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# INFLUENCE OF AUSTENITIZATION TEMPERATURE ON MICROSTRUCTURE OF STEEL S355J2

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## RESUME
*The austenitization is the first operation at most heat treatment processes, and it is implied heating of the steel on the austenitizing temperature and holding at this temperature until complete transformation of origin microstructure into austenite is achieved. Two base parameters which implicate an effect of austenitization are austenitizing temperature and time holding at the austenitizing temperature. This paper presents the results of the influence of the austenitization temperature on the microstructure of steel S355J2.*
**Keywords:** austenitization, microstructure, hardness

## 1. INTRODUCTION
Austenitization is the first operation for the most heat treatment processes (hardening, carburizing, normalization, etc.) and the quality (properties) of the heat treated parts depends on it. Actually, the austenitization is a process of transformation of the starting microstructure (ferrite, cementite) into the austenitic microstructure. The most important parameters of every austenitizing process are the austenitizing temperature and holding time at that temperature. For each type of steel there is an optimum austenitizing temperature. The heating temperature and time are very important parameters, not only from the point of view of furnace productivity and economical aspects but also the quality of the treated products. Two processes occur during the austenitizing of steel: the homogenization of the composition of carbon and alloying elements in the newly formed austenite and the grain growth of the austenite grains. The rate of the homogenization process will increase by increasing the austenitization temperature but the grain growth rate will also increase. During the quenching, the coarse grain microstructure of austenite will result in coarse martensite grains or in case of annealing the rough network of ferrite (cementite) on the austenite grain boundaries will be formed. Also, in case of pearlite result microstructure will be coarse grain perlitic microstructure. It is known that coarse grain microstructure adversely affects the mechanical properties of materials. Therefore, the fine-grain microstructure is preferred in practice [1,2,3]. This paper presents the results of the effect of the austenitizing temperature on the microstructure of steel S355J2.

## 2. EXPERIMENTAL
Chemical composition of the tested samples (structural steel S355J2) is given in Table 1.

*Table 1.Chemical composition of steel S355J2 (EN10025-2/04)*

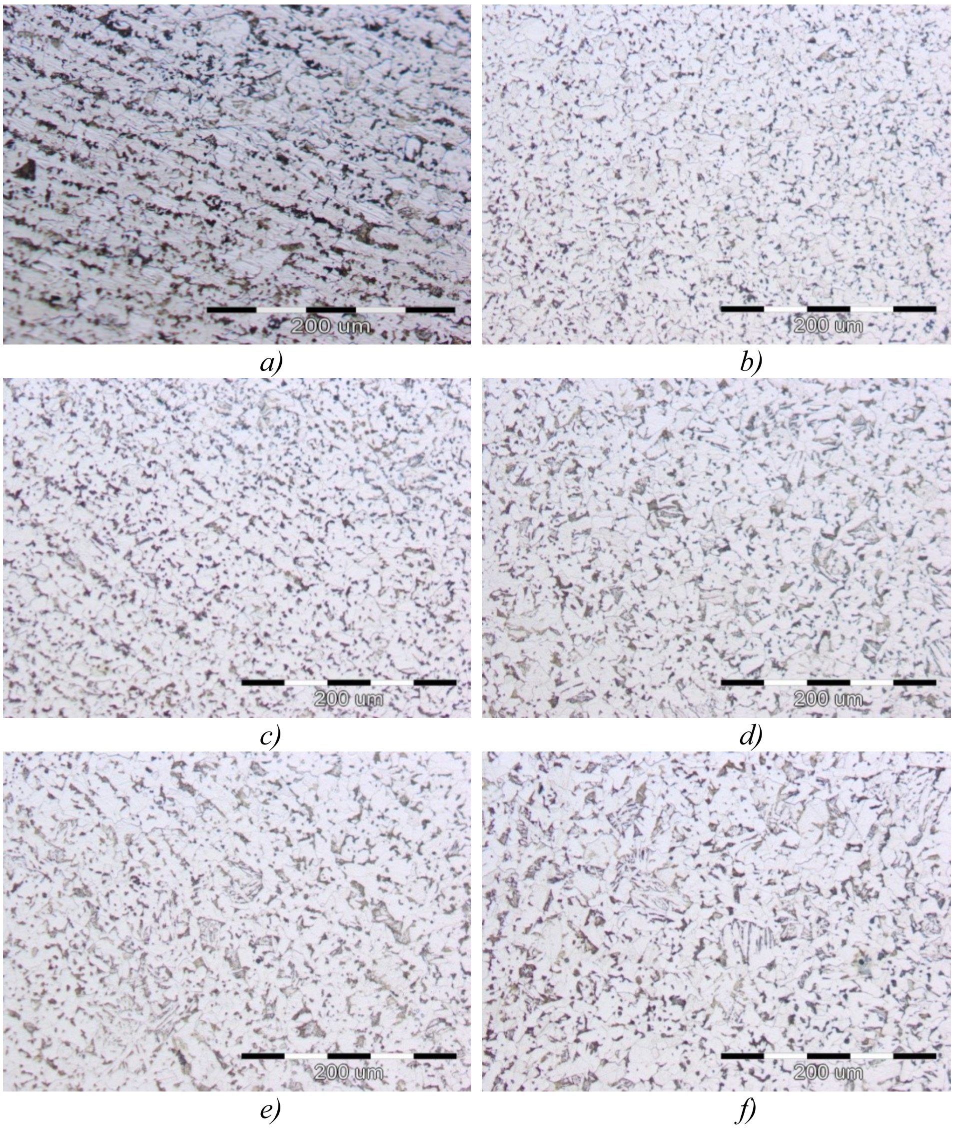
| Chemical composition , wt/% | | | | | |
|---|---|---|---|---|---|
| $C_{max}$ | $Si_{max}$ | $Mn_{max}$ | $P_{max}$ | $S_{max}$ | $Cu_{max}$ |
| 0,22 | 0,55 | 1,6 | 0,025 | 0,025 | 0,55 |

