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The Effects of Ferrochrome on Polystyrene (PS) Melt Flow Indices and Density

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Abstract: *In the present study, changes in density and melt flow index of Polystyrene (PS) based on its ferrochromium content were investigated. The ferrochrome material was mixed into Polystyrene (PS) in different proportions (10%, 20% and 30%) and the changes in viscosity and density in the said mixes that occur under certain temperatures and pressures were investigated. Finally, the changes observed due to the increased ferrochrome are presented in graphs.*

Keywords: *Polystyrene, recycling, melt flow index, density.*

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I. Introduction

Polymers have been uses as alternative material for several years to fulfill our needs in daily life, and the areas that they are utilized increase consistent with the increases in these needs. The most important polymer group includes thermoplastics. Polystyrene (PS) will be discussed in the present study [5, 13, 14].

Polystyrene is a polymer produced with mono-styrene polymerization. It is obtained from petroleum. It is abbreviated as PS in the plastics industry. At room temperature, the polystyrene is a solid thermoplastic, but it is melted at high temperatures for use in injection or extrusion processes. It is then cooled and solidified again. It resists well against UV rays, it has good impact and tensile strength, low price and ease of processing. It is also resistant against acid alkalis and salts [1, 3, 4, 18, 19].

It is widely used as an insulation material in thin walled containers, cooling towers, pipe Styrofoam, rubber, various tools, automobile parts, panels and plastic electronic device parts. It is also used frequently in disposable cups, plates, yoghurt cups, soda containers. It is found in the structure of the vessels used for cell culture, one of the most basic applications of genetic and molecular biology. It is used in packaging and disposables, electronic and domestic applianceindustries, refrigerator and air conditioner manufaturing, TV and HI-FI devices and household electrical appliance bodies, cassette bodies and boxes, cd, CD-ROM and DVD boxes, polystyrene condenser, automotive industry, optics and medical instruments, construction and furniture industries [2, 5, 11, 13, 14, 16, 17, 19].

Ferrochrome is an alloy that contains 50% - 70% chromium and 30 - 50% iron. The alloy is iron magnesium chromium oxide, melted in the electric arc furnace. The steel industry is the largest consumer of this alloy utilizing more than 80% of the global ferrochrome production in stainless steel production. The average 18% chromium content in stainless steel provides the steel its characteristic appearance and corrosion resistance. High carbon ferrochromium, a high-grade chromium, is used in special applications [11, 16, 17].

Figure 1: Ferrochrome

II. Experimental

The temperature and pressure values required for melt flow index (MFI) measurements of thermoplastic material used in studies are presented in Table 1. The filler material is Ferrochrome.

Table 1: Thermoplastics used and temperature and weight values for MFI.

Thermoplastics	Manufacturer/Product Code	Temperature and Pressure for MFI
1 Polystyrene	Eplamid PA 6 Naturel	200°C / 5 kg

The ferrochrome will be mixed separately with the thermoplastic (PS) given in Table 1 at the rates of 10%, 20% and 30% by weight and 4 to 8-gram mixtures will be prepared. Severalsimilar studies in the literaturedemonstrated that the tensile stress of thermoplastics was significantly reduced with increasing filler material [6, 7, 8, 10, 12]. For the analysis of the mass and volumetric melt flow indices and densities of the mixtures, the JPT EQUIPMANT brand XRL-400A model device was used in Munzur University Mechanical Engineering Department laboratory shown in Figure 2 and the experiments were conducted in accordance with ASTM D1238 and TSE1323 standards [9, 15, 16].
The experiments were conducted with 5 kg polystyrene under200^{o}C.

