Study the Effect of Iron Powder Additives on Mechanical properties of Recycling of Aluminum Cans Scrap

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ABSTRACT
This paper involves the effect of iron powder in recycling of aluminum cans scrap on some mechanical properties. This process includes burning aluminum cans to remove paint and shredding into small pieces then melting aluminum pieces using an electrical furnace at (750 ºC). Iron powder (0.6, 1.2 and 1.8 wt %) was added to the melt sequentially. The composition is then casted into cylinder steel molds. The mechanical and metallurgical characteristics of the fabricated alloys were studied through an optical microscope including hardness, tensile testing, scanning electronic microscope and X-ray fluorescence. The results indicated that the maximum value of tensile strength and elongation percentage are recorded for the addition of (1.2%) of Iron powder. While maximum modulus of elasticity reported was at (0.6%) Iron powder cast. Hardness also increased with the increase of Iron additives.
Keywords: Recycling, Aluminum cans Scrap, Iron Powder, Casting.

INTRODUCTION
Recycling is a process to change waste materials into new products to prevent waste of potentially useful materials, reduce the consumption of fresh raw materials. The recycling of aluminum cans reduces waste, saves energy, conserves natural resources, lessens use of municipal landfills and provides recyclers and municipalities with considerable revenue. Used aluminum ships are an end waste that can be recycled to obtain valuable products and it involves the separation and collection of materials for processing and remanufacturing into new products, and the use of the products to complete the cycle [1, 2].
Iron contamination may occur in the bath in secondary aluminum industries, resulting from the Iron scrap mixed with aluminum scrap. Additionally, aluminum scrap can itself contain high Iron concentration, from aluminum Production by a die-casting molding process [3].
W. Khraisat & W. Abu Jadayil, (2010) have studied the effect of strengthening Aluminum scrap by Iron (Fe) powder in order to achieve better mechanical properties. Aluminum (Al) scrap was melted in a heated furnace to form a melt composition. Iron has been added by (1, 2, 3 and 5 wt %). Superior properties have been obviously manifested in the casted Aluminum (Al) with (1 wt %) Iron addition. Ultimate tensile strength and elongation to fracture and Vickers hardness were all increased respectively [4].
Generally, the effect of Fe-rich phases on the mechanical properties of aluminum alloys depends on their type, size and amount in the microstructure. Manganese has been widely used

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to suppress the development of long needle-shaped Fe-rich phases and to promote the formation of compact Fe-rich phases in aluminum alloys [5, 6].
The main purpose of this project is to study the effect of adding Iron powder through recycling aluminum cans on surface morphology and hardness and tensile properties of ingot, and how we can develop mechanical properties.

Experimental work

Coatings of the old aluminum cans have been removed by burning using torch. This was done to reduce the amount of slag present in the molten metal and to avoid or minimize the oxide present in the castings. Then aluminum cans have been cut into small pieces. First melted and then iron powder has been added to the melt. An amount of powder was added and the total composition of the mixture were completely melted and degassed. The powder added was (0.25 %) and then iron powder of (53- 65 μm) has been added to the melt by (0.6, 1.2, and 1.8 % wt) in temperature (750 °C) and held for (10 min) with a controlled atmosphere. The mixture was stirred continuously in order to avoid sedimentation and to achieve a more homogeneous mixture. Finally, the mixture was poured into a tube shaped metal mold and cooled by air.

Materials

Beverage cans consist mostly of sheet body and a lid so have a different sizes but the most commonly used in Iraq is the size (330 ml), the thickness of the sheet body is about (90 μm) with a diameter of about (65 mm) and the weight of an empty aluminum can is about (15 g). The alloy of the sheet body of the cans is either (3004 H19) or (3104 H19) and the alloy of the lid is; 5182 H19). In aluminum (Al) melting and especially in re melting of scrap, oxide forms and nonmetallic impurities are common. Impurities appear in the form of liquid and solid inclusions that persist through melt solidification into the casting. Cleaning degassing (KCl-NaCl- NaF) was usually used richly in chlorides to facilitate wetting of the oxide inclusions for easier separation from the melt. Cleaning degasser is used at the start of the melting of the charge to a (0.25%) of the charge weight.

For getting good aluminum alloy strength, it was reinforced by iron powder having (53-65 μm) diameter. Iron (Fe) was tested by XRD test as shown in figure (1). Iron powder has been used after melting the charge to three different percentages of the charge weight. The mixture (vibratory) device was also used for good distribution of iron powder into the smelter aluminum (Al).

