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A Review on Effect of Heat Treatment Process on Micrograin Structure of Steel

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ABSTRACT: *This paper discusses the effect of heat treatment process on micro grain structure of steel in different electrical furnaces at different temperature levels and varying the holding time and heat treatment mediums. This study shows the effect of heat treatment process (annealing, normalizing, hardening, and tempering) on micrograin structure of steel. By heat treating the steel the material properties like ductility, toughness, hardness, tensile strength can easily be changed which would suit our design. This study summaries the alteration of mechanical property of steel undergoing various heat treatment process in comparison to untreated samples.*

KEYWORDS: *Annealing, Normalizing, Quenching, Tempering, Hardness, Dual phase steel,first wall materials, Austenite, Marten site, Strain hardening parameter, Ductility, Precipitation hardening*

I. INTRODUCTION:

Today in this modern era high mechanical properties can be easily achieved by heat treatment process. The medium carbon steel has high fatigue strength, has high yield strength and high proportional limit. There is various heat treatment processes out of which Annealing, Hardening, Normalizing, Tempering are the most suited one for improving the microstructure of the engineering material such as steel. In normalizing process the material is heated to austenitic temperature range and then air cooling is done.In hardening process the steel is heated to such a temperature that it can support the formation of austenite ,and it is held in temperature up to carbon has dissolved or quenched in water or oil. Steel is the alloy of iron which has carbon % around 0.15-1.5% [1] plain carbon are those which has % around 0.1-0.25 [2].The main two reason that steel is so used because:

[1] There is large amount of Feco3 inside the earth crust and little amount of energy is require to convert it to Fe.
[2] The great variety of microstructure can be exhibits by it and it has wide range of mechanical properties.

The application of this steel is that it is used in trains, railroad, beams of building support structure reinforcing rods in concrete, construction of ship, tubes for boiler in power generating plants, car radiator, oil and gas lines.

II. PROPOSED METHODOLOGY:

T.Senthilkumar and T.K. Abiboye proposed a research paper on effect of heat treatment processes on mechanical property of low grade steel [3]. In this the author had taken a specimen The specimens were then prepared for a tensile test using a standard format of ASTM [4] and alternatively different heat treatment processes were applied the method of analysis are:

- The tensile specimen should have 0.30% carbon steel.
- Then heat treatment process is done on it.
- Tensile testing of carbon steel is done to analyze itsproperties after heat treatment done on it

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The heat treatment process is done are as follows:

[1] Hardening process: in this process the specimen is heated in furnace upto the temperature 850̊ C after this they were poured to different water container for rapid cooling to room temperature.

[2] Tempering process: in this process the hardened steel is heated to 350̊ C by this process macrostructure modification is there by this hardness is improved and ductility is increased.

[3] Annealing process: full annealing is carried out in material by heating it to 870̊ C. and the tested surface is put at this temperature for around 1 hour. The grain structures are now coarse pearlite.

[4] Normalizing process: each sample is now placed in furnace and heated upto 850° C and the sample were cooled for two hours for full transformation to austenite.

The results were: The heat treatment specimen ere then subjected for tensile testing under universal testing machine. And the results were shown in graphical form for annealed, normalized tempered and hardened specimens. The value of ultimate tensile strength were in order of hardened was first one then tempered then normalized and the last one was annealed. This was refined after primary phase when subsequent cooling is done. The higher the toughness of the material the material has lower curve in stress curve in the plastic region, there is lower in strain hardening parameter when the strain hardening parameter increases and the stress of the material also increases. And the conclusion after the result obtained is that the mechanical properties depend largely upon the various forms of heat treatment process done and also on the cooling rate. Hence depending upon the application they may be used for any design procedure but suitable amount of process should be adopted.For getting the properties like high ductility and minimum toughness annealing would give the satisfactory results and the final result are shown on graph:

