International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 11 Issue 1 ǁ January 2023 ǁ PP. 01-05

The Influence of Hot & Cold Rolling and Hot-Dip Galvanizing Process on the Mechanical Properties and Microstructure of Low Carbon Steels.

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Abstract- *This study focused on the effect of hot and cold rolling processes, and hot dip galvanizing process on the mechanical properties and microstructure of low carbon steels, produced by the Libyan Iron and Steel Company. The obtained results show, that the yield stress, tensile strength and hardness values of the cold-rolled steel are significantly increased, compared to hot rolled and hot dip galvanizing steels, while the elongation and grain size are decreased. The decrease in yield stress, tensile strength and the hardness and an increase in the elongation rate for the steel produced by hot-dip galvanizing process, contribute to the growth of the granules, which helps to increase the steel's ability to form during subsequent manufacturing processes.*
Keywords*-Hot rolling, Cold Rolling, Galvanizing Process, Mechanical Properties, Microstructures.*

Date of Submission: 22-12-2022 Date of acceptance: 03-01-2023

I. NTRODUCTION

Rolling is one of the oldest processes known for reducing the cross section of a metal sheet. Rolling done above recrystallization temperature of a material is Hot-rolling and below that temperature is Cold-rolling. low carbon steel is the most widely used steel type due to its good weldability, high strength and high ductility[1].It is well known that new microstructures might be created and new properties might be developed by heat treatment and processing of low carbon steel. Cold rolling reduces the grain size and increases the hardness of low carbon steel[1–3]. Rolling is a deformation process in which the thickness of the work is reduced by compressive forces exerted by two opposing rolls, the rolls rotate as illustrated in Fgure (1) to pull and simultaneously squeeze the work between them. Cold rolling strengthens the metal and permits a tighter tolerance on thickness. In addition, the surface of the cold rolled sheet is absent of scale and generally superior to the corresponding hot rolled product. These characteristics make cold rolled sheets, strips, and coils ideal for stampings, exterior panels, and other parts of products ranging from automobiles to appliances and office furniture[4-6]. Hot-dip galvanizing is a metallurgical process where a coating is created on the surface of a steel sheet by mutual reaction of the base material of the product and molten zinc from a bath [7].The thickness, structure, and quality of the zinc coating are strongly impacted by the composition of the molten zinc and by the condition of the steel surface [8]. Within the metallurgical reaction of iron with molten zinc, intermetallic phases of iron and zinc are gradually created (gamma, delta, zeta).The phases form layers in which the content of iron drops from the zinc–iron interface towards the surface see Figure(2), the zeta phase contains 6.0 wt.% Fe, the delta phase 10 wt.% Fe, and the gamma phase 25 wt.% Fe. During the extraction from the bath, a layer of pure Zn (eta phase) with<0.03 wt.% Fe is formed on the surface [9-11].There is a lack of studies on effect of hot ,and cold rolling and hot dip galvanizing process on mechanical properties of low carbon steels in the literature. The Thickness of the Zinc coating used in this study was 200 g/m^2.

The aim of this paper is to study the effect of hot rolling, cold-rolling, and hot-dip galvanized processes on the mechanical properties and microstructure of low carbon steel (0.13 % carbon content).

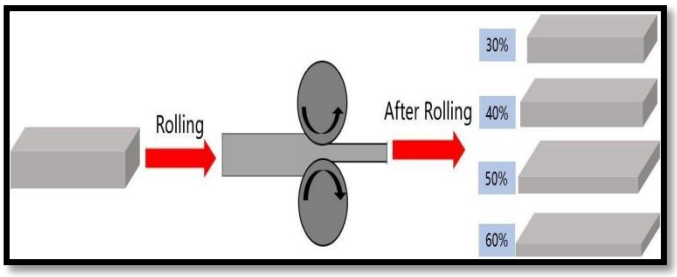


Figure 1. Schematic Diagram of Cold Rolling Process [4].