Optical Microscopic (OM)

The microstructure is also studied by an optical microscope in order to see the grains and the phases existing; this test has been done at samples preparation laboratory/ University of technology.

Scanning Electron Microscope (SEM):

A scanning electron microscope (SEM) was used to scan the samples by a high-energy beam of electrons in a raster scan pattern. This test has been done at Ministry of Science and Technology /Materials Research Center in Nano Lab by using SEM device type (VEGA3 TESCAN), the magnification applied to samples is (1.00Kx and 5.0Kx).

X-ray Diffraction (XRD):

In order to find out the phase identification of each sample, the XRD test has been conducted at Ministry of Science and Technology /Materials Research Center in XRD Lab by using, Shimadzu X-ray diffraction meter (type XRD- 6000/7000).

Hardness Test

The hardness of all alloys has been taken by using Vickers micro hardness tester type (TP μP-A, HV- 1000) which is located at the Corrosion Laboratory as shown in figure. The average of (5 reading) was taken. All hardness values were taken at a load of (1kg).

Tensile Test:

Tensile test specimens were prepared and tested in order to obtain the values of tensile property of the material according to the ASTM (E-8) at room temperature with strain rate of (mm/min) by using Universal Testing Machine type (LARYEE) mad in China with a capacity load of (50 kN).

Results and Discussion

Microstructure:

Figure (2) shows the microstructure of the recycling Aluminum cans without adding iron. Figure (3) shows the microstructure of the recycling aluminum cans with adding iron. The effects of Iron (Fe) on the microstructure are obvious. It consist of two phase, the dark phase which is Iron aluminize located at grain boundaries and a light phase which is aluminum grains.

Scanning Electron Microscopic (SEM)

Figure (4) shows the microstructure of (SEM) results of chosen lab sample with (0.6, 1.2 & 1.8% wt) additives iron powder. Since the color which may give an indication about the appearance of most phases, the light phase is aluminum manganese grains and the dark is aluminum iron grains phase. The porosity and some parallel shrinkage were caused by condition of casting which side effect of this section defect, some particles are also shown on the section for all powders.

X-Ray Diffraction Result (XRD)

Figure (5) illustrates the XRD pattern sample without adding iron powder. The strong peaks are at angles (38.6˚), (44.8˚), (65.2˚), (78.3˚) and (82.46˚). Aluminum cubic phase appears with plans (111), (200), (220), (311) and (222).

Figure (6) illustrates the XRD pattern of the sample with adding (0.6 %) iron powder. The strong peaks are at angles (38.6˚), (45.8˚), (65.16˚), (79.32˚) and (82.46˚). Aluminum cubic phase appears with plans (111), (200), (220), (311) and (222) as shown in figure. The weak peaks are at angles (41.68˚), (43.88˚) so $Al_{86}Fe_{14}$ face center cubic phase appears.

Figure (7) illustrates the XRD pattern of the sample with adding (1.2 %) iron powder. The strong peaks are at angles (38.6˚), (44.8494˚), (65.22˚). These angle shows aluminum cubic phase appears with plans (111), (200) and (220) as shown in figure (4.28). The weak peak is at angle (40.14˚) Al_3Mn phase appears. Angles (42.27˚) and (48.605) $FeMn_3$ phase appears. Angle (44.09˚) Al_5Fe_2 phase appears.

Figure (8) illustrates the XRD pattern of the sample with adding (1.8 %) iron powder. The strong peaks are at angles (38.576˚) ,(44.8599˚), (65.1955˚). Aluminum cubic phase appears with plans (111), (200) and (220).

The weak peaks are at angles (36.0796˚), (39.4343˚) Al3Mn phase appears. Angles (43.23˚) and (47.62˚) Al_5Fe_2 phase appears. Angles (42.27˚) and (48.599˚) FeMn3 phase appears.

Hardness Result

Figure (9) shows that the highest Vickers micro-hardness (92 MPa) was obtained with (1.8 %) of iron powder and the lowest micro-hardness (86 MPa) with (0.6 %) of iron powder, which indicates that with increasing iron content the hardness increased. The iron powder has a limited solubility in aluminum and thus cannot improve the strength, by solution hardening, but the strength can be improved by producing chemical compound. Increasing strength is due to formation of Al-Fe intermetallic with decreased ductility.