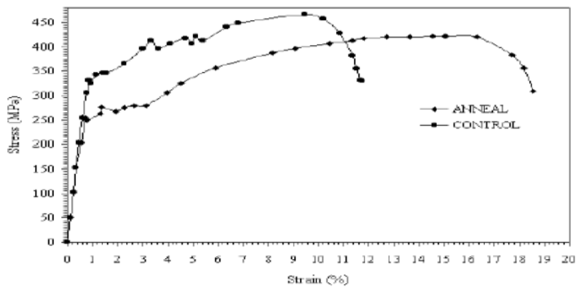

Fig. 1: Stress versus curve for annealed and control specimen

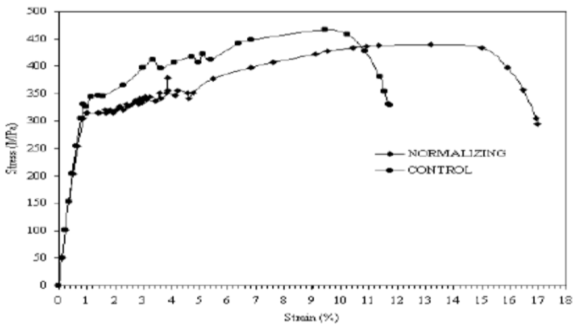

Fig. 2: Stress verses strain curve for normalized and controlled specimen

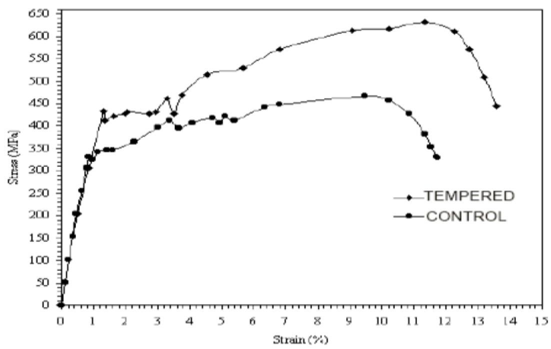

Fig. 3: Stress versus strain curve for tempered and control specimen.

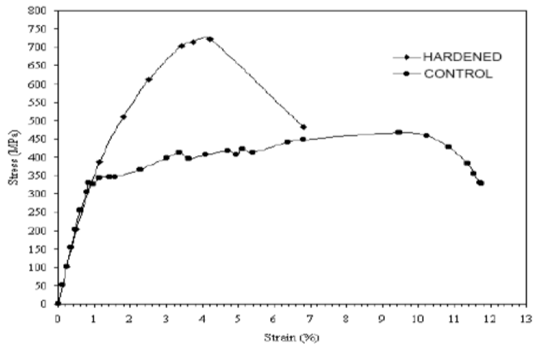

Fig.4: Stress and strain curve for hardned and control specimen

S.K. AKAY, M. YAZICI, A. AVINC Proposed [5] research paper on effect of heat treatment processes on mechanical property of low grade steel. In this he proposed that new classes of the HSLA (high-strength low alloy steels) known as DPS (dual phase steels) are developed to improve safety standards and fuel economy. Dual phase steel microstructures can be produced by annealing steel in the region of equilibrium phase diagram. The steel microstructures have a ferrite matrix along with particle of marten site. The physical properties are depending upon morphology of two phases. This can be determined by changing the annealing temperature with timethe annealing procedure quenching medium and alloying element. In this the author has discussed about of heat treatment followed by quenching on the physical properties of Fe 0.055% C steels. The experimental procedure was the specimen used in this is 2.5mm thick and the chemical composition is specified firstly it was normalized at 910°C hold for 45 minute and then air cooling is done.

In this process the received specimen has been annealed at 940°C in the region of austenite and it is hold for 45 minutes and then water quenching is done to form a whole marten site phase. Now these specimen is heated at the temperature of 780°C, 825°C and 870°C for around 1 hour and water quenched is done to produce is done as shown in diagram:

Table1: Chemical composition of specimen

The chemical composition of a studied material (wt. %). C	Mn	Si	P	Al	Fe
0.055	0.272	0.016	0.005	0.034	Balance

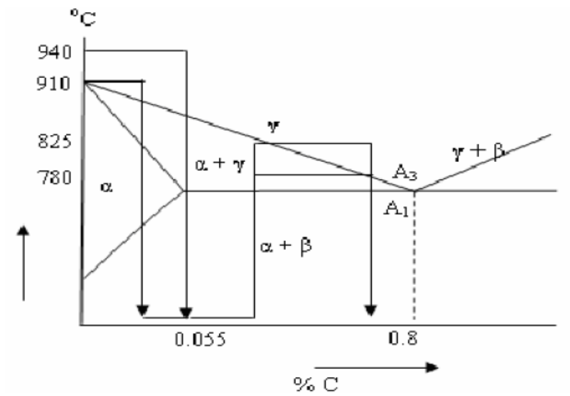

Fig. 5: Schematic heat treatment diagram: As received and intermediate quenching process α Ferrite, β: Cementite, γ: Austenite

The result of this experimental procedure shown by optical metallurgy is that the dual phase steel microstructures are made of marten site (light area) distributed in ferrite in (dark area) as shown in figure 6. The ferrite phases do not have any structure change after quenching from austenite + ferrite region. As the temperature increases the volume fraction of marten site increases.The same result was seen by Bayrametal [6].And the final conclusion from this was when intermediate annealing of low carbon steel is done then ferrite plus marten site structure grain structure is formed. As the intermediate temperature time increases the volume fraction of marten site increases. When XRD analysis is done it shows that as compared to α′ marten site there were large amount of γ- retained austenite forms in dual phase microstructure.