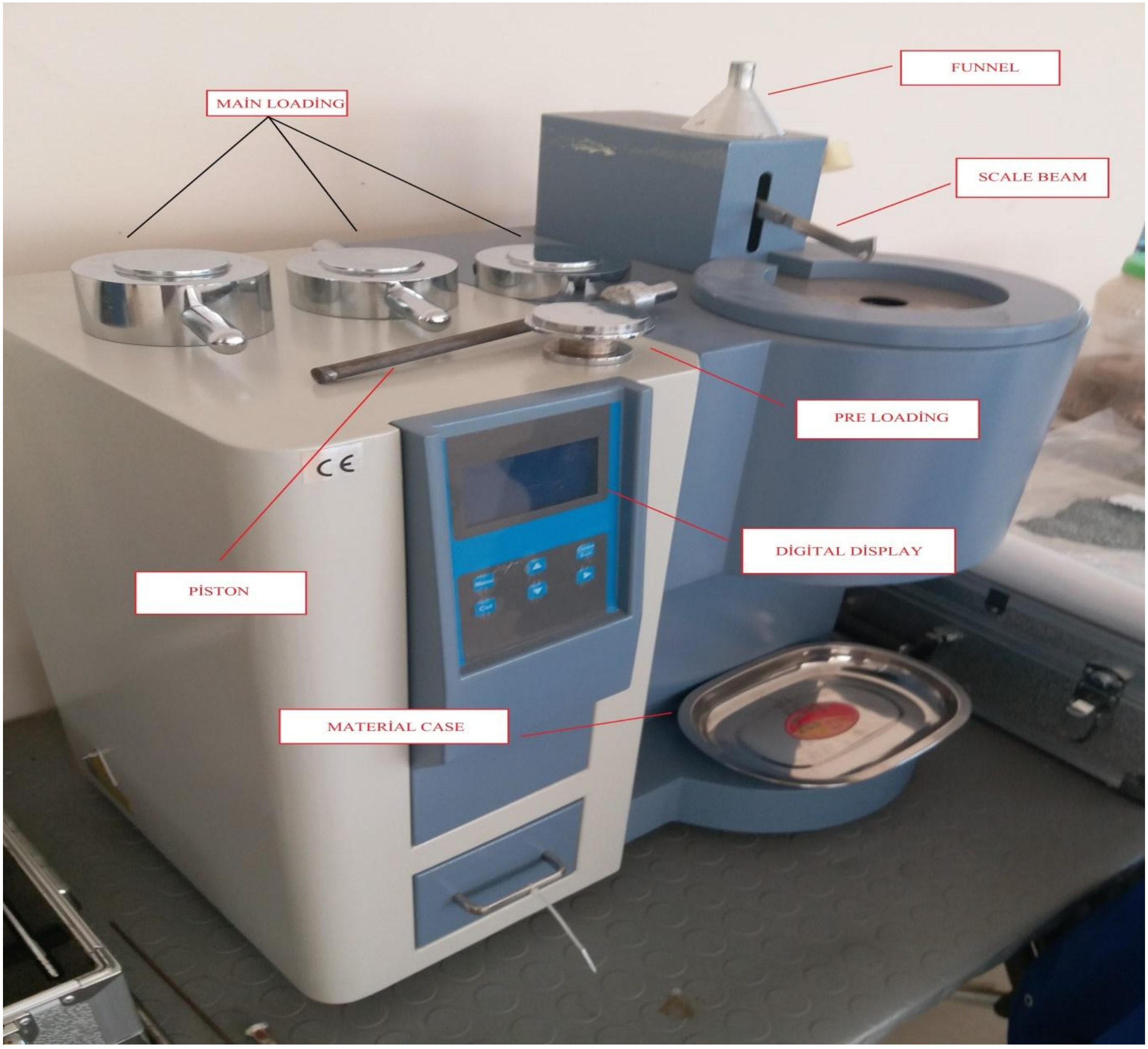

Figure 2: JPT EQUIPMANT brand XRL-400A model MFI melt flow device.

