*Pak. J. Engg. Appl. Sci. Vol. 25 July, 2019 (p. 14–17)*

# Findings of Grain Coarsening Temperature and Grain Growth of Light Weight Steel Used in Automotive Industry

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## Abstract

*Efforts have been made in this research work to observe the grain coarsening temperature (GCT) by keeping in view the formation of second phase particles. Three steels having different chemical compositions were heat treated at series of temperatures i-e 850°C, 925°C, 1000°C, 1100°C and 1175°C with holding time of 1 hour and 2 hours respectively. After revealing the microstructure grain size distribution at each temperature was calculated by using matrox inspector and the result was plotted with origin data analysis software. It was found that presence of second phase particles can affect the grain growth phenomena in the experimental steels and also grain growth have consequences on grain coarsening temperature on the steel under investigation. Steel A (Nb-Al) showed the finest grain structure, Grain size of steel B (Nb) was slightly higher than that of steel A. In steel C (Al), AlN particles did not exist. The only particles present were of TiN. Hence, the mean grain size of steel C was higher than that of steel A and steel B.*

**Key Words:** grain growth, grain coarsening, second phase particles, steel

## 1. Introduction

The basic concept of grain growth is the increase in the packet size of grain and enlarges the size of the grain. [1-4] It is commonly known that grain growth always play a crucial role when steels are subjected to metal forming i-e rolling or forging therefore grain controlling is the universal method to dominate the mechanical properties of the steel [5,6]. Grain coarsening temperature on the other side is must step to know that what is the actual temperature from where the grain coarsening stimulate and that point is always critical point for the metallurgists to design any plastic deformation process for rolling and forging to make the steel components and parts for end users [7-9].

## 2. Materials and experimental procedure

The chemical compositions of the specimens that were investigated in this present work are given in the table. 1 below:

**Table 1:** Chemical compositions of the specimens involved in the study

| | C | Mn | Al | Ni | Ti | Nb | N2 |
|---|---|---|---|---|---|---|---|
| **A** | 0.196 | 1.04 | - | 0.25 | 0.019 | - | 0.0079 |
| **B** | 0.202 | 1.04 | 0.041 | - | 0.025 | 0.047 | 0.0058 |
| **C** | 0.196 | 1.03 | 0.008 | - | 0.025 | 0.048 | 0.005 |

Each of these samples were made 12 in numbers and were subjected to heat treatment.

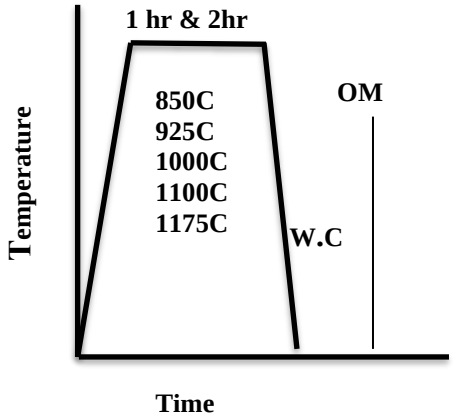


**Fig. 1:** Heat treatment cycles to be followed. (Left) One hour, (right) two hours soaking time

The heat treatments were followed by metallography and microscopy to reveal the changes due to micro alloy addition and their resulting precipitation. By the resulting

microstructure using the software matrox inspector the GSD (Grain Size Distribution) histograms and sizes were obtained. Then the solubility isotherms of different phases such as AlN were plotted which have been compared to other related works and research [10-15].

## 3. Results and discussion

The heat treatments of the each specimen's 12 samples are shown below along with their grain size distribution.

