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Editorial

We start this pioneering work, which do not seek perfection as much as aiming to provide a scientific window that opens a wide area for all the distinctive pens, both in the University of Sabratha or in other universities and research centers. This emerging scientific journal seeks to be a strong link to publish and disseminate the contributions of researchers and specialists in the fields of applied science from the results of their scientific research, to find their way to every interested reader, to share ideas, and to refine the hidden scientific talent, which is rich in educational institutions. No wonder that science is found only to be disseminated, to be heard, to be understood clearly in every time and place, and to extend the benefits of its applications to all, which is the main role of the University and its scholars and specialists. In this regard, the idea of issuing this scientific journal was the publication of the results of scientific research in the fields of applied science from medicine, engineering and basic sciences, and to be another building block of Sabratha University, which is distinguished among its peers from the old universities.

As the first issue of this journal, which is marked by the Journal of Applied Science, the editorial board considered it to be distinguished in content, format, text and appearance, in a manner worthy of all the level of its distinguished authors and readers.

In conclusion, we would like to thank all those who contributed to bring out this effort to the public. Those who lit a candle in the way of science which is paved by humans since the dawn of creation with their ambitions, sacrifices and struggle in order to reach the truth transmitted by God in the universe. Hence, no other means for the humankind to reach any goals except through research, inquiry, reasoning and comparison.

Editorial Committee

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All submitted research manuscripts must follow the following pattern:

- Title, max. 120 characters.
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- Keywords, max. 5 words.
- Introduction.
- Methodology.
- Results and Discussion.
- Conclusion.
- Acknowledgments (optional).
- References.

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- Basic Science.
- Medical Science & Technology.
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Refereeing

The Editorial Committee delivers researches to two specialized referees, in case of different opinions of arbitrators the research will be delivered to a third referee.

Editorial Committee

CONTENTS

THE EFFECT OF ADDING POLYMER COMPOUNDS TO METALS ON ITS MECHANICAL PROPERTIES

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Abstract

Metals, especially iron, are the basis of most industries, especially metal industries. Since the general trend now in all countries and all sectors is to achieve sustainability, whether economic, environmental, or social sustainability, it was natural to search for new ways and methods to develop and improve both properties of metals, whether mechanical or physical. Adding polymer compounds to metals improves their mechanical properties and increases the strength of the metal by distributing stresses more uniformly, which reduces the possibility of fractures and cracks, and also increases the durability of metals by improving their ability to withstand repeated loads without breaking. It also increases the hardness of metals by improving their resistance to deformation. Polymer compounds increase the shock resistance of metals by absorbing impact energy. In this study, Polymer compounds were added to iron by dissolving the polymer in molten iron, and then the change in mechanical properties such as hardness, durability, shock resistance, and strength was studied, the experimental methodology in this study was used. The results showed that adding polymer compounds (Polyethylene, polyester, glass fiber reinforced polymers) to iron improved iron's main mechanical properties. The all properties were increased, strength by 20:25%, toughness by 15:23%, hardness by 12.5:28%, and impact resistance by 15:40%. This means that adding polymer compounds to iron can be an effective way to improve its mechanical properties.

Keywords: sustainability; metals; improvement mechanical properties; stresses; durability; resistance hardness; Polyethylene; polyester; glass fiber reinforced polymers.

Introduction

The mineral sector plays an important role in the global economy. It provides raw materials for infrastructure, manufacturing, energy, and new technologies. However, the mineral sector also faces a set of environmental and social challenges, so it was necessary to achieve sustainability in this field, and sustainability in its general form means preserving the rights of current generations, whether environmental rights, economic rights, or social rights, without compromising the rights of future generations. Minerals are natural resources and are the mainstay of industries, especially iron because it is one of the most widely used metals in the world and is used in a variety of applications, including construction, manufacturing, and transportation (Azapagic, 2003). However, the iron industry also faces a set of environmental and social challenges. To overcome these challenges, it was necessary to develop and improve the mechanical and physical properties of this metal. Sustainable initiatives in the field of iron lead to a range of benefits, in terms of environmental protection, as recycling and sustainable mining can help reduce the environmental impact of the iron industry, social justice, as improving the properties of iron reduces the rate of consumption of iron ore, which is our right and for future generations, and also helps Sustainability in the steel industry enhances economic growth and improves the economic level of people and individuals (Ostrom, E., 2009).