Tensile Test

Figure (10) shows the stress- strain curve of three samples with additives of iron powder (0.6, 1.2, &1.8 %). Mechanical properties can be obtained and the difference between the three samples is clear.

Figure (11) presents the tensile strength of samples with different amounts of iron powder.

It is clear from this figure that the maximum tensile strength is (130 MPa) with (1.2 %) Iron powder, which is higher than minimum value (110 MPa) with (0.6 %) Iron powder by (17 %).

Figure (12) shows the modulus of elasticity for the samples with different added Iron powder. As shown in the figure; the maximum modulus of elasticity obtained was for alloy (1.2 %) and then decreased with increasing iron powder added due to the increase of the hard inter-metallic phase amount in the microstructure. The additive of iron powder by (1.2 %) gives higher modulus by (38 %) than (1.8 %) additive.

Figure (13) shows the elongation to fracture for the different added Iron powder. It shows that the maximum elongation obtained was for alloy (1.2 %) and then decreased with increased iron powder added. The additive of iron powder by (1.2 %) gets higher elongation by ratio of (57 %) at (0.6%) iron powder.

CONCLUSIONS

Superior tensile properties are obviously manifested in the cast Aluminum (Al) with (1.2 wt%) Iron (Fe) addition; where tensile strength and elongation to fracture of (1.2 %) Iron (Fe) gets higher elongation by (57 %) than that of (0.6 %) additive and higher modulus of elasticity by (38 %) than that of (1.8 %) additive and tensile strength by (17%) than that of (0.6 %) Iron powder, While Vickers hardness is increased with adding Iron powder.

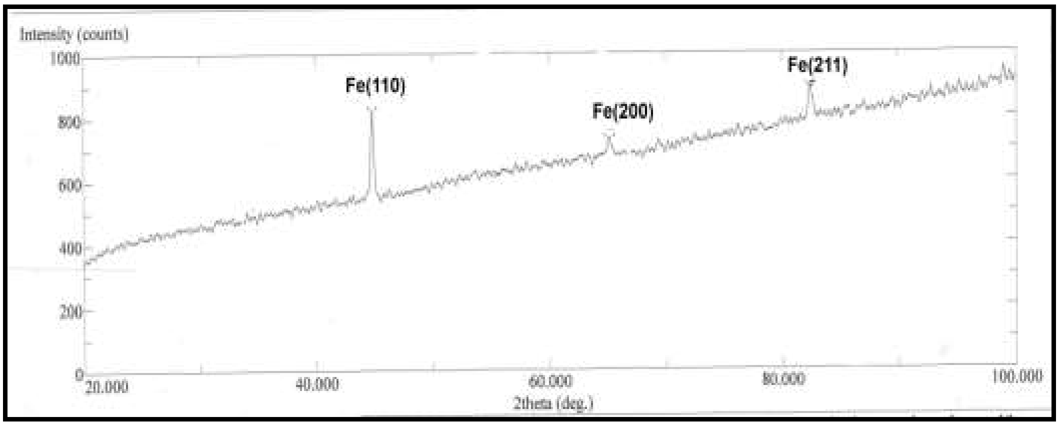


Figure (1): XRD-test for iron powder used.

