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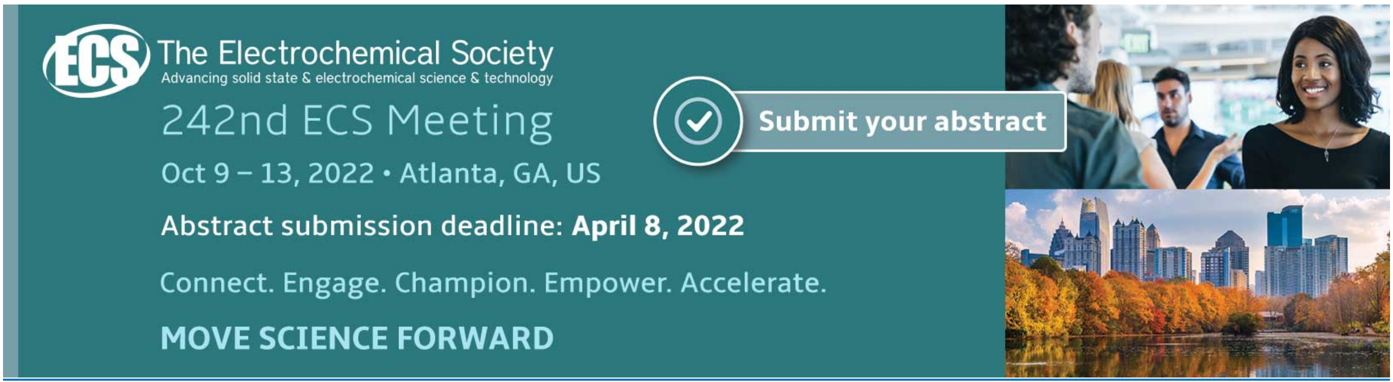

OVERVIEW IMPACTS OF HEAT TREATMENT TECHNIQUES ON GRAIN STRUCTURES OF A STEEL.

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Abstract: In this study, various techniques used in the modification of the grain structure of steel were considered. It was found that different heat treatment techniques cause changes in the grain structure of steel and subsequent improvement in the mechanical properties of the material. More so, the bimodal grain size, as well as the lamellar structure in steel, will lead to work hardening effect and improved ductility of the steel. The carburization technique also improves the mechanical properties such as hardenability, compressibility, tensile strength, and toughness. While nitriding effects will lead to excellent tribocorrosion performance. More importantly, these heat treatment techniques help to improve the resistance against cyclic load in different application environments. Thus, failures resulting from crack propagation and other failure modes are prevented. In this regard, structural failures are prevented by grain structure modification using heat techniques.

Keyword: Nano, nano-additives, grain structure, heat treatment, mild steel, industrial application