Iron is one of the most widely used metals in the world, used in a variety of applications, including construction, manufacturing, and transportation (Ebbesen, J.B. and Hope, A., 2013). The efficiency and safety of these applications depend on the mechanical properties of iron (Shatoka, V., 2016) and (Piontek, A., Bise, E.2018). These properties are strength, which means the ability to bear loads without breaking, flexibility, which means the ability to bend without breaking, and hardness, which means the ability to resist deformation and shear stresses and bending moments (Li, Jei, et, al. 2010) and (Cavadar,U, et, al, 2015). Improving the mechanical properties of metals in general and of iron in particular leads to increased safety, as improving strength, flexibility and hardness can make iron more resistant to breakage or deformation, which reduces the risk of accidents, increasing efficiency as improving shock resistance can make iron more resistant to shocks, Reducing the need for maintenance or replacement, expanding the range of applications as improving the mechanical properties of iron can make it suitable for new applications, such as applications requiring greater strength, rigidity or impact resistance (Han, B.Q., et, al. 2003) and (Peng, J., et, al. 2017). There are a variety of ways to improve the mechanical properties of iron, such as adding other elements to the iron: adding other elements to the iron, such as carbon, manganese, or nickel, can lead to polymer compounds improving its mechanical properties, heat treatment, which means heating and then rapid annealing, Manufacturing using new technologies: Using new manufacturing technologies, such as 3D printing, can improve the mechanical properties of iron. Research into improving the mechanical properties of iron continues, as scientists seek to develop new ways to improve these properties and expand the range of possible applications for iron (Kobyliukh, A., et, al. 2020).

Polymer composites can be used to improve the mechanical properties of iron in several ways. Polymer compounds can be added to the iron during the manufacturing process, or they can be applied to the surface of the iron after manufacturing (Tasdemir, Mal., and Gulsoy, H. O., 2008) These methods include adding polymer compounds to the molten iron during the casting process or adding the polymer to specific areas of the iron, such as the surface or the inner surface by injection. Surface addition, where polymer compounds are applied to the surface of iron after manufacturing, high molecular-weight polymer compounds result in better strength and toughness than lower molecular-weight polymer compounds (Kobyliukh, A., et, al., 2020). The manufacturing method can also affect the resulting mechanical properties, as direct addition of the polymer to the metal tends to be more effective than surface addition. It is a polymer compound that can be used to improve the mechanical properties of iron. (Masood, S.H. and Song, W.Q., 2004) Thermoplastic polymers: such as nylon, polyester and polyethylene, can improve strength, toughness and toughness. Thermoplastic polymers: such as polyacrylonitrile butadiene styrene (ABS) and polyethylene terephthalate (PET), can improve strength, toughness, and impact resistance. Composite polymers: such as recycled polymers Fiber-reinforced polymers can provide broad improvements in a variety of mechanical properties, Thermoplastic polymers: such as nylon, polyester, and polyethylene, can improve strength, toughness, and toughness. (Naveen Kumar, K., et, al. 2016) (Cvek, M., Mrlík, M., et, al. 2017).

This study aims to know the effect of polymer compounds on the mechanical properties of iron, such as durability, hardness, flexibility, and resistance to shocks and deformations. The study gains its importance from the importance of answering some important questions, such as how to develop the mechanical properties of iron, which is the most widely used metal in the world and is used in a variety of applications, including This includes construction, manufacturing, and transportation. The efficiency and safety of these applications depend on the mechanical properties of iron, and the importance of polymer compounds in improving those properties. A practical experiment was conducted by injecting a sample of iron metal with a polyethylene polymer, heat treating it, and simulating that experiment using the ANSAS program and calculating the changes that occurred in shear and bending stresses and comparing them. (Before and after the polymer injection process), and then analyse the results.