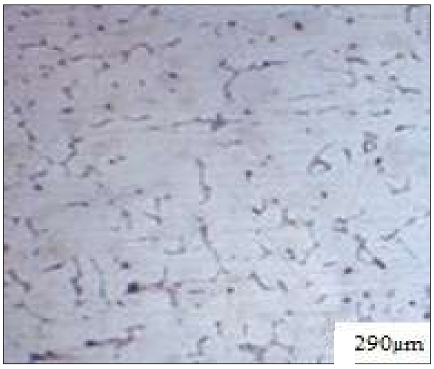
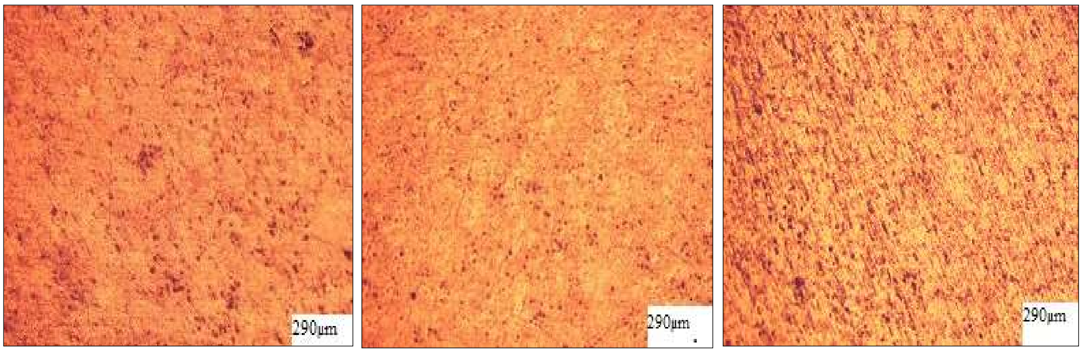
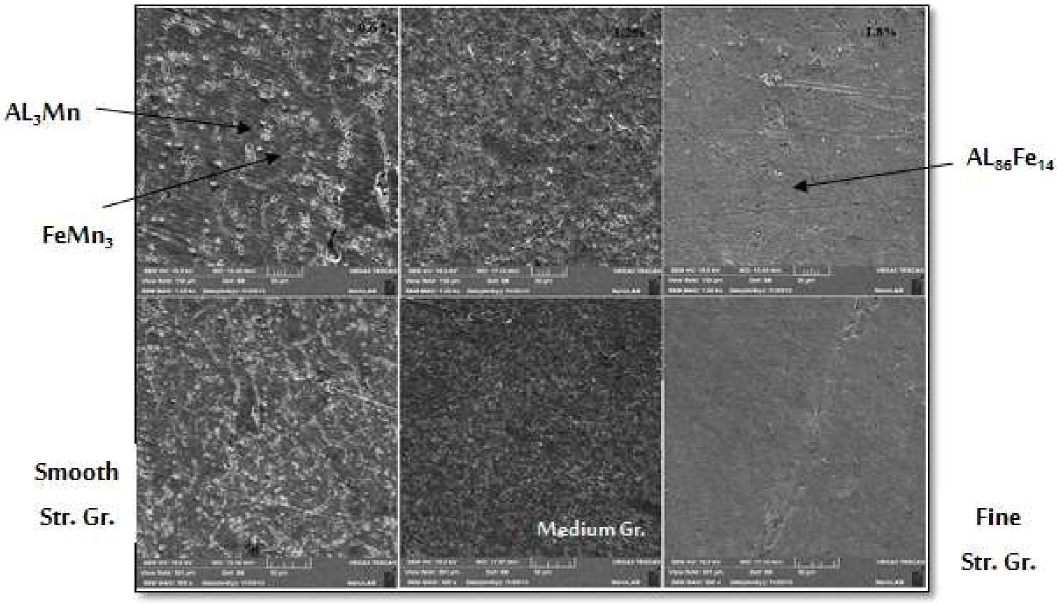


Figure (2): Microstructure of ingot recycling aluminum cans with add degassing.



(A) 0.6% (B) 1.2 % (C) 1.8 %

Figure (3): Microstructure of samples with different amount of Iron powder.



(A) 0.6% (B) 1.2 % (C) 1.8 %

Figure (4): Microstructure results (SEM) of chosen samples lab and (0.6, 1.2 &1.8% wt) add Iron powder.