When the above device reaches the set measurement temperature, previously prepared mixes were poured using a funnel into the device's chamber and the material in the hot chamber was compressed with a piston as seen in the figure. After these operations, 0.325 kg preload weight was applied to the pistons for the test. The mixes were allowed to dissolve in the heated device chamber for a period of about 6-8 minutes. The process was conducted at 200^{o}C for polystyrene (PS) and when the melted material started to flow slowly from the lower part of the chamber, a further 4.675 kg weight was added, and the molten material flew under 5 kg total load. Under these temperature and weight values, the flow of the material from the nozzle was observed and the piston under pressure moved in the same direction with the material. In the expected measurement range, the lower surface of the total weight loaded on the upper section of the piston contacted the scale arm of the instrument and activated the sensor and the device was automatically activated. The molten material flowing from the nozzle after the activation was automatically cut with a switch located next to the nozzle at 30 second intervals. The cut samples were collected in the material chamber of the device and then the average ofthe weights was calculated. The calculated average weight was entered into the relevant area on the instrument's digital display, and the mixture mass melt flow index (MFI) and densities (ρ) were automatically calculated by the instrument.

The samples cut from PS and Ferrochrome mixes are presented in the below figure. The cut samples were collected in the material chamber of the instrument and then the average weight was calculated. The calculated average weight was entered into the relevant area on the instrument's digital display, and the mixture mass melt flow index (MFI) and densities (ρ) were automatically calculated by the instrument. The same procedure was conducted for each thermoplastic and ferrochrome mixture and the results are presented in graphs.

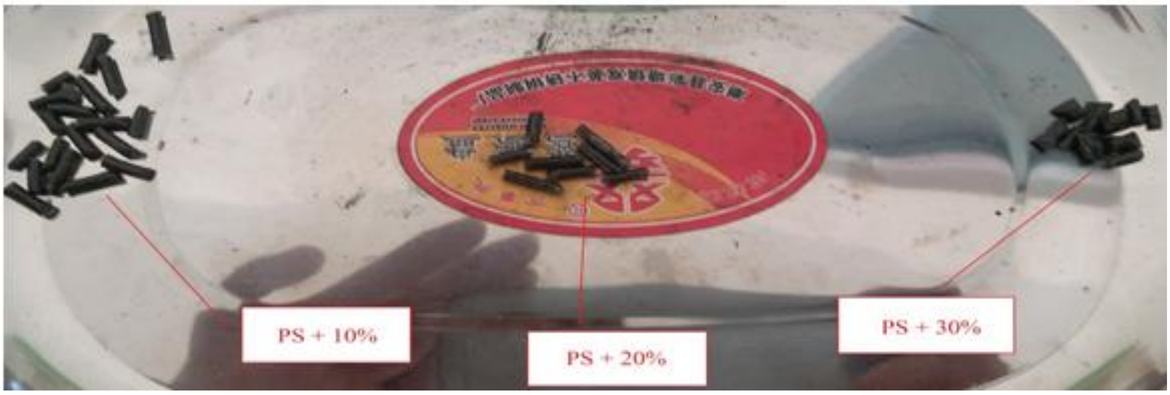

Figure 3: Polystyrene (PS) and different percentages of ferrochrome mixture samples.

Figure 4: RadwagAs 220 R2 Density Measurement Instrumen

In the density measurement device presented above, the densities of PS and Ferrochromium mixtures were calculated. First, the beaker on the weighing section was filled with alcohol (Ethanol) for use in density measurement. Before the measurement starts, the device tare must be reset to zero. Thus, resetting is done by pressing the key labeled '0-Delete'. After checking the mark on the upper left corner indicating stability, the key labeled " Insert " is pressed and the tare is saved. The " Unit-Esc" key is pressed to select the weight unit that will be used for density measurement. Then the " Mode " key is pressed to select 'F6 Solid Dens'using the up-down arrow keys and the "Enter" key is pressed to accept the selection. Then the 'Function' key is pressed and when “Start” caption is seen the "Enter" key is pressed again. The liquid type (Ethanol) that will be used for density measurement is then selected. The 'Enter' key is pressed again and the temperature reading on the thermometer placed in the beaker is read and saved on the next screen. When " Enter " key is pressed again, the display will read " In Air ". The material that will be measured is placed on the upper scale pan (not in contact with the liquid) located in the beaker for density measurement. The value displayed on the screen is read and when "Enter" key is pressed again, "In Liquid" notification appears. Then, the material that will be measured is placed on the scale pan located in the liquid (Ethanol) and the value that appears on the screen is read again. When the "Enter" key is pressed again, the device will automatically provide the density of the material.