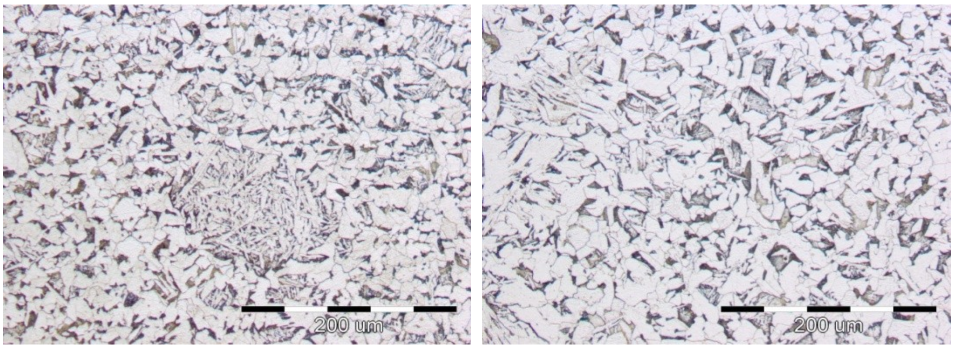
The heat treatment was carried out on two series of samples (two sample for each temperature) in order to ensure reproducibility of results. The dimensions of the samples were Φ20 x10 mm. An electric furnace without protective atmosphere was used for the heating of samples. The samples were heated from the room temperature to the austenitizing temperature (870, 900, 940, 950, 960, 1000 and $1050^{0}$C), and held at the austenitizing temperature for 20 minutes and after cooled in the air to room temperature. The microstructural analysis was carried out using the light microscopy technique. The samples for microstructure analyzing were prepared with standard grinding and polishing techniques and etched by Nital. Hardness was measured by the *Brinell* hardness *test* method.

## 3. RESULTS AND DISCUSION

The metallographic analysis of the heat treated samples, Figure 1, showes a fine grained ferrite-perlite microstructure at lower austenitizating temperatures. The microstructure consists of light areas of ferrite and dark areas of perlite [4]. The primary strip microstructure (mainly perlite) was not more present after the austenitizting at 870 $^{0}$C.