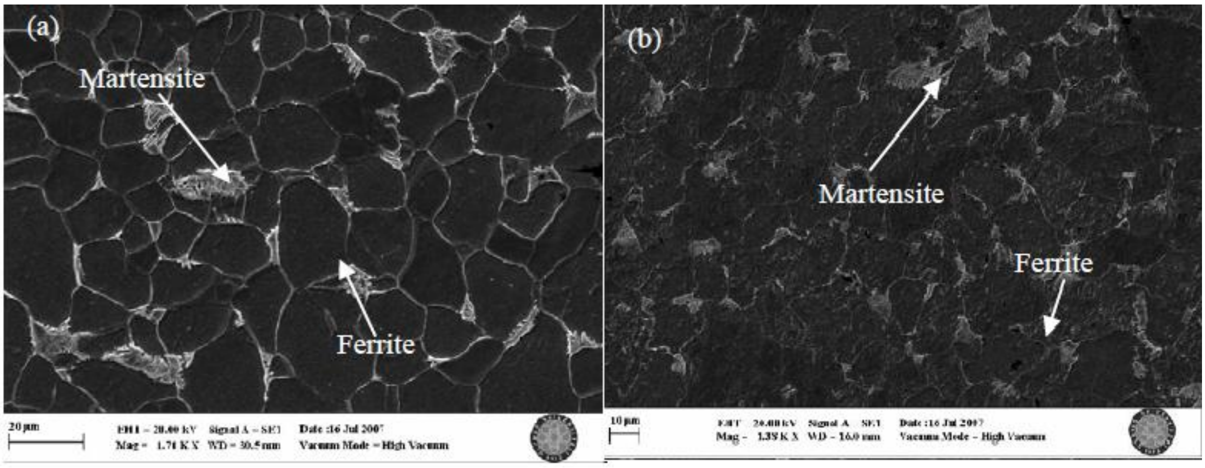

Fig. 6: Optical micrograph of (a) DPS-780˚C (b) DPS -825˚C

B.S. Motagi, Ramesh Bhosle proposed a research paper on effect of heat treatment processes on mechanical property of medium carbon steel [7].Steel specimen was allowed to heat treatment processes alternately as: 1.Annealing, 2.oil quenching, and 3.tempering at different temperature as200℃, 400℃ and 600℃ for around 1hr. Now steel specimens were mechanically testing as tensile, ductility and hardness. So, all the variation in the mechanical properties as shown in figure7. So, the mechanical testing was perform at room temperature and conclusion is that: on increasing the tempering temperature, the hardness of the steel is decreasing shown in fig.7.On increasing the tempering temperature, the ultimate tensile strength of both the grades i.e. with copper and without copper. But steel with copper has high ultimate strength as compared to without copper. Also, on increasing the tempering temperature, the ductility of the steel is increased. But steel with copper has low ductility as compared to without copper.