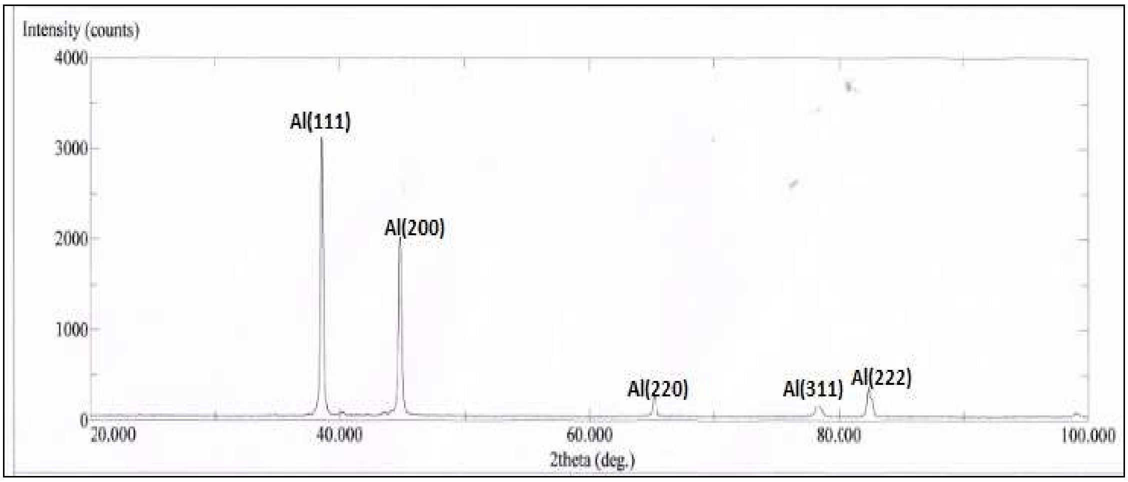


Figure (5): XRD test without adding iron powder.

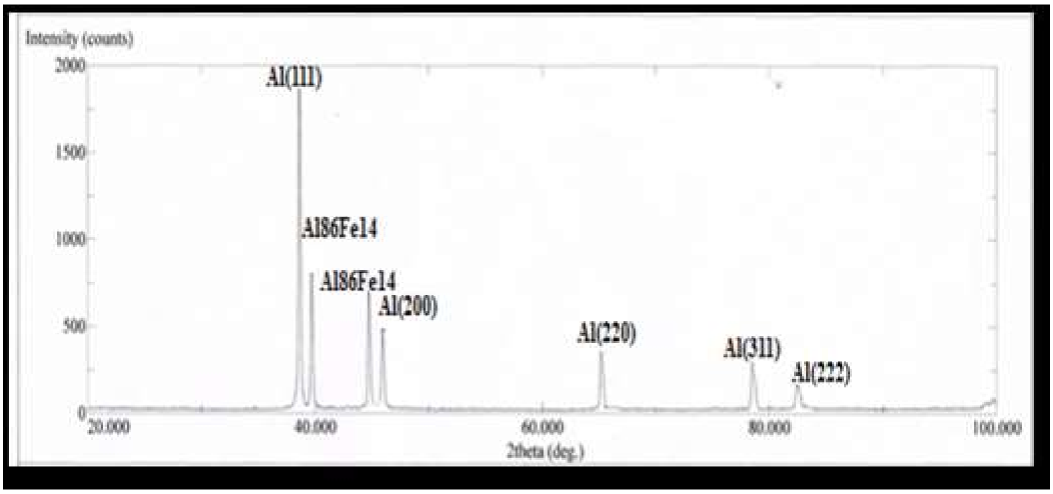


Figure (6): XRD test of sample with adding (0.6 %) iron powder.

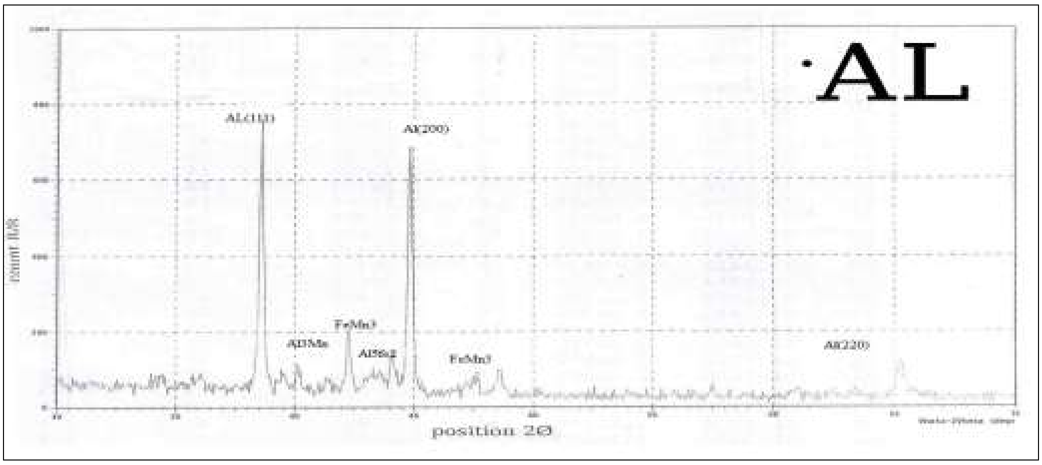


Figure (7): XRD test of sample with adding (1.2 %) iron powder.