1.0 Introduction

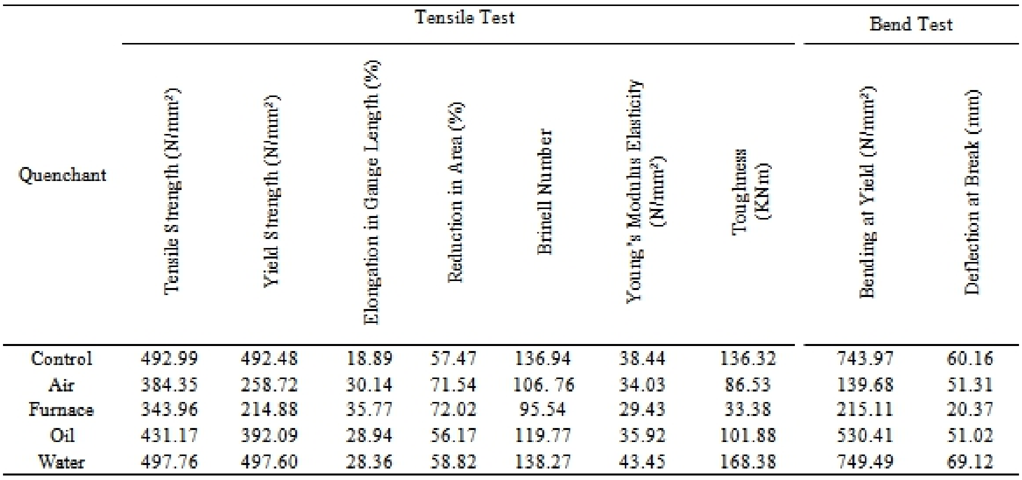
The importance of steel in terms of application and versatility cannot be overemphasized. It is presumably known that there is a smidgen of iron in every human's life. Steel has different doable bids in each area of human living. The kind of steels with unimaginable chattels are the finest amid the product. Steel is, therefore, classified into three main groups, which are low, medium, high carbon, high carbon steel subject to carbon content [1]. In recent times, there has been a significant increase in the demand for metal with certain characteristics suitable for specific purposes [2]. An example is a metal used in the construction or automotive industry where it is required to withstand particular conditions at a low manufacturing cost [3]. To meet such needs, a metal with high ductility and also soft is needed. It must also be acceptable by the usual repetition of strategy to the proportion of parts [4]. This kind of issue needs to be solved by the manufacturer, which in turn constitutes the issue of case hardening [5]. According to Sun et al. [6], an effective way of producing an improved grain structure of low carbon steel is by using rolling as well as annealing process to attain stress relieved steel, which in turn will improve the mechanical properties of the material. More so, the magnetic and corrosion resistance of steel produced using these heat treatment techniques are usually better in construction and other fabrication processes [7]. Grain refinement of ferritic stainless steel will improve the tensile and yield strength as well as excellent corrosion resistance [8]. However, grain boundary design is essential to mitigate the intergranular corrosion effect in a specific medium, and this requires higher austenitization techniques to refine the grain structure [9]. This has been one of the major factors faced by material design specialists [10]. Study has shown that, the difference in the deformation of coarse and fine grain steel structure lies in the variation of the density in their grain sizes [11]. However, the balance between strength and ductility as well as strength and toughness must be achieved in every heat treatment which requires good techniques [12-16]. According to Hu et al. [17], there seem to be significant variations in the deformation behavior of nano and ultrafine grain structure of stainless steel material [20]. This is attributed to the activation energy of the grain size. Thus, there is the possibility of reducing the loss in iron due to the reduction in the width of grain sizes as well as protecting ultrafine martensitic steel in a corrosive environment [19]. Hence, the study aimed to review the different techniques of improving the grain boundaries of steel in general, their behavior in different applications as well as the effects of altering the grain structure during heat treatment. In summing up, the study will inform material specialist on the need for changing the grain structure of steel to suit different application environment [20].

2.0 Heat Treatment Steel

Heat treatment is utilized to enhance the mechanical properties of the metal combinations. Essentially, the item execution will be enhanced when the quality of material expands [21]. It can be broken into three fundamental procedures in particular, annealing, quenching and tampering. With everything taken into account, the technique for heat treatment procedure contains three stages [22]. Regardless starting with heating the material, hold the temperature for a time period and, chill off the metal to room temperature [23]. The treatment of medium carbon steel with heat can by and large changes the mechanical properties, for instance, adaptability, hardness and quality [24]. Heat treatment of steel imperceptibly impacts various properties, for instance, its ability to direct heat and power moreover. A grouping of systems exists for treating steel with heat. The carbon and manganese content in medium carbon steel make quenching and solidifying the most generally perceived system for heat treatment for this sort of steel [25]. This methodology generally incorporates more than once heating the steel to under 723°C, and cooling it rapidly by smothering it in a liquid, for instance, oil or water. The temperature and time of this method empowers the maker to conclusively control the last properties of the steel [26-30].

