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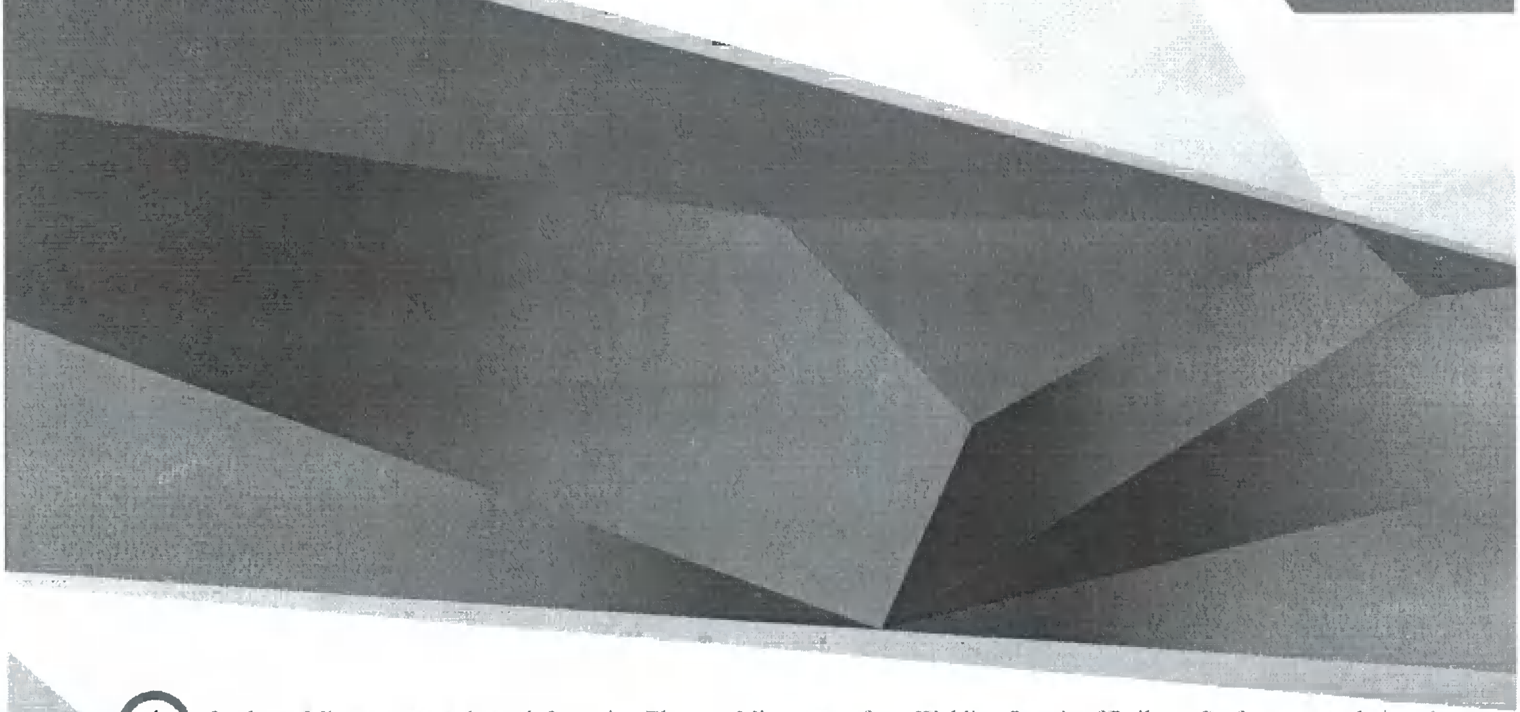

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Study on Microstructure through Scanning Electron Microscope from Welding Repair of Railway Surface 70 ponds / yards with Welding Electrodes E110-16G and E1-UM-350

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Abstract

This research aimed to find the most effective variable for welding repair of railway's adhesive surface and apply this welding technology in cooperation with Khon Kaen Permanent way, Maintenance Division of State Railway of Thailand. Microstructure was studied with advanced analysis technology through the Scanning Electron Microscope (SEM) with welding repair of railway surface sizing 70 ponds/yards. Variables of the experiment were 2 types of welding electrodes: E110-16G and E1-UM-350. After welding experiment, the macrostructure was examined and found that the welding zone with E110-16G was deeper and well permeated than welding with E1-UM-350. This was because the Silicon (Si) in welding electrode of the austenite structure affected the ability of welding and permeation. From welding with E110-16G, the structure of ferrite phrase had alternating lengths with pearlite structure in the welding zone. From welding with E1-UM-350, bainite structure was consistently dispersed in the welding zone. However, from microstructure examination in heat-affected zone of the welding with E110-16G, the microstructure was consisted of ferrite phase combined with pearlite structure. Martensite structure was found to occur and consistently disperse without any defect. The martensite structure occurred in the welding with E1-UM-350 and porosity was dispersed in the heat-affected zone.