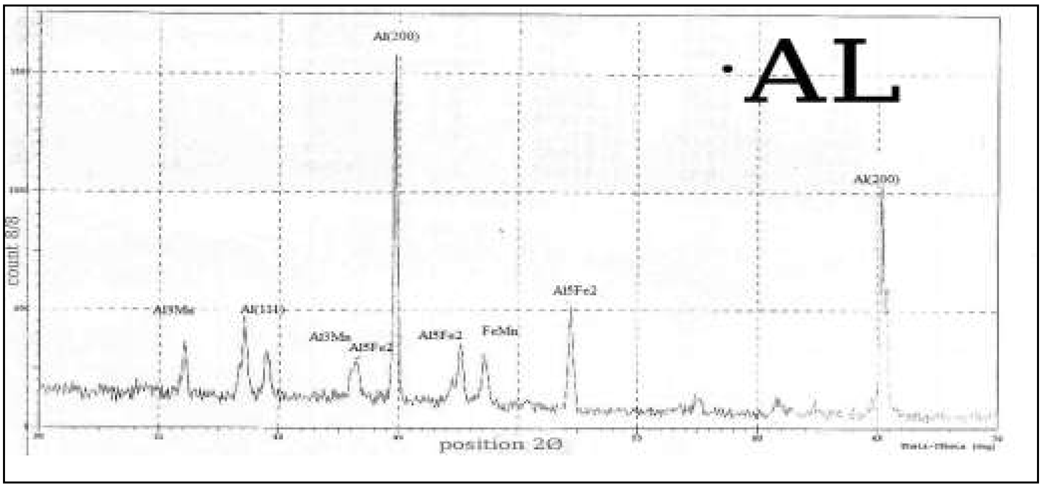


Figure (8): XRD test of sample with adding (1.8 %) iron powder.

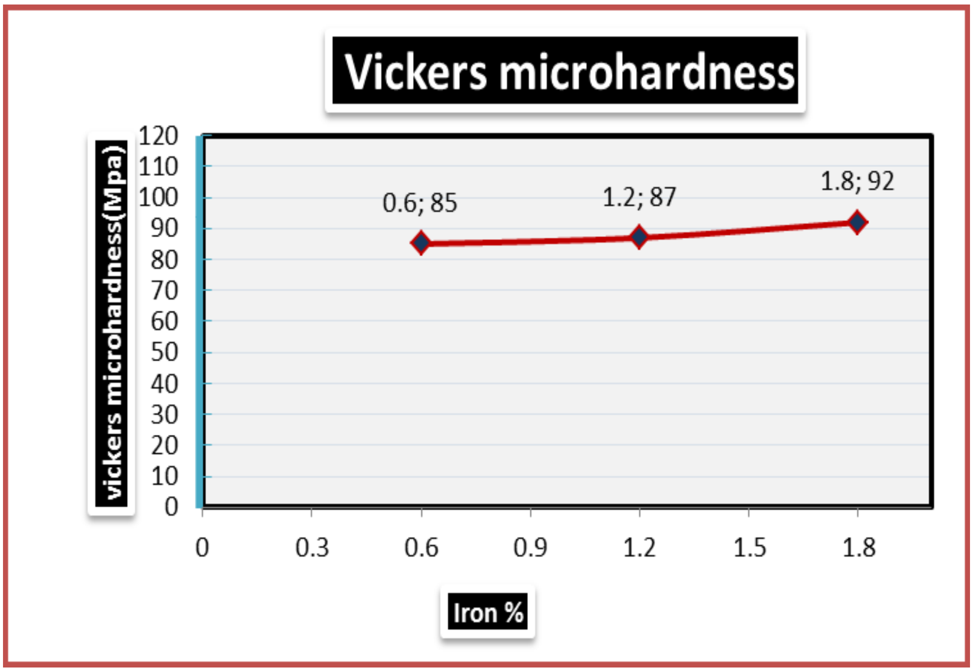


Figure (9): Micro-hardness of casting with additives of Iron (0.6, 1.2, and 1.8 %).