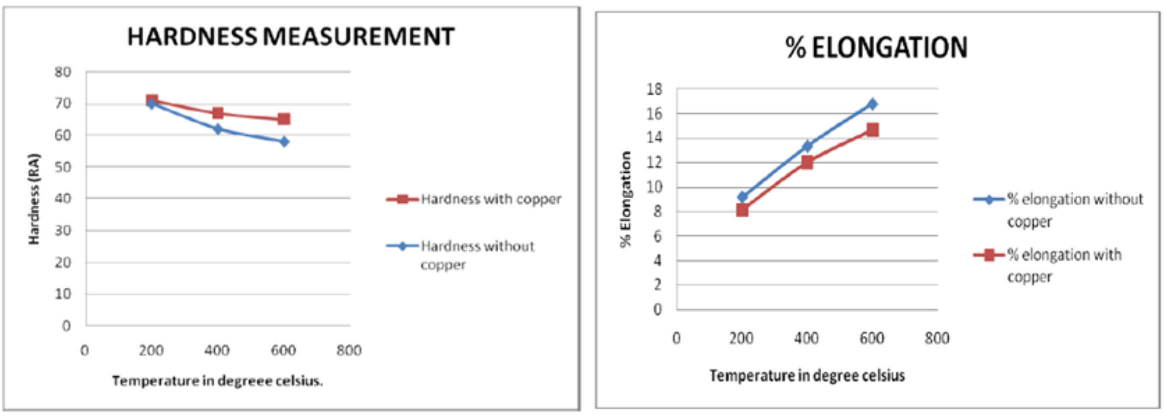

Fig. 7: Hardness and Elongation measurement

Eiichi Wakail, Shingo Matsukawal, ShiroJitsukawa [8] In this study, effect of doped boron and nitrogen radiation on F82H steel occurred mainly at irradiation temperatures lowerthan about 400 ℃and it increased with decreasing irradiationtemperature up to about 250℃The issue of helium accumulationon mechanical properties has been an ongoing concern. The first purpose of this study is focused to evaluate quantitatively the contribution of helium production on hardening fracture behavior in irradiated at 300℃foreffect of helium. .When the 60mass ppm boron or both of 60 mass ppm boron and 200 mass ppm nitrogen was determined, and the F82H doped withboron and nitrogen had an excellent mechanical [9]. The second purpose of the present study is to examine the effect of specimen size on tensile properties and doped with boron and nitrogen.In order to produce helium atoms the materials were doped with Boron. Thepurity of isotope elements of 10B and 11B used in this studywhen the neutron irradiation, tensile testing was carried out in a hot cell of hot laboratory. After the tests, the fracture surface was observed by a scanning electron microscope (SEM). The concentrations of helium in the specimens after the irradiations were measured by using a mass analyzer of magnetic flections type. The effect of specimen size on mechanical properties was examined for a doped with about 60 mass ppm B and200 mass ppm N and the result were as the tensile testing was donethe increments of yield stress, and ultimate tensilestrength, due to irradiation shown in figure 8 and the fracture stress was reduced by a high amount of heliumproduction shown in figure 9. So, final idea from the radiation hardening due to helium production was detected at 330 mass ppm He. The measured reduction area decreased with helium production in steels tested at room temperature. So by evaluated helium product from the fracture strength and the reduction in area causes the degradation of fracture stress. The stress and elongations obtained by using different size specimens were very similar to each other. The ductile brittle transmission temperature measured in smaller size specimen was 95°C and it was lower than that 83°C, in the standard specimen.

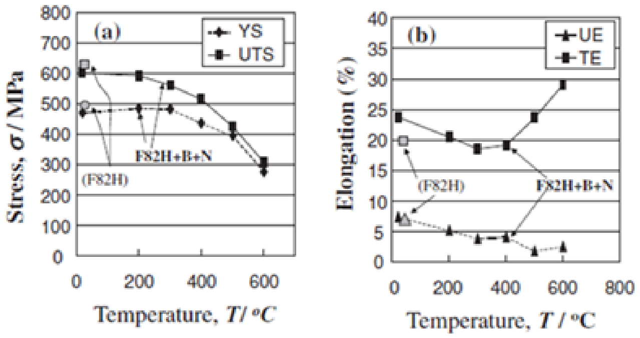

Fig. 8, 9: Tensile properties of F82H+60ppm+200ppm N steel

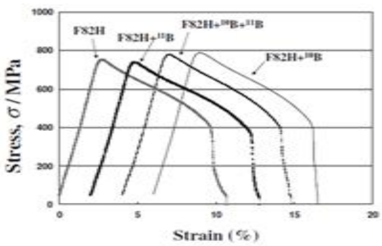

Fig. 10: Tensile curves

Kai LIU, Yiyin SHAN, Zhiyong YAN, JianxiongLIANG, LunLU and Ke YANG [10]. In this the author has shown the on the prior grain size and mechanical properties of maraging steel was done. Precipitation hardening maraging stainless steel (PHS) is a special class of ultrahigh strength and good toughness martensite steel, which is also stainless i.e.containing more than 11% Cr. these steels are suitable for many marine and petrochemical applications, particularly where chlorides are present subzero temperature.PHS is aged at 400 to 600° C for suitable hours to form the fine precipitates, such as Ni3Mo, Fe2Mo, andR phase, in the martensite matrix, which enables PHS to reach its highest strength level and also keep good toughness ST plays a very important role on the subsequent heat treatment, micro structure and mechanical properties, which have been investigated. So far, concerning the exact nature, its influence is still unclear to some extent, although different conclusions have been drawn for different maraging steels. Condition For high Cr (>13%) containing maraging steel, there were only few reports about the effect of ST on its mechanical properties, and typically ST at 1000°C