Keywords: Railway Sizing 70 ponds/yards; Welding Repair; Railway Surface; Welding Electrode; E110-16G; E1-UM-350

1. Introduction

Currently, railway sizing 70 ponds/yards (As UIC 1986 standard was grade 700 railway) was mostly applied in Thailand. The railways in monorail type were used in every part of the country for a long time in heavy working condition with a certain amount of damage and loss from operational circumstance. A transportation system by railway or train was mainly related to consumption products because it had many advantages, including ability to transport in a large amount, safety, time and money saving, and low

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Research Paper

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transportation cost [1-2]. However, from the investigation for fundamental information from Khon Kaen Permanent way of the Maintenance Division of State Railway of Thailand, it was found that the major problem occurred from the working condition of railway, causing by wear and erosion on surface of the railway as shown in Fig. 1A. The adhesive wear from friction between the wheel and the surface during the breaking and moving of the trains [2-3] was mostly 3-5 centimeters long and 1-3 centimeters deep [1]. This adhesive wear of railway was disunited and the State Railway of Thailand must replace it with the new one. If this was not repair, it could cost a large amount of money and time loss in operation.

The welding repair of railway surface with welding electrodes E110-16G and E1-UM-350 was an alternative way in repairing the railway's surface. From previous studies, hard-facing welding of railway sizing 50 ponds/yards and 100 ponds/yards with different welding electrodes depended on the properties of welding electrode and grading of railway. Consequently, the concept of this study in surface welding of railway sizing 70 ponds/yards was that different types of railway steel might have different effects after welding. Thus, selecting the right welding electrode was highly important. As the chemical composition of welding electrode directly affected railway steel - whose component was a large amount of Carbon, Silicon, and Manganese - after welding, the welding electrode with the most similar properties to the railway should be considered [4-5]. In this study, steel welding electrodes were selected for the experiment and the weldability of two types of welding electrodes was compared by considering the most similar tensile strength. Therefore, the steel welding electrode E110 16G with impact force and vibration resistance and the hard-facing welding electrode E1-UM-350 with pulling force resistance [1-2] were selected. After that, the microstructure was analyzed with Scanning Electron Microscope (SEM) to study dispersion of phrases in welding zone (WZ) and heat-affected zone (HAZ) because these dispersions affected the railway's surface welding repair in a long term of working operation.

2. Research Methodology

2.1 Materials and Welding Electrode

This research focused on the microstructure with Scanning Electron Microscope (SEM) from welding repair of 70 ponds/yards steel railway that Thailand currently used, as well as studied the type of welding electrode that affected the structure of steel railway after welding. Chemical and mechanical properties of railway steel and welding electrodes were presented in Table 1 [6]. Welding electrodes of AWS standard, code A5.5 E110-16G and welding electrodes DIN 8555 standard, code E1-UM-350 were used.

The experimental working pieces were cut by mechanical saw with coolant system to 120 millimeters long. This length was obtained from the wear investigation which found that the size of adhesive wear was not over 85 millimeters. Then the surface of working piece was cleaned with sandpaper before welding repair of the railway's surface.

Table 1 Chemical composition and mechanical properties of railway steel and welding electrodes

Types	**Chemical composition** [wt.%]							**Tensile properties**	
	Fe	**C**	**Si**	**Mn**	**P**	**S**	**Cr**	**UTS** [N/mm^2]	**Elongation** [%]
BS 70	Balance	0.40-0.60	0.05-0.35	0.80-1.25	0.05	0.05	-	680-830	14
E110-16G	Balance	0.075	0.43	1.45	0.011	0.010	0.35	785-835	20-25
E1-UM-350	Balance	0.18	0.29	1.12	-	-	1.35	1,010	-

2.2 Welding Repair of Railway Surface Repair Process

Shield Metal Arc Welding (SMAW) was not complicated. the material and equipment were easily transferred to apply with small generator in every weather condition. Thus, this process was appropriate to apply in this study. The welding with arc source between electrode and working piece would create melting pond while the electrode would fill metal substance all the time. However, before welding the working piece, the railway's surface should be pre-heated at 350 degree Celsius with Acetylene and Oxygen (Carburizing Flame) for 5 minutes. Temperature was measured with K-type infrared inspector. The welding power was adjusted to 130 amp, with welding current in DCEN (negative electrode) and 3.2 millimeters electrode [1-3]. Multi-pass welding was applied to fill the adhesive wear, with about 5-7 welds occurred as shown in Fig. 1B.