Samples heat treated at temperature of $940^{0}$C and higher show the presence of Widmanstätten microstructure and unequally increasing of grain size, Figure 1.g.





*g) h)*

*Figure 1. Microstructure of samples before and after heat treatment, 200x: a) nontreated state, b) 870 $^0$C / 20 min, c) 900 $^0$C / 20 min, d) 940 $^0$C / 20 min, e) 950 $^0$C / 20 min, f) 960 $^0$C / 20 min, g) 1000 ° C / 20 min and h) 1050 $^0$C / 20 min*

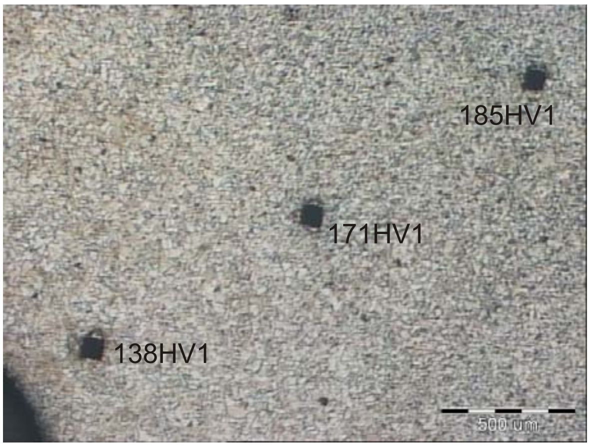



*Figure 2. The microstructure of the surface layer*

The complete and partial decarburization in the surface layer was observed for samples treated at 1050 $^0$C as result of beeing treated without protective atmosphere, Figure 2. The microhardness value ranging from the surface to the center of the sample was as follows: 138, 171 and 185 HV1. The average value of depth of the completely decarburization layer was 242.3 μm and depth of the partly decarburization layer was 467.1 μm. Determination of the grain size was performed according to ASTM method with magnification of 100 x. Observation of the grain size was carried out on 30 different fields at each sample. The grain size of samples heat treated at 870 and 900$^0$C was 8 according ASTM scale while for the samples heat treated at higher temperatures the value was 7.

After the metallographic analysis of samples, the hardness testing was done in accordance with the standard BAS EN ISO 6506-1: 2007 [5]. Results of the hardness testing after heat treatment are given in Table 2.

*Table 2. Hardness test by Brinell method*

| **Heat treatment** | **Results (HBW)** | | | | | |
|---|---|---|---|---|---|---|
| | **Measured values** | | | | | **Average value** |
| 870 ˚C/20 min | 161 | 167 | 164 | 167 | 167 | **165** |
| 900 ˚C/20 min | 160 | 167 | 166 | 160 | 164 | **163** |
| 940 ˚C/20 min | 160 | 167 | 164 | 166 | 164 | **164** |
| 950 ˚C/20 min | 160 | 166 | 170 | 170 | 170 | **167** |
| 960 ˚C/20 min | 166 | 170 | 170 | 170 | 170 | **169** |
| 1000 ˚C/20 min | 164 | 164 | 164 | 167 | 164 | **165** |
| 1050 ˚C/20 min | 161 | 164 | 161 | 164 | 164 | **163** |

The results showed that no significant differences in hardness for the different values of austenitizing temperature.

## 4. CONCLUSIONS

The fine grain size ferrite - pearlite microstructure without expressed strip microstructure was obtained at a lower austenitizing temperature (870 and 900$^0$C). The presence of Widmanstätten microstructure was observed for the samples heat treated at 940 $^0$C and higher temperatures. The Widmanstätten microstructure is the result of the higher cooling rate from higher austenitization temperature [6]. Also, the uneven increase of grain size was noticed at higher austenitization temperature. Uneven grain increase did not generally affect average hardness value of the heat treated samples. The values of hardness ranged from 163 to 169 HBW. The complete and partial decarburization were present for samples heated at the highest temperature (1050$^0$C) because of the air atmosphere in the furnace and the diffusion coefficient increases with increasing temperature.

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