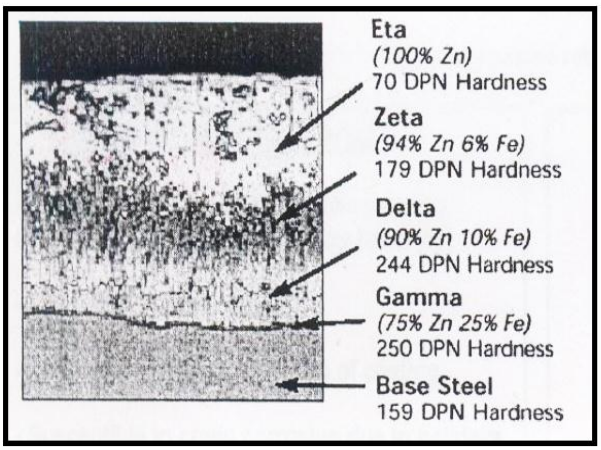


Figure 2. Structure of Galvanized Layers[9].

II. METHDOLOGY

The methodology followed for this study was**:**
The following samples with thickness 2.0 mm were taken from hot rolled sheet
1. Three samples to conduct the tensile test by using Tensile Testing Machine.
2. Three samples to conduct the hardness test by using Rockwell Testing Machine.
3. One sample to investigate the microstructure by using Optical Microscope.

The following samples with thickness 0.6 mm were taken from cold rolled sheet:
1. Three samples to conduct the tensile test by using Tensile Testing Machine.
2. Three samples to conduct the hardness test by using Rockwell Hardness Testing Machine.
3. One sample to investigate the microstructure by using Optical microscope.

The following samples with thickness 0.6 mm were taken from galvanized sheet:
1 .Three samples to conduct the tensile test by using Tensile Testing Machine.
2. Three samples to conduct the hardness test by using Rockwell Hardness Testing Machine.
3. One sample to investigate the microstructure by using Optical microscope. Figure(3) showed the tensile test sample.

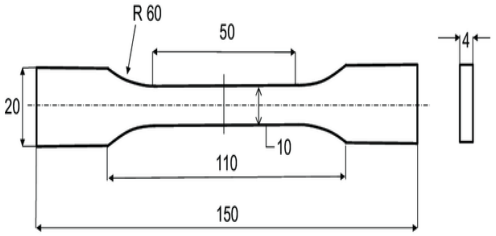


Figure 3. Tensile Test Sample.

III. PRACTICAL PART

In this part, we will define the materials, machines, and equipment's that are used, and the types of tests that have been applied in order for us to understand the effect of hot and cold forming and continuous hot dip galvanizing on the mechanical properties of low carbon steels.Table-1 shows the chemical composition of the steel alloy used for this study.

Table 1: Chemical Composition of the Steel alloy.

Element Name	Percentage (%)
C	0.13
Si	0.03
Mn	0.25
P	0.02
S	0.02

A. Tensile Test

The tensile test conducted on the samples by tensile test machine Figure (4) existing in Libyan iron and steel company Laboratory to determine the yield stress value ,tensile strength value and elongation rate.

Figure 4. Tensile Testing Machine.

B. Hardness Test

The hardness test was carried out by Rockwell method on a scale (B) and with a load of (100 kg) for samples by using Rockwell Hardness Testing Machine Figure (5) existing in Libyan iron and steel company laboratory.

Figure 5. Rockwell Hardness Testing Machine.

C. Microscopy

Microscopy of the samples was carried out with a LEICA DM 2500 Optical Microscope as shown in Figure (6), to take pictures of the crystal structure of the tested samples.