III. Results And Discussion

The viscosity and density analysis results for the polystyrene (PS) and ferrochrome mixtures are presented in the graphs below. The changes in the mass melt flow index (MFI) and density (ρ) of the polystyrene (PS) based on the increase in the ferrochrome amount are presented in Figures 5 and 6. Based on the results, the calculated MFI value for completely pure polystyrene (PS) without ferrochrome was approximately 6.519 gr / 10 min. It was observed that 10% Ferrochrome - Polystyrene (PS) MFI value was decreased to 6.378 gr / 10 min. However, as the filler material content was increased, an increase in MFI was observed.

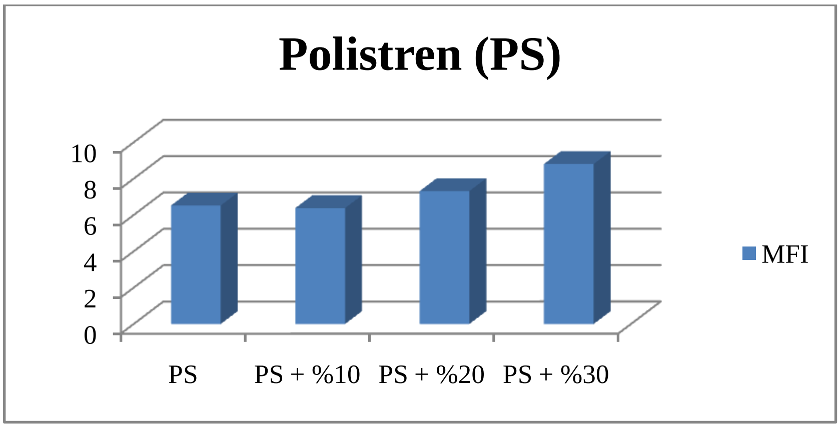

Figure 5: Variation in Polystyrene (PS) mass melt flow index based on Ferrochrome content.

The polystyrene (PS) density initially increased as shown in Figure 6, and then, an increase and decrease was observed. This value increased from about 1.032 g / cm3 to 1.084 g / cm3 based on the ferrochrome content. The density increased to 1,086 g / cm3 when 20% filler material was added, butwhen 30% filler material was added, this value decreased to 1,014 g / cm3.

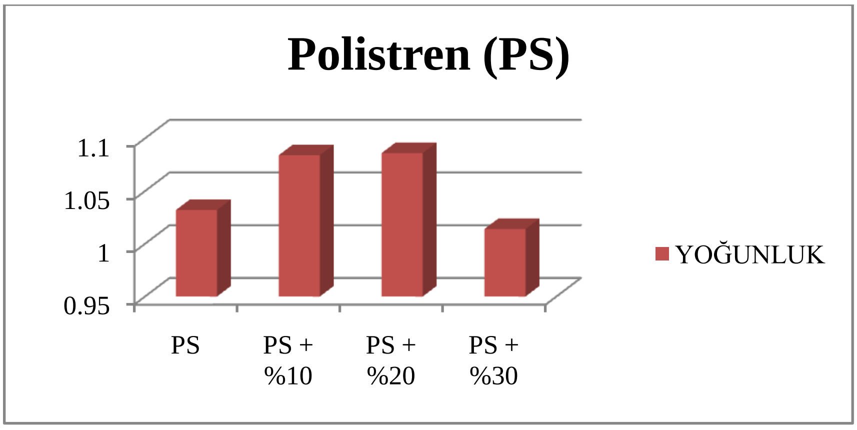

Figure 6: Variation in Polystyrene (PS) density based on Ferrochrome content.

IV. Conclusion

In the present study, variations in Polystyrene (PS) viscosity and density based on ferrochrome content were determined. According to the study results;

1. Polystyrene (PS) melt flow index value (MFI) decreased based on the increase in ferrochrome content and this value then increased with the increase in filler material amount.
2. Polystyrene (PS) density increased up to the addition of a certain ferrochrome filler material content, however when ferrochrome rate was increased even further, it was observed that the density decreased below the pure Polystyrene (PS) density level.

Resources

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