Overview of Analysed Experiments

iron is one of the oldest metals used by humans, and its use dates back more than 5,000 years. However, the natural properties of iron are not ideal for all applications. For example, pure iron is weak and prone to rust. In the Iron Age, which began more than 1200 BC, humans began to use iron more commonly (Guyatt, G.H., et, al., 1992). A variety of methods were developed to improve the properties of iron in this era, including adding carbon taken from coal to iron to produce steel, which is a stronger and harder material than pure iron, and the use of forging and heating to perform tempering and normalizing processes. In the modern era, a variety of methods were developed to improve the properties of iron (Álvarez-Sanchís, J.R., 2000). Developing a variety of new methods to improve the properties of iron, such as adding other elements to iron. New methods have been developed to add other elements to iron with greater precision, which has greatly improved the properties of iron. Among these methods is the addition of polymer compounds. Modern heat treatment: new methods of heat treatment of iron have been developed, such as laser-controlled heat treatment, which can improve the mechanical properties of iron more efficiently (Plug, I., 2000). Manufacturing using new technologies: new manufacturing technologies have been developed, such as 3D printing, which can produce materials A mineral with specific mechanical properties (Anderson, W.B., 1982).

Many experiments have been performed to evaluate the effect of adding polymer compounds to iron on its mechanical properties. The general results of these experiments depend on the type of polymer used, method of addition, and manufacturing conditions. (Lai, Y., et al., 2020) On ways to improve the mechanical properties of iron by adding other materials, the study dealt with adding tantalum carbide (TaC) to iron, as it is known that tantalum carbide (TaC) has a noticeable effect on the mechanical properties of metal matrix compounds thanks to its high hardness, high melting point, and resistance. Excellent corrosion and chemical stability, as iron reinforced with TaC particles was manufactured by mechanical alloying using high-pressure grinding followed by subsequent hot pressing (HP) at 1250 °C under 60 MPa, and no heat treatments were performed. The results indicated Density, hardness, compressive performance, and corrosion resistance of the manufactured TaC/Fe composites were measured using the Archimedes method, Rockwell hardness test, universal electromechanical testing machine, and abrasion corrosion tester, respectively. There was a significant improvement in mechanical properties (Lai, Y., et al., 2021).

One of the most important methods of hardness testing is the Brinell test, as this test uses a hard steel ball to create a dent in the surface of the material to be tested. The depth of the dent is measured, and this data is then used to calculate the hardness of the material (Stachurski, Z.H., 2006). Vickers test: This test uses a conical diamond to create a dent in the surface of the material to be tested. The depth of the dent is measured, and this data is then used to calculate the hardness of the material, Rockwell Test: This test uses a hardened diamond or carbide tip to make a dent in the surface of the material to be tested. The depth of the dent is measured, and this data is then used to calculate the hardness of the material. The Rockwell test is a non-destructive test to measure the hardness of solid materials. This test uses a pen-like scale that has two tips, one hard and one soft. The hard tip is applied to the surface of the material to be tested, and the softer tip is then applied to it. The penetration depth of each tip is measured, and this data is then used to calculate the hardness of the material. There are two main types of Rockwell hardness tests:

- Rockwell B Test: This test uses a hard diamond tip and a softer steel tip.
- Rockwell C Test This test uses a hard carbide tip and a softer steel tip.

The hardness of a material is measured in a unit called "Rockwell". Rockwell scores range from 0 to 100, with a higher number indicating greater hardness. The testing steps are as follows: The surface of the material to be tested is cleaned, the material is then installed on the testing platform, and then the hard tip is applied to the surface of the material. The material is mounted on the testing platform, and the softer tip is then applied to the surface of the material The solid tip is applied to the surface of the material, and the penetration depth of each tip is read the softer tip is applied to the surface of the material next (Walley, S.M., 2012) (Mao, W.L., et, al. 2008).