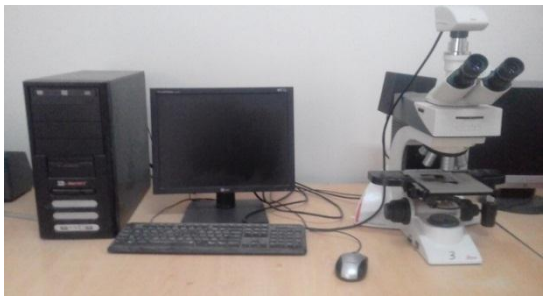
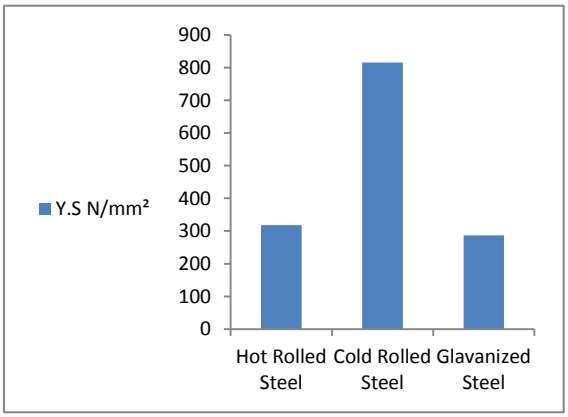


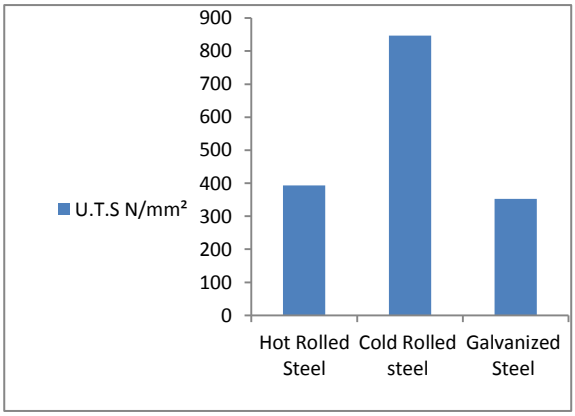
Figure 6. Optical Microscope.

IV. RESULTS AND DISCUSSIONS

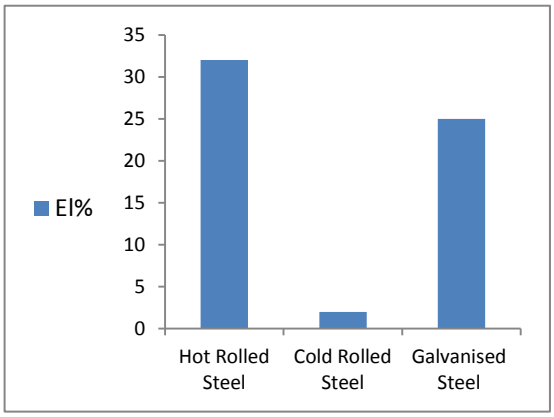
The obtained results, showed that a significant increase in the values of yield stress, tensile strength and hardness for cold-rolled samples, compared to hot rolled samples and galvanized samples, a sharp decrease in the elongation rate, this is due to the increase in the density of the dislocations and the elongation of the grains in the direction of the applied force, while for the galvanized samples there was a decrease in the yield stress, tensile strength and hardness with a drastically increase in the elongation rate. The reason for this is that the galvanized steels was subjected to heat treatment by passing it through an electric reheating furnace at a temperature of about 730 C^o ,and immersing it in the zinc bath at 450C^o Figure (7a-d) showed mechanical properties of hot and cold rolling and galvanized sample. Microstructure of hot rolled sample indicated growth of the grains. Cold rolled samples showed, that elongation of the grains and decrease in their sizes, while the microstructure of galvanized sample revealed growth of grains after relief from residual stress by heat treated in reheating furnace and dipping it in zinc bath as shown in Figure (8 a-c).