Strengthening is an extremely expansive term used to portray an assortment of heated medicines, yet it is a procedure generally connected to expel stresses or work solidifying [31]. With the end goal of the heat treatment utilized on carbon steels in the material determinations, the more particular term full tempering better depicts the procedure. Full strengthening is characterized as "tempering a steel question by austenitizing it and after that cooling it gradually through the change extend [32]. The outcome is that the most extreme change to ferrite and to coarse pearlite is accomplished, which compares to the least hardness and quality [33]. Normalizing is a particular term characterized as "heating a steel protest a reasonable temperature over the change range and afterward cooling it in air to a temperature significantly underneath the change go" [34]. For huge numbers of the carbon steels talked about in this report, the cooling rate in air is not sufficiently fast to keep critical change from austenite into ferrite and a pearlite microstructure. Higher amalgam, air-hardenable materials can be altogether solidified by normalizing. The normalizing temperature is commonly 55ºC over the upper basic temperature [35]. The table below showed the heat treatment effects on mechanical properties of mild steel.

Table 1. Heat treatment effects on mechanical properties of mild steel [36]



	Tensile Test							Bend Test	
Quenchant	Tensile Strength (N/mm²)	Yield Strength (N/mm²)	Elongation in Gauge Length (%)	Reduction in Area (%)	Brinell Number	Young's Modulus Elasticity (N/mm²)	Toughness (KNm)	Bending at Yield (N/mm²)	Deflection at Break (mm)
Control	492.99	492.48	18.89	57.47	136.94	38.44	136.32	743.97	60.16
Air	384.35	258.72	30.14	71.54	106. 76	34.03	86.53	139.68	51.31
Furnace	343.96	214.88	35.77	72.02	95.54	29.43	33.38	215.11	20.37
Oil	431.17	392.09	28.94	56.17	119.77	35.92	101.88	530.41	51.02
Water	497.76	497.60	28.36	58.82	138.27	43.45	168.38	749.49	69.12

2.1 Effects of Carburization of Steel

The term called carburization uses heat treatment process to make the surface of the steel dense to decline, at the same time sustaining its useful properties. This application is common in steels with low carbon contents in the process of machining, and additionally increased composite steel distinctive portions, gears and bearings [36]. Carburizing constructs superiority and wear assurance by disseminating carbon into the surface of the steel putting forth a defense while holding a liberally lesser hardness in the inside. This treatment is associated with low carbon steels in the wake of machining. Strong and solid-surface parts of mind boggling and complex shapes can be made of tolerably cut down cost materials that are quickly machined or surrounded before heat treatment [37]. The degree of carburizing is determinants of holding time to holding temperature; the carburizing state is brought into the radiator for the normal time to ensure the correct significance of event. The amount of carbon in the gas can be lowered to permit scattering, keeping up a key separation from excess carbon in the surface layer [38]. Coming about to carburizing, the work is either immediate cooled for later cover solidifying, or splashed especially into oil. Drench affirmation is made to accomplish the ideal properties with excellent dimensions of dimensional change. Hot oil smothering might be utilized for insignificant curving, yet might be obliged in application by the quality necessities for the thing. Obviously, bearing races might be press extinguished to keep up their dimensional qualities, limiting the essential for over the top post warm treatment beating [39-40]. So often, the material is tempered, by then cryogenically took care of to change over held austenite to martensite, and after that retempered. Carburizing is usually utilized for an extended time. Regardless, the carburizing methodology has created with movements in heat treatment processing frameworks that have enhanced the rigidity and solidness of things like carbon steel wire springs and carbon steel forgings. Carburizing is fundamentally the development of carbon at the surface of low carbon steels at fitting temperatures [41].

This is mostly encountered in which high carbon constituents are used, recalling the goal is to obtain increased solidity [42]. To counter this natural state, the process of case hardening has been arranged for steels. The point in cooling from the austenitizing temperature is to deliver a hard martensitic microstructure in the carbon-enhanced zone at the surface [43]. Most case-solidifying steels should be extinguished in oil, water, or liquid salts at low temperatures keeping in mind the end goal to limit or suppress the change of austenite for the situation to unattractively delicate microstructures which happen at intermediate temperatures [44]. The subsequent martensitic case is severe, having hardness above Rockwell C 60 and generally about Peng [45]. The low-carbon center stays at a lower hardness level following to extinguishing, and along these lines retains high protection from effect. Albeit some alleviation of inward worry of the case can be affected by heating at a temperature below 200 °C, e.g., in the range 120 -180° C., the fragility of the hard, high-carbon, martensitic case endures unless it is tempered by heating to temperatures well in an overabundance of 200 °C. Such hardening, be that as it may, even in the scope of 200 - 250 °C has the unwanted impact of causing checked loss of hardness, and decreasing any ideal compressive anxieties [47]. In this manner, such treating medications are of exceptionally restricted esteem [48]. The hardness and rigidity of the low-carbon center are. Again, far less influenced by tempering and low-carbon steels with great profundity solidifying attributes can be tempered at 350 °C.