One of the methods of measuring elasticity is defined as the ability of a material to return to its original shape after removing the load applied to it. Flexibility is one of the most important mechanical properties of materials, as it plays an important role in determining the material's ability to bear various loads without being permanently deformed (Matthies, S., et, al. 2001).

Non-destructive methods are used to measure elasticity without damaging the material to be tested. The most important of these methods are the following:

- Bending test: This test is used to measure the resistance of a material to bending. A gradually increasing force is applied to a sample of material, and the amount of bending before fracture is measured.
- Compression test: This test is used to measure the resistance of a material to compression. A gradually increasing force is applied to a sample of material, and the amount of compression before fracture occurs is measured.
- Shear test: This test is used to measure the resistance of a material to shear. A gradually increasing force is applied to a sample of material, and the amount of shear before fracture occurs is measured.
- Destructive methods are used to measure elasticity by permanently damaging the material to be tested. The most important of these methods are the following:
- Tensile test: This test is used to measure the tensile strength of materials. A gradually increasing force is applied to a sample of material, and the amount of tension before fracture is measured.
- Compressive tensile test: This test is used to measure the tensile and compressive strength of materials. Gradually increasing force is applied to a sample of material in opposite directions, and the amount of tension and compression is then measured before fracture.
- Choosing a method to measure elasticity depends on several factors, including:
- Type of material to be tested.
- The nature of the required application.
- Required accuracy.

In a study of (Obasi, H. et, al. 2023) they mixed natural rubber (NR) and low-density polyethylene (LDPE) in a two-roller mill to manufacture NR/LDPE compounds with liquid natural rubber (LNR) and hematite (a-Fe2O3), and the effect of liquid natural rubber (LNR) was studied) on the mechanical properties and external appearance of NR/LDPE composites. The NR/LDPE composites were prepared in three different compositions: 70/30, 50/50 and 30/70, with filler content at different concentrations (3, 5 and 7 g) while the LNR at 10 g for the modified composites. The results showed an increase in tensile strength, tensile modulus, and compressive and flexural properties, but with a decrease in elongation at break, the contents of a-Fe2O3 and LDPE increased (Matthies, S., et, al. 2023).

In a study by (Tamilarasan, et, al. 2022) he pointed out that fine particles of polyethylene and ferric oxide were mixed in this work to produce a new polymer compound. The effect of this on tensile strength and Young’s modulus was studied, and the response surface methodology was used in the research. The results indicated an improvement in the mechanical properties of the composite. Where Young's modulus and tensile strength increased by 340 percent and 65 percent, respectively (Tamilarasan, U., et, al. 2022).

In a study by (Gu, X. et, al. 2007) the compositional effects of polymer compounds on the ductility and elastic properties of amorphous steel were studied. The measured breaking strength was 4.4 GPa. A study of the relationship between the elastic modulus of the alloy and that of the alloying elements revealed that interactions between atoms in addition to the elastic modulus of the alloying elements must be taken into account when designing BMGs based on ductile iron (Gu, X.J., et, al. 2007).

The Method and Methodology

We will use an experimental methodology and simulation methodology to obtain the results of the effect of adding polymer compounds to iron.

Methodology for testing flexibility, hardness, and toughness of steel reinforced with polymer composites the methodology for testing flexibility, hardness, and durability of steel reinforced with polymer composites is based on a set of basic steps According to the practical framework shown in Figure (1).