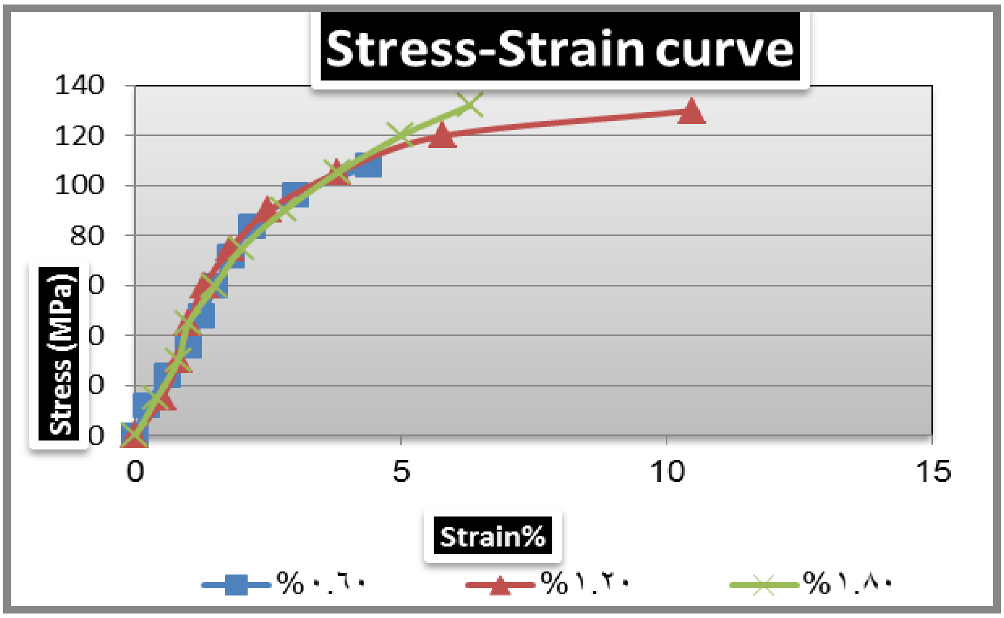


Figure (10): Stress-Strain curve of samples with different amount of Iron powder.

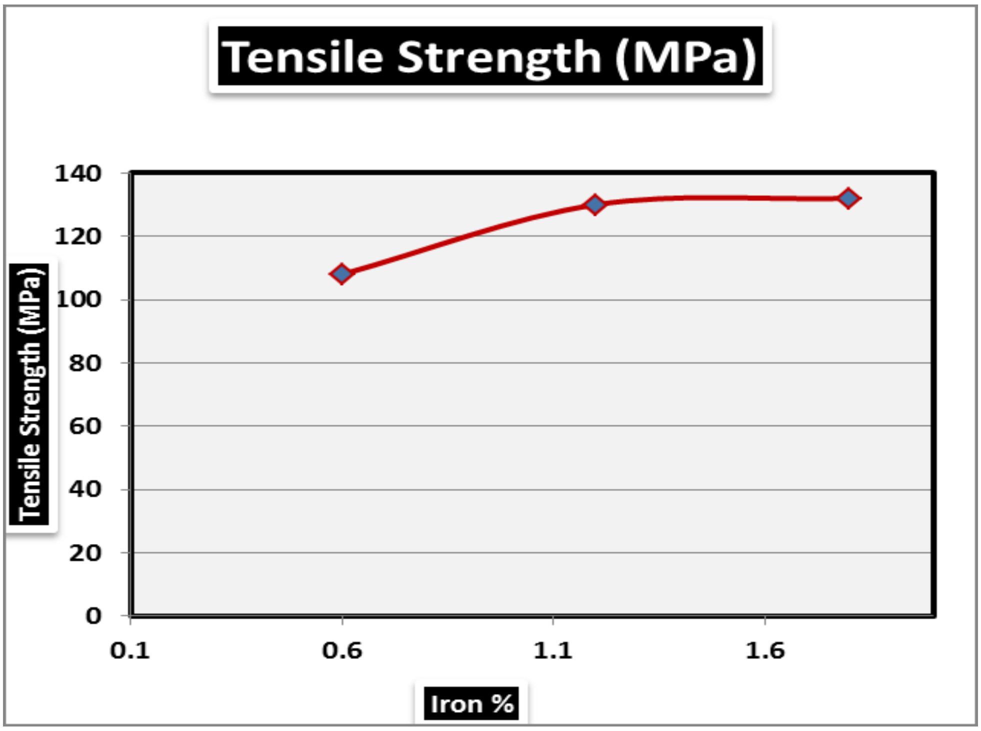


Figure (11): Tensile strength curve of samples with different amount of Iron powder.