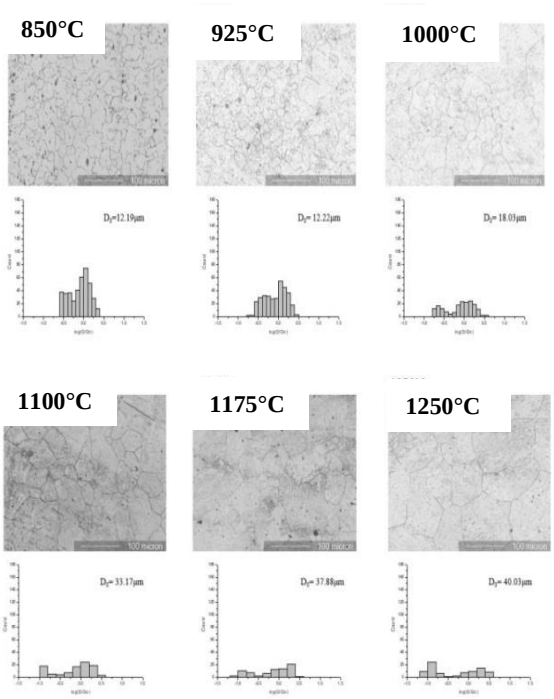


**Fig. 2 (a):** Steel A soaking time 1 hr

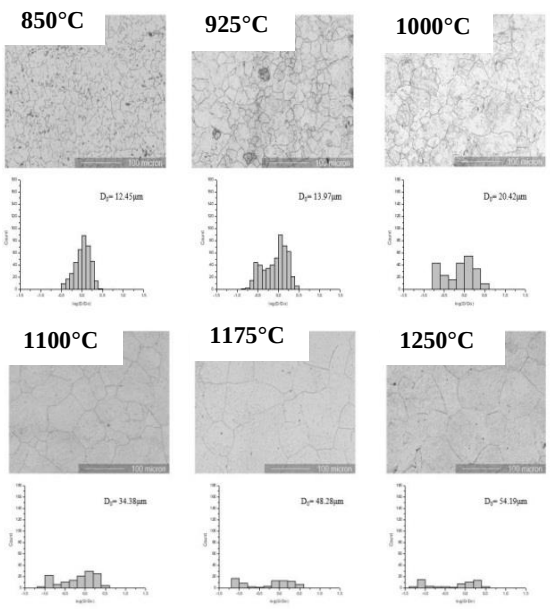


**Fig. 2 (b):** Steel A soaking time 2 hr

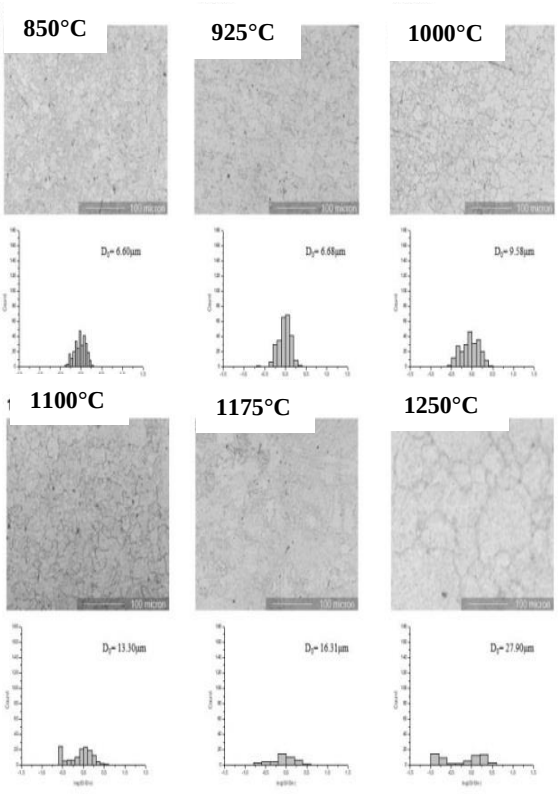


**Fig. 3 (a):** Steel B soaking time, 1 hr

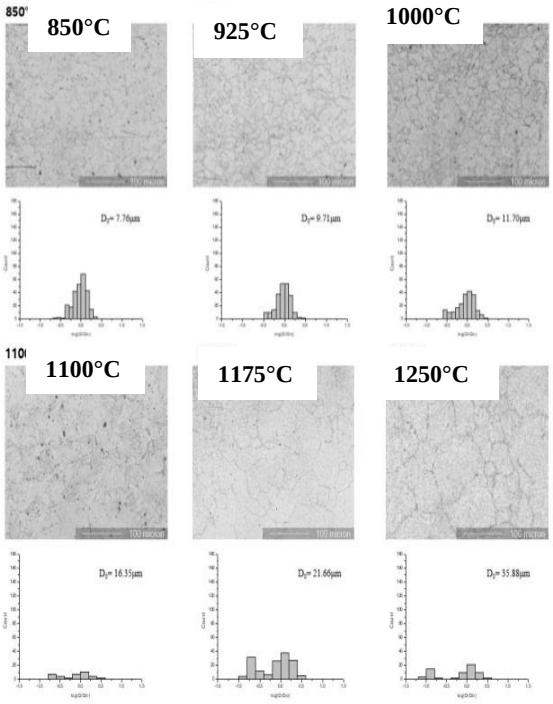


**Fig. 3 (b):** Steel B soaking time 2 hr

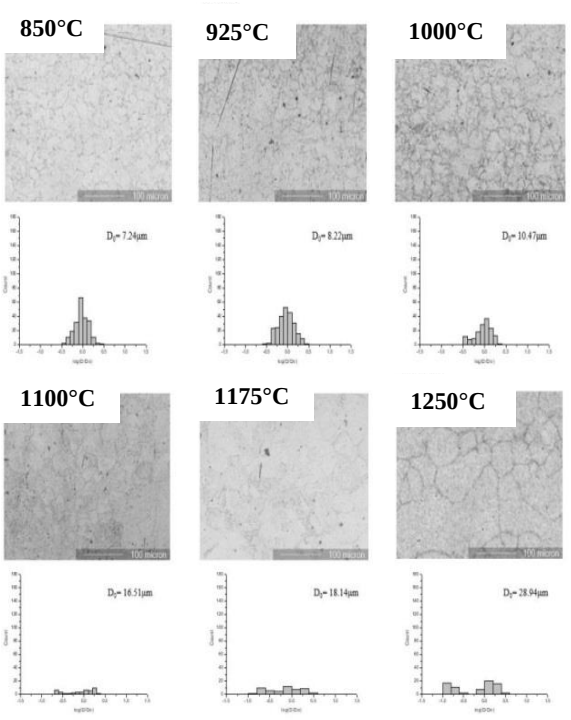


**Fig. 4 (a):** Steel C soaking time 1 hr

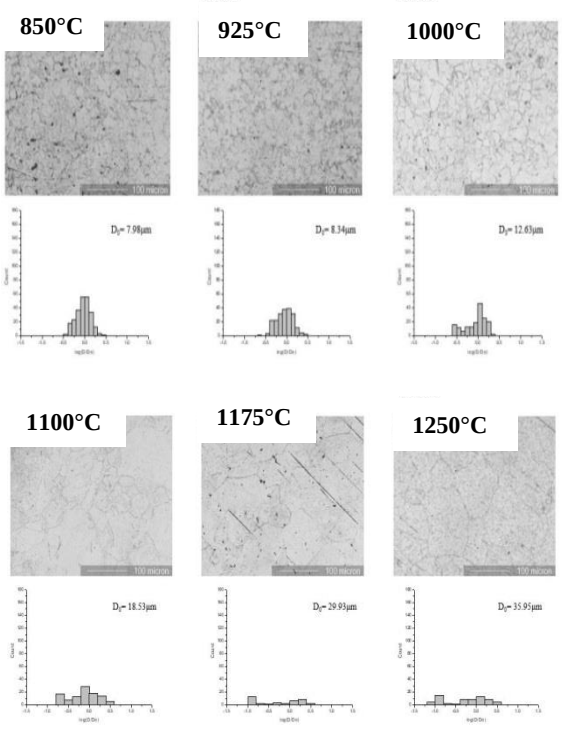


**Fig. 4 (b):** Steel C soaking time 2 hr

After taking the grain size calculation of 12 samples at four different temperature ranges the data was plotted using origin data plotter software and the result was shown in mean grain size $D_0$ vs absolute temperature as shown in fig. 5 a and b. The circle indicates the range of GCT area.

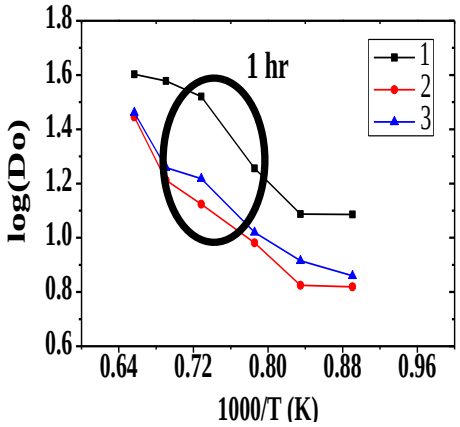


**Fig. 5:** A Log Do vs 1/T (K) for Steel A, B, C, at 1hr shows Variation of p-AGS with heating temperature and time (GCT range)

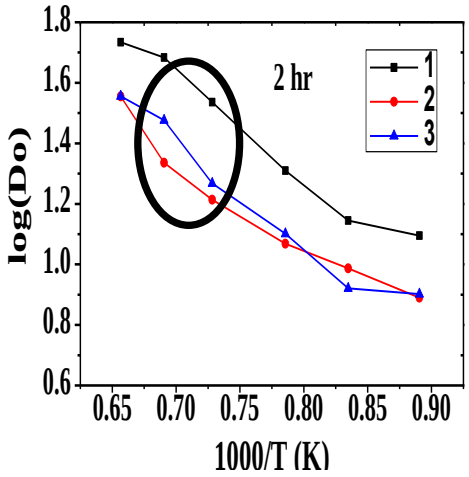