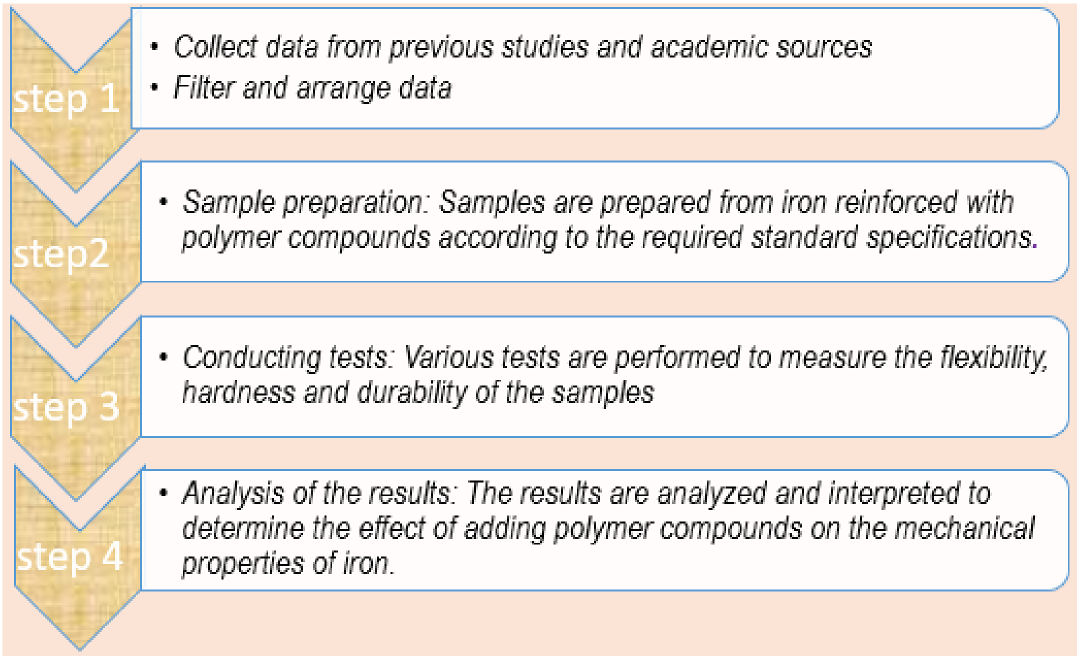

Figure (1): The Practical Framework (Author).

Experimental Methodology

Sample preparation: Samples are prepared from iron reinforced with polymer compounds according to the required standard specifications. Pouring method: The polymer compounds are dissolved in the iron, and then the mixture is poured into a metal mold. The mixture is left to cool and harden, then the sample is removed from the mold. Steps in the casting method for preparing samples from iron reinforced with polymer compounds (Stepanov, I., et, al., 2019).

The following are the steps of the casting method for preparing samples of iron reinforced with polymer composites:

1) Sample preparation, preparation of materials.
The materials needed for the procedure are prepared), prepare a set of samples: melted iron, (Polyethylene, polyester, and glass fiber-reinforced polymers), the ratio of metal mold to Polymer compound is 3:1

100 grams of polyethylene.

2) Preparing the mold (Anameric, B. and Kawatra, S.K., 2008).

- Mixing materials (prepare a casting mold in the shape of a bar with a diameter of 8 mm, use a laboratory melting furnace and heat it to a temperature of 1400 degrees Celsius).
- Using a melting pot and placing the raw materials.

- The dissolved iron and polymer compounds are mixed in a suitable tank or vessel. The materials are mixed well to ensure that the polymer compounds are evenly distributed in the iron. See Figure (2).

Figure (2): Iron Smelting Method.

Pour the mixture into the mold see Figure (3)