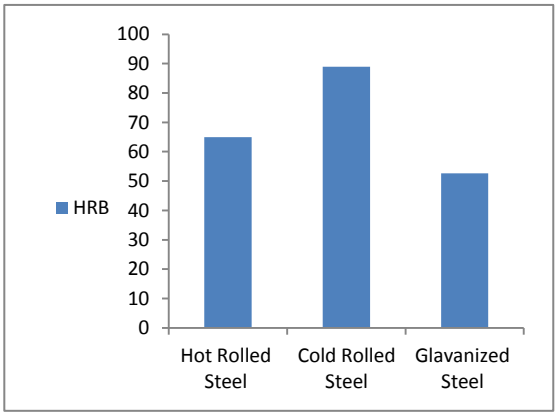
(a)



(b)



(c)



(d)

Figure 7. Showed Mechanical Properties of hot rolling ,cold rolling and Galvanized samples (a) Yield Stress (b) Ultimate tensile stress (c) Elongation (d) Rockwell hardness.

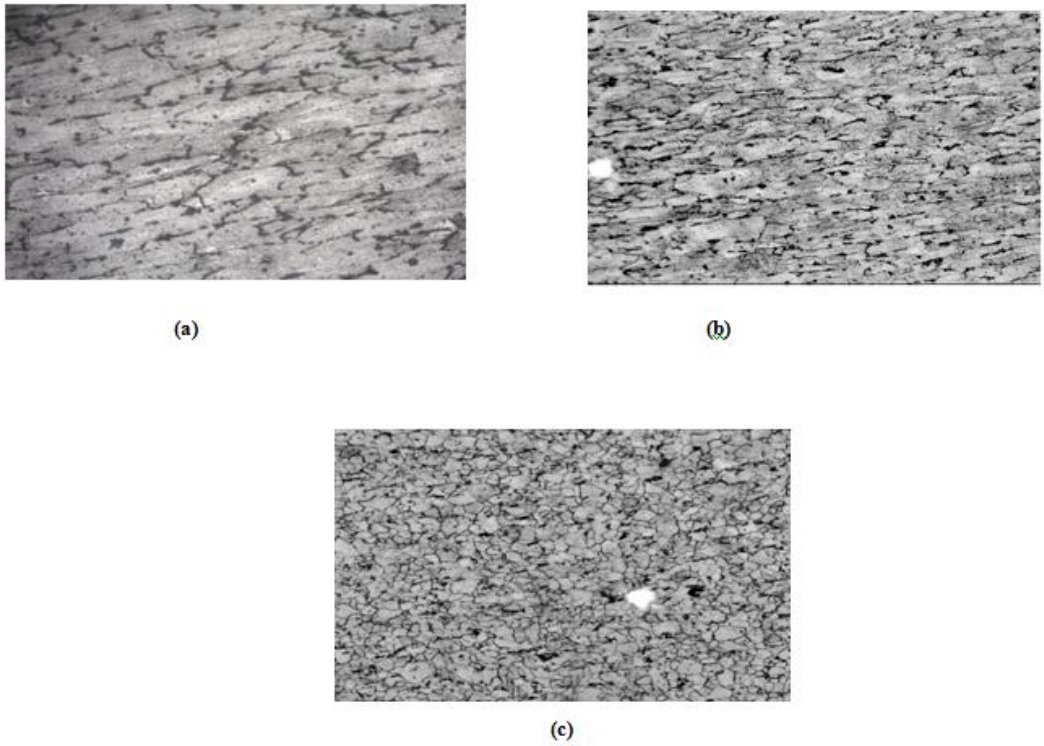


Figure 8. Microstructures of samples where, (a) is hot rolled sample ,and (b) is cold rolled sample(c)is galvanized sample.

V. CONCLUSIONS

The following conclusions have been drawn from this study:

1. Higher values of yield stress, tensile strength and hardness of cold-formed steel samples compared to their values of hot and galvanized steels.
2. Elongation ratio of cold rolled samples is much lower than that of the hot and galvanized steels.
3. The results of the microscopic examination of the cold-formed steel samples showed, the elongation of the grains and small their size as a result of the increased intensity of the dislocations.
4. The results of the microscopic examination of the galvanized steel samples showed, the large size of the grains as a result of being subjected to heat treatment.

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