**Fig. 6:** Log Do vs 1/T (K) for Steel A, B, C, at 2 hr shows Variation of p-AGS with heating temperature and time (GCT range)

## 4. Conclusion

**a)** Austenite Grain Size

- Steel A (Nb-Al) showed the finest grain structure because of the presence of higher precipitates.
- Grain size of steel B (Nb) was slightly higher than that of steel A. But the particle pinning efficiency was also high in steel B (Nb). Both steels contain the same type of precipitates i.e. TiN and NbC.
- In steel C (Al), AlN particles did not exist. The only particles present were of TiN. Hence, the mean grain size of steel C

was higher than that of steel A and steel B.

**b)** Grain Coarsening Temperature (GCT)

| | 1 hr | 2 hr |
|---|---|---|
| Steel A (Nb-Al): 925℃ - 1000℃ | | |
| Steel A (Nb-Al): 925℃ - 1000℃ | | |
| Steel B (Nb): 1000℃ - 1100℃ | | |
| Steel B (Nb): 925℃ - 1100℃ | | |
| Steel C (Al): 1175℃ - 1250℃ | | |
| Steel C (Al): 1000℃ - 1100℃ | | |

## 5. Acknowledgement

Authors are greatly thankful to Department of Materials and Engineering at NED University of Engineering and Technology laboratory staff and the experimental facilities throughout this research work for the support of this work.

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