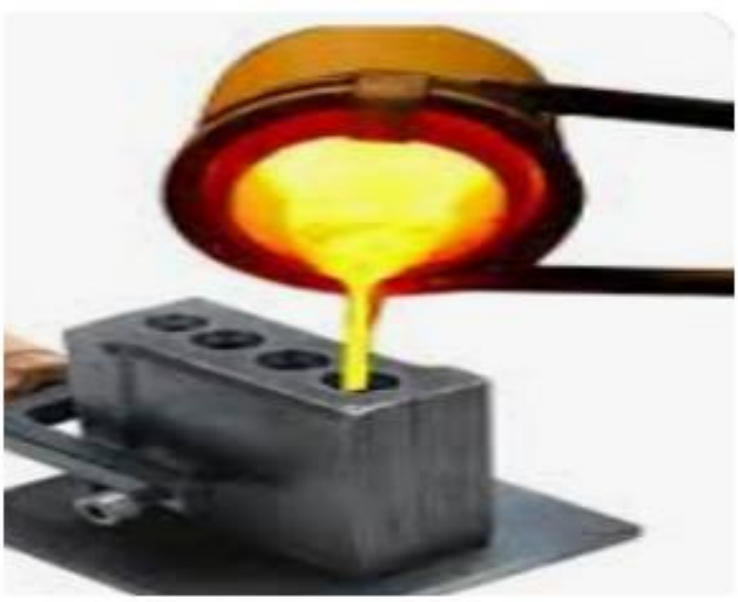

Figure (3): Pouring the Mixture into the Mold.

The mixture is left to cool and harden completely (Zhu, G., et, al. 2015).

- Remove the sample from the mold.
- After the mixture has completely cooled and solidified, the sample is removed from the mold. The sample is carefully cleaned and dried before testing.

Table (1): The Specifications of the Iron Sample.

Sample Components	Percentage
Fe	95%
Mn	0.15%
C	0.25%
P	0.04%
S	0.04%
Si	0.04%

Conducting Tests

- **Hardness Test**

The hardness test will be done with a piston see Figure (4) where the iron sample is placed on a flat surface, then the endurance piston is placed on the sample. Force is gradually applied to the bearing piston, and the amount of force needed to make the specimen bend or break is recorded.

Figure (4): The Hardness Test with a Piston.

- **Tensile Test**

to measure the strength of irons, see Figure (5).

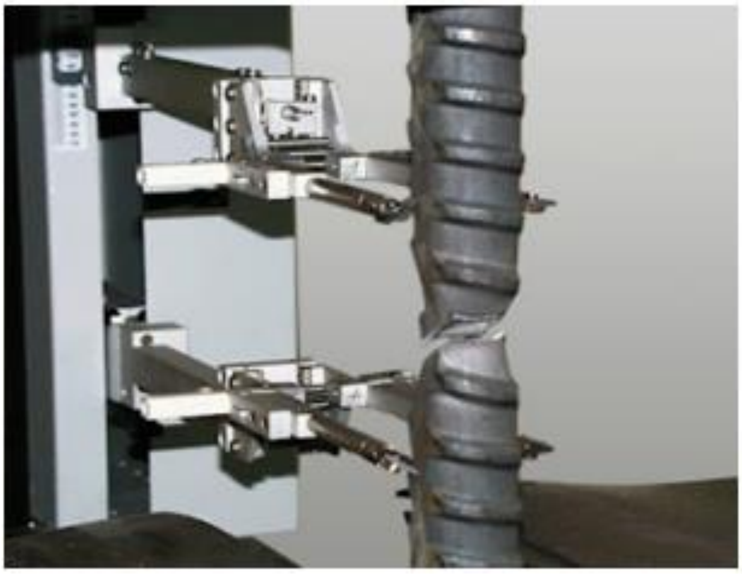

Figure (5): Tensile Test to Measure the Strength of Iron.

- **Bending and Elasticity Testing**

The value resulting from the bending test is known as the bending strength. Bending strength is the amount of force necessary to bend the sample to the breaking point. See Figure (6).

Figure (6): ASTM C1499 Standard Test for Uniaxial Bending Strength.

Results and Discussion

Now we will present the results of measuring the hardness, flexibility, and strength of the iron bar before melting and after melting and adding the polyethylene compound.

Results

Table (2): Hardness, Elasticity, and Bending Values for a Sample of Rebar before & after Adding Polyethylene.

	Sample Before Adding Polymer	Sample After Adding Polymer
Hardness Mpa.	400	480
Elasticity and bending	4%	4.60%
Durability Mpa.	1000	1150

Table (3): Hardness, Elasticity, and Bending Values for a Sample of Rebar before & after Adding Polyester.