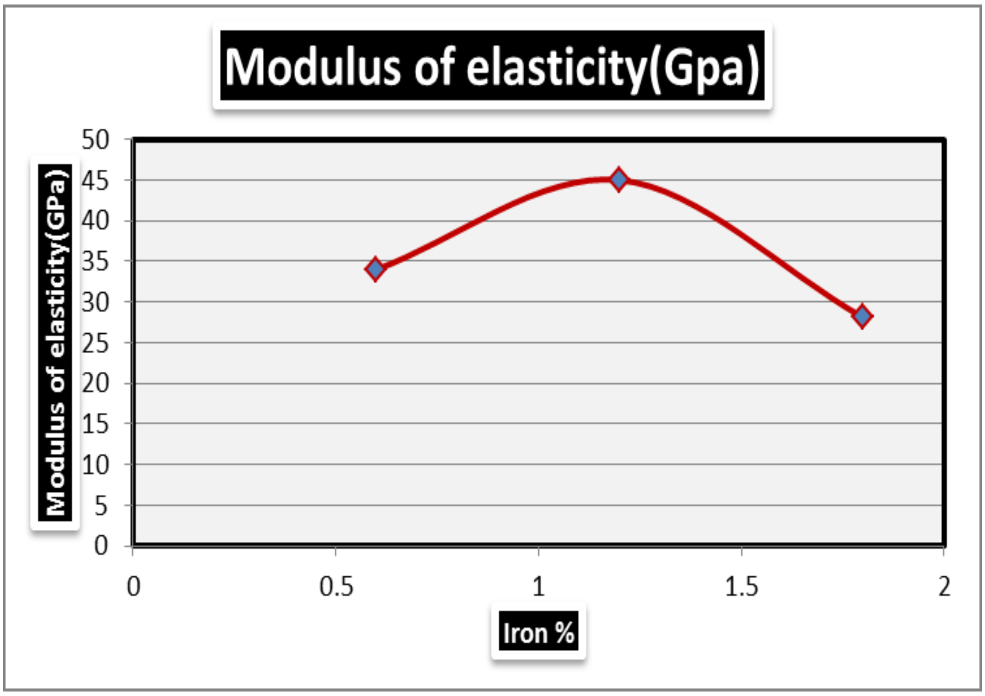


Figure (12): Modulus of elasticity curve of samples with different amount of Iron powder.

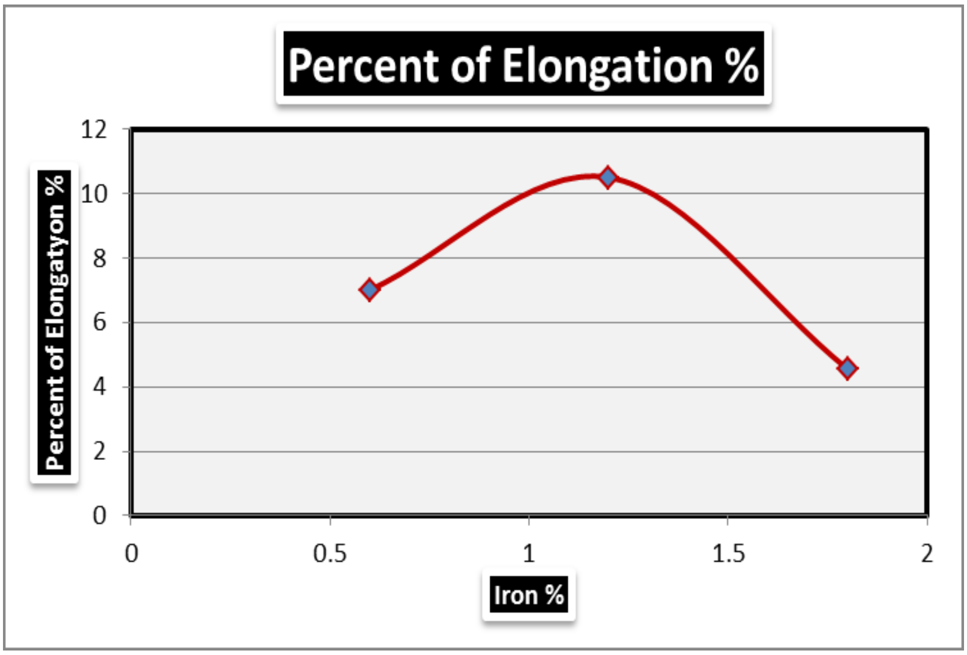


Figure (13): Percentage elongation curve of samples with different amount of Iron powder.

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