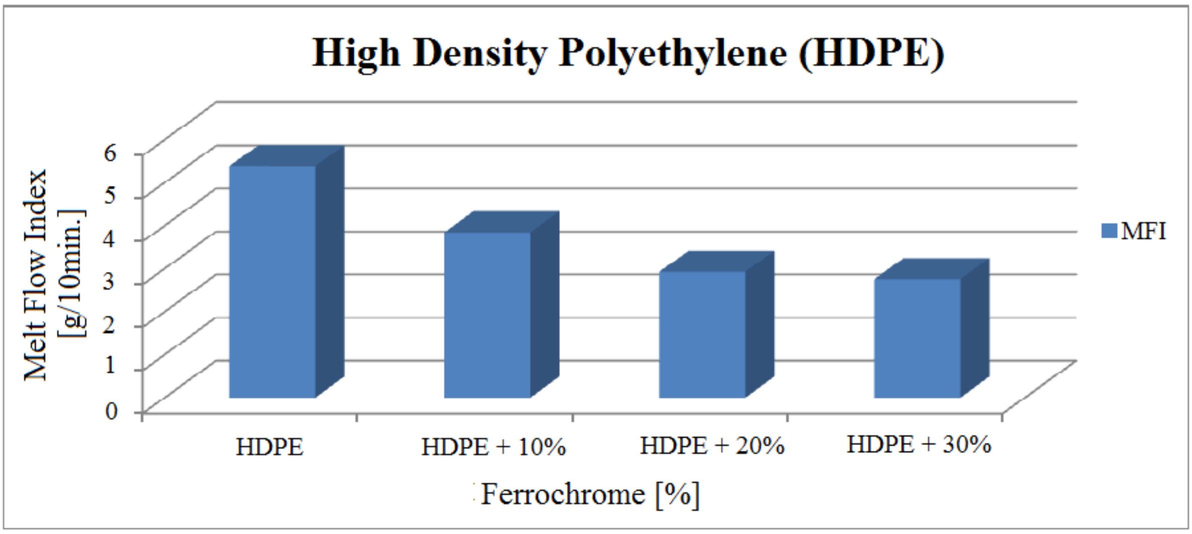

Figure 3: Variations in melt mass flow index of High Density Polyethylene (HDPE) based on the ferrochrome content.

On the contrary, the density of high density polyethylene (HDPE) increased as shown in Figure 4, and this figure increased from about 0.963 g/cm^3 to about 1.106 g/cm^3 based on the ferrochromium content. This was due to the fact that the density of ferrochromium is higher than the density of high density polyethylene (HDPE).

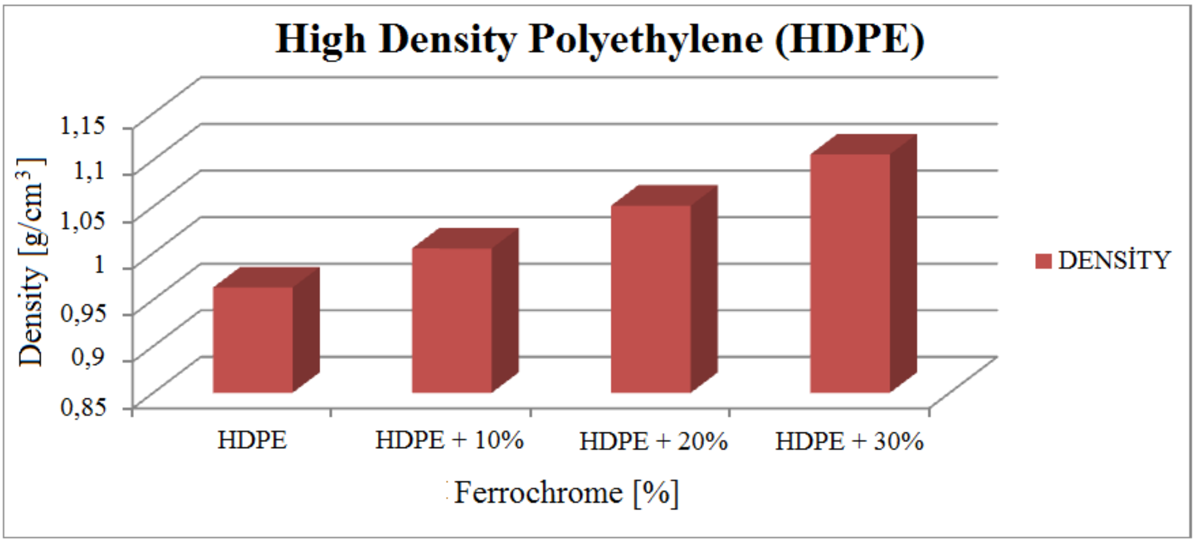

Figure 4: Variations in density of High Density Polyethylene (HDPE) based on the ferrochrome content.

Figures 5 and 6 demonstrate the changes in the melt mass flow index (MFI) and density (ρ) of polypropylene (PP) based on the increase in the ferrochrome content. Thus, the melt mass flow index (MFI) figure for the completely pure polypropylene (PP) without ferrochrome was approximately 11.376 g/10 min and this figure decreased in the 0% ferrochrome-added polypropylene (PP) mixture to 9.910 g/10 min. For samples that contained 20% ferrochrome, this figure was 8.917 g/10 min. Similar to the high density polyethylene, a polypropylene mixture that contained 30% ferrochrome by weight was prepared, but the material resisted the flow by generating a force against the force exerted by the piston and the measurement was not conducted due to the lack of fluidity.