	Sample Before Adding Polymer	Sample After Adding Polymer
Hardness Mpa.	400	450
Elasticity and bending	4%	5.5%
Durability Mpa.	1000	1080

Table (4): Hardness, Elasticity, and Bending Values for a Sample of Rebar before & after Adding Glass Fiber Reinforced Polymers.

	Sample Before Adding Polymer	Sample After Adding Polymer
Hardness Mpa.	400	515
Flexibility and bending	4%	4.36%
Durability Mpa.	1000	1230

Table (5): Hardness, Elasticity, and Bending Values for a Sample of Rebar before & after Adding.

	Hardness	Elasticity and Bending	Durability Mpa.
Iron mixture with polyethylene compound	480	4.60%	1150
Iron mixture with polyester compound	450	6%	1080
Iron mixture with glass fiber reinforced	515	4.36%	1230

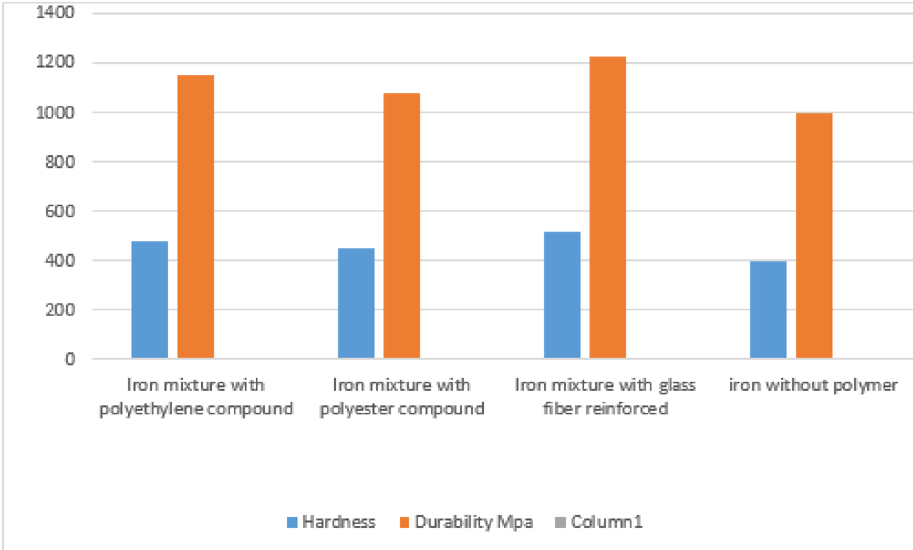

Figure (7): Comparison between Durability and Hardness when using Different Types of Polymer Compounds.

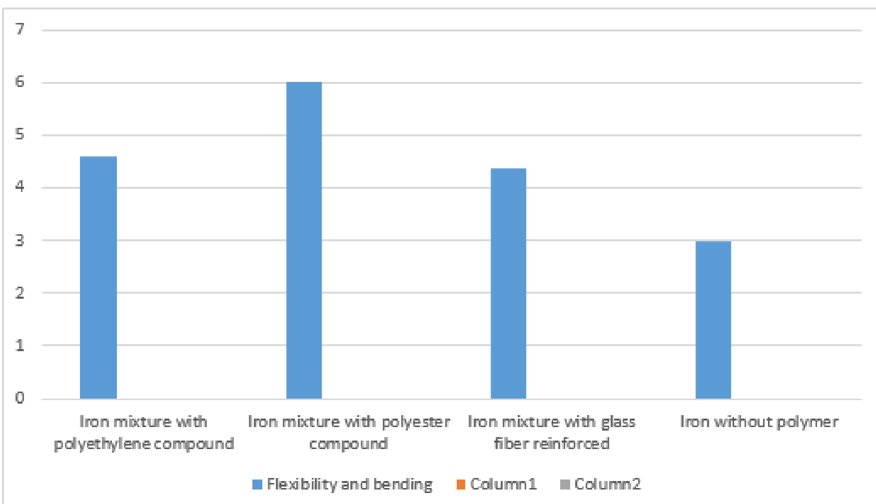

Figure (8): Comparison between Elasticity Values when using Different Types of Polymer Compounds.