Or, on the other hand, even 400 °C without weakness of these properties. Steels with relatively lower profundity solidifying attributes can be tempered at temperatures as high as 500 °C before there is lost quality and hardness more prominent than approximately 10 % [49-51]. It has now been found that by changing the austenite in the center of a carburized material or part and treating the change item before changing the case to martensite, there is the possibility of the part having a case that is center equipped for performing elastically under high pressure however, which holds the hardness what is more, wear protection..

3.0 Effects of Nitriding in Steel.

The nitriding procedure, which includes the presentation of nuclear nitrogen (N) into the surface of a part, has been a generally adaptable and what's more is the strong technique for surface treatment of (typically) press base materials for a long time. The appearance of nitriding as a specialized procedure in the mid twentieth century was crafted by Haruman et al. [52].

In the course of time, an extraordinary number of process variations have been presented. One important advancement is the procedure of nitro-carburizing, whereby carbon is presented at the same time with nitrogen. In perspective of the experience of one century of nitriding, incredibly has just rather not entirely been gotten. Diverse techniques exist for presenting nuclear nitrogen, or both nuclear nitrogen and nuclear carbon, into the surface of steel [52-55]. A dispersion zone (of thickness, say, up to a few 100 mm), where, on account of unadulterated iron or carbon steel, in the wake of nitriding, upon either gradually cooling or after maturing consequent to extinguishing. [56]. The nitrogen broke down at the nitriding temperature hastens as iron nitrides in the dissemination zone, or then again, on account of steel containing alloying components with proclivity for nitrogen, as aluminum what is more, chromium, alloying component nitrides hasten amid nitriding [57]. The innovative significance of nitriding is gotten from the articulated increment of the protections against exhaustion, wear, and consumption, which can be accomplished by tuned utilizations of the nitriding procedure. The articulated property change is, generally, because of the high hardness, the inner anxieties, and the adjusted science in the nitride zone [58]. In general, positive wear and erosion properties can be because of particular compound layers and that great weakness and furthermore wear properties (in the event that the compound layer has been evacuated after nitriding or its development has been maintained a strategic distance from) can be attributed to the dissemination zone [59]. Nitro-carburizing forms, when contrasted with nitriding forms, to a great extent impact the piece what's more, constitution of the compound layer what's more, therefore can be pertinent for wear (and erosion) properties. To comprehend what is going on amid nitriding/ nitro carburizing and to have the capacity to upgrade the process in perspective of wanted properties [60], it is basic to comprehend the thermodynamics and energy of the procedure. Such essential comprehension is less regular than one may expect [61]. It is quite amazing that compounds that have high stiffness mostly tend too vulnerable to quick break if stress is applied, and along these lines a fragment finished through from such a blend would not perform properly under effect or various sorts of directly linked tensions but through carburization [62].

4.0 Conclusion

The abundance of steel in nature and the ability to manipulate the properties of steel has made it suitable for use in several industries. In this review, it is observed that case hardening of metals is an effective method of increasing ductility and yield strength; this ensures the metal is wear-resistant and also resist fatigue. It was observed that grain refinement strength could be improved upon by good structuring in the layers. More so, the bimodal grain size as well as the lamellar structure in steel will lead to work hardening effect and improved ductility of the steel. The carburization technique also improves the mechanical properties such as hardenability, compressibility, tensile strength and toughness. While nitriding effects will lead to excellent tribocorrosion performance. Thus, this study helps in informing the material design specialist on the best way of improving different steel materials.

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