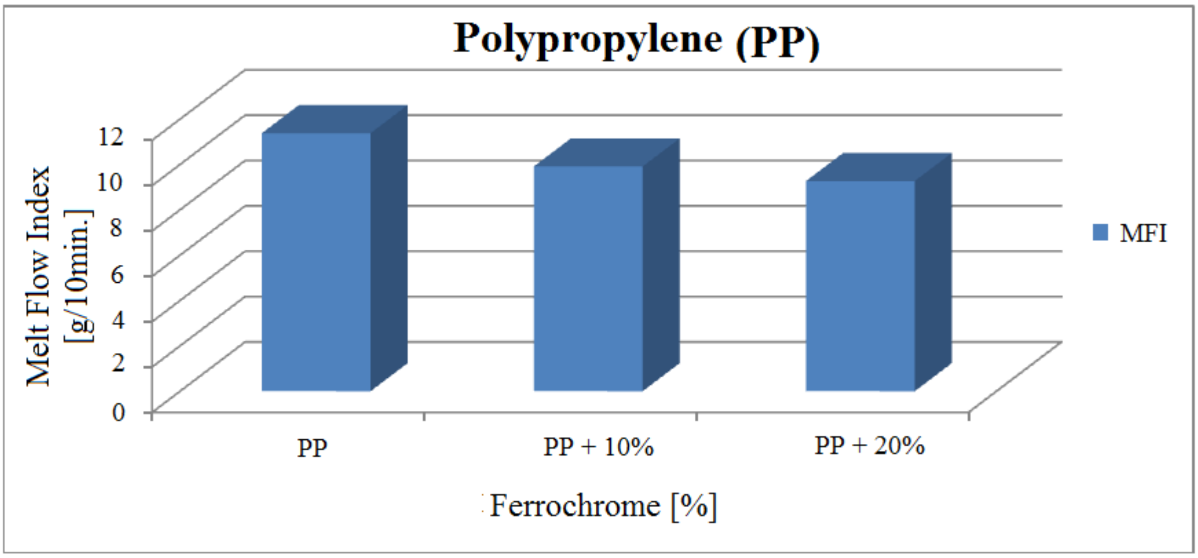

Figure 5: Variations in melt mass flow index of polypropylene (PP) based on the ferrochrome content.

Contrary to the melt flow index, the density of polypropylene (PP) increased based on the increase in the ferrochrome content. As shown in Figure 6, the density of pure polypropylene was 0.927 g/cm^3, which increased to approximately 0.967 g/cm^3 in samples that included 10% and 20% ferrochrome.

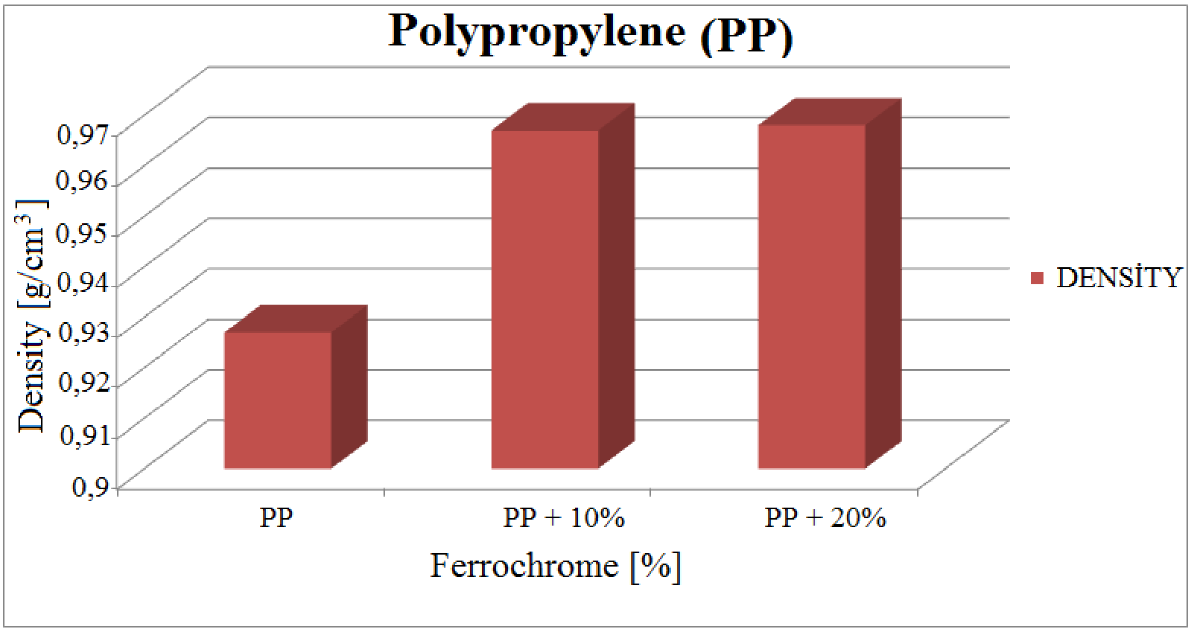

Figure 6: Variations in density of polypropylene (PP) based on the ferrochrome content.

IV. CONCLUSION

In the present study, the variations in the viscosity and density of high density polyethylene and polypropylene of the polyolefin group based on the ferrochrome content were determined. Based on the study findings;

The melt flow index or fluidity is inversely proportional to viscosity. It was determined that the melt flow indices of both high density polyethylene and the polypropylene decreased with the increase in ferrochrome content. Therefore, with increasing ferrochrome content, fluidity of matrix material decreased and their viscosities increased. Polypropylene sample fluidity was significantly adversely affected when compared to polyethylene samples, and no fluidity was obtained in polypropylene samples that contained 30% ferrochrome.

In contrast with the melt flow index, the densities of the mixtures with increased ferrochromium content also increased. These variations in density could be utilized in the industry based on the requirements.

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