Discussion

According to Table (2), we find that when adding the polyethylene polymer compound to the limit, the hardness improved from 400 MPa to 480 MPa, meaning the hardness property improved by 20%, while the toughness improved by 15%, as it increased from 1000 MPa to 1150 MPa. Pascal, while the elasticity and shock resistance properties improved by 15%, rising from 4% to 4.6%.

According to Table (3), we find that when adding the polyester polymer compound to iron, the hardness improved from 400 MPa to 450 MPa, meaning that the hardness property improved by 12.5%, while the toughness improved by 8%, and the toughness property Increased from 1000 MPa to 1080 MPa. While the properties of elasticity and shock resistance improved by 37.5%, rising from 4% to 6%.

According to Table (4), we find that when the fiberglass compound was added to the iron, the hardness improved from 400 MPa to 515 MPa, meaning that the hardness property improved by 28%, while the toughness improved by 23%, and the toughness property improved by 15%. Increased from 1000 MPa to 1230 MPa. While the properties of elasticity and shock resistance improved by 9%, rising from 4% to 4.36%.

According to Figure (7), it is clear that the improvement in hardness as a result of using the fiberglass compound with iron has the largest value, reaching 28%, followed by an improvement of 20% in the case of using the polymer compound polyethylene, then by 12.5% in the case of polyester.

According to Figure (7), it is clear that the improvement in hardness as a result of using the fiberglass compound with iron has the largest value, reaching 28%, followed by an improvement of 15% in the case of using the polymer compound polyethylene, then by 8%% in the case of polyester.

According to Figure (8), it is clear that the improvement in elasticity and shock resistance as a result of using the polyester compound with iron carries the largest value, reaching 37.5%, followed by an improvement of 15% in the case of using the polymer compound polyethylene, then by 9% in the case of fiberglass.

Conclusion

Adding polymer compounds to iron can improve its mechanical properties in several ways, by increasing hardness: Polymer compounds can increase the hardness of iron by providing an additional network of molecular bonds. This can increase the resistance of iron to deformation or breakage. Increased flexibility: Polymer compounds can increase the flexibility of iron by providing an insulating layer that separates the metal atoms. This can increase the ability of iron to stretch without breaking, increasing durability. Polymer compounds can increase the durability of iron by providing a protective layer from corrosion or rust. This can extend the life of the iron and prevent damage (Findik, F., 2014).

Thermoplastic polymers: Thermoplastic polymers, such as polyethylene and polypropylene, can be used to improve the hardness and corrosion resistance of iron. They are better than plastic polymers by up to 5%, but fiberglass polymers are superior to them by up to 8%. Thermoplastic polymers: can be used Thermoplastic polymers, such as polyamide and polyester, improve the flexibility and rust resistance of iron.

They are superior to polyethylene polymers by up to 12% and fiberglass by up to 30%. Composite polymers: Composite polymers, such as glass fiber-reinforced polymers, can be used to improve the hardness and resistance. Corrosion and deformation of iron, which is superior to thermoplastic and plastic polymers.

Improving the mechanical properties of iron leads to achieving sustainability in the field of steel industries in several ways, by reducing material consumption: Improving the mechanical properties of iron can reduce the amount of materials needed to produce a particular product (He, K. and Wang, L., 2017). For example, the use of polymer-reinforced iron can reduce the weight of the product by up to 30%. This can reduce the consumption of raw materials, such as iron ore, reduce carbon emissions, and also increase the shelf life as improving the mechanical properties of iron can increase the life of the product. For example, using corrosion-resistant iron can extend the life of the product by up to 50%. This can reduce the need for product maintenance and replacement, reducing waste. Improve energy efficiency: Improving the mechanical properties of iron can improve the energy efficiency of products. For example, the use of high-density iron can improve the fuel efficiency of cars by up to 10%. This can reduce carbon emissions (Raabe, D., Tasan, C.C. and Olivetti, E.A., 2019).

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