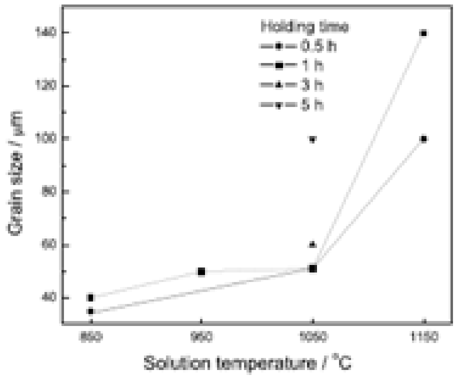

Fig. 11: Effect of solution treatment (ST) and holding time on PAG size on tested steel.

the result were as theGrain growth increasing holding time results in an increase in size of the tested steel Generally, for 18Ni maraging steel, He et al:[11] and Corn and Wazzan [12] proved that with increasing ST temperature, the PAG size increases sharply and on the tensile properties mechanical properties of the tested steel after holding at various temperatures for 1h shown in figure 12 and 13. It has be seen that the slightly decreased from 1206 MPa of ST at 850C to 1132 MPa of ST at 1150C. The conclusion of this paper was as optimum heat treatment for the tested maraging stainless steel is at 1050°C for 1 h at 70°C for 8h at 535C for 4 h. By this treatment, the yield stressof the steel could reach1774 MPa and 1932 MPa. In the holding temperature range of 850C to 1150C increasing holding time could result slight increase in prior austenite grain size untilST at 1050°C for 1 h. so after study, the abnormal grain structure growth was seen at1050°C for 3hr.

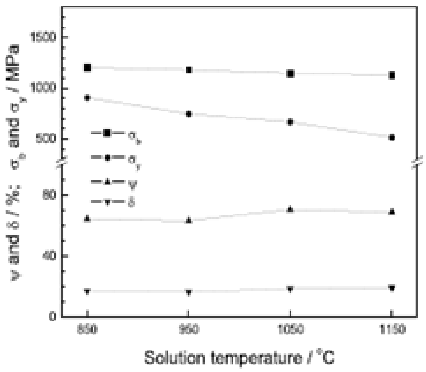

Fig. 12: Effect of ST temperature on tensile properties of tested steel in ST condition.

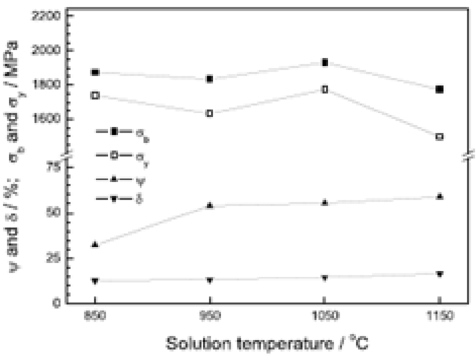

Fig. 13: Effect of ST temperature on tensile properties after ST+CT+AT at 535°C for 4 h.

III. CONCLUSION:

On increasing the tempering temperature, the hardness of the medium carbon steel with copper is high as compared to the steel without copper. On increasing tempering temperature, the ductility of both the steel grade is increasing. The steel with copper has low ductility as compared to steel without copper. The optimum heat treatment for the tested maraging stainless steel is at 1050°C for 1 h at 70°C for 8h at 535°C for 4 h. By this treatment, the yield stress of the steel could reach1774 MPa and 1932 MPa. In the holding temperature range of 850 to 1150°C, increasing holding time could result in slight increase in prior austenite grain size until at1050°C for 1 h. Whereas, abnormal grain growth was seen at1050°C for 3 h or longer holding time .The ductile brittle transition temperature measured in smaller size specimen was 95°C and it was lower than the 83°C in the standard specimen. The radiation hardening due to helium production in was detected at 330 ppm He. The measured reduction area decreased with helium production in steels tested at room temperature. Yielding of low carbon steel with a ferrite + martensite grains by the process of annealing.With the increase in temperature-time, the volume fraction of martensite is also increased. By the XRD analysis, there was a large amount of gamma-retained austenite forms compared to that of alpha-martensite.

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