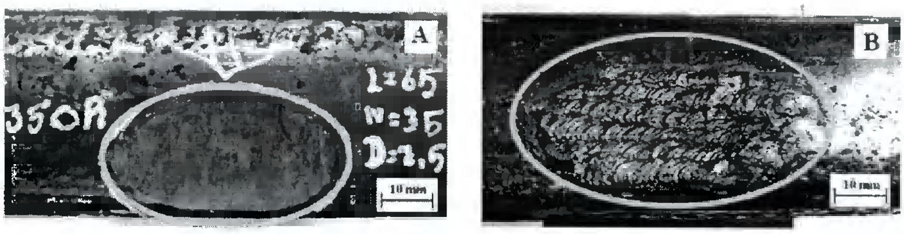

Fig. 1 Surface welding repair of 70 pound/yard railway

(A) wear and erosion on railway's surface (B) surface welding repair of the railway

2.3 Specimen Preparation for Microstructure Examination

The preparation of working pieces in testing was an important process. There were many kinds of appropriate tests in consideration. The steel railway was prepared to be working piece with ISO 6892-1 standard to investigate macrostructure and microstructure by polishing with metal polishing machine and sandpaper No. 100-1,000. The surface was prepared by polishing with flannel and 3-micron alumina polishing powder, mixing with water with acid etching (Nitric acid 5%, alcohol 20%), for 2 to 5 seconds and dried with hot air. After that, welding defects in welding zone (WZ) and heat affected zone (HAZ) [1-2] were investigated.

3. Results and Discussion

3.1 Macrostructure Analysis Results

The macrostructure was investigated with digital camera. As shown in Fig. 2A, the welding zone (WZ) with electrode E110-16G showed deep permeation around 5-8 millimeters, deeper than welding with E1-UM-350 as shown in Fig. 2B which was around 5-6 millimeters. Since the electrode E110-16G had a larger amount of Silicon (Si), it better affected the welding ability and permeation [7] and, in turn, made a strong weld and adhesive wear resistance [1].

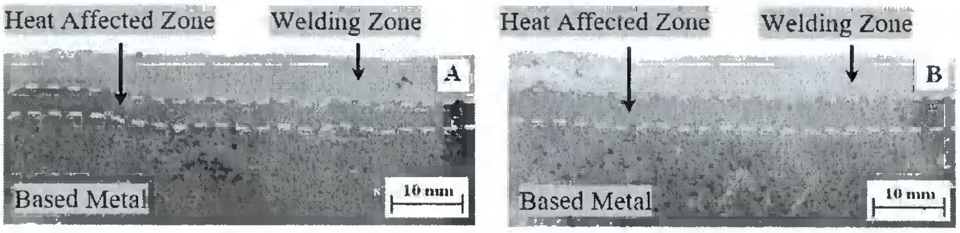

Fig. 2 Macrostructure from welding with electrode (A) E110-16G and (B) E1-UM-350

3.2 Microstructure Analysis Results

Currently, railways had several function groups. The 70 ponds/yards railway sizing was in a Natural Hard Rails group that was made from steel with a base metal (BM) microstructure of pearlite type (α+Fe_3C). It was applied as railways in general transportation system with a wear rate of 0.7-1.0 millimeters and 100 million tons loading in a straight railway [6]. The pearlite microstructure type had strong mechanical properties and resistance and also had significant ability for welding [1].

From the investigation of microstructure in welding zone (WZ), it was consisted of ferrite phrase (Ferrite: α) combined with pearlite structure (Pearlite: P) as shown in Fig. 3A. From the welding with electrode E110-16G as illustrated in Fig. 3C, the ferrite phase had alternating lengths with pearlite structure [7], resulting from silicon and manganese in the welding wire. These metals affected the heating process while welding did not cool quickly. However, this structure caused the weld to withstand impact and vibration well [2,6]. On the other hand, the welding with E1-UM-350 welding wire as shown in Fig. 3B revealed that the structure of the ferrite phase was finer and dispersed more on the Pearlite structure than by the welding with E110-16G electrode because the large amount of carbon in the E1-UM-350 welding electrode directly resulted in rapid cooling of the weld [8]. The bainite structure (B) was consistently dispersed through the weld [9-10] as shown in Fig. 3D. Even though this structure yielded well wear resistance [11-12], a risk to crack could occur if there was no heating process before or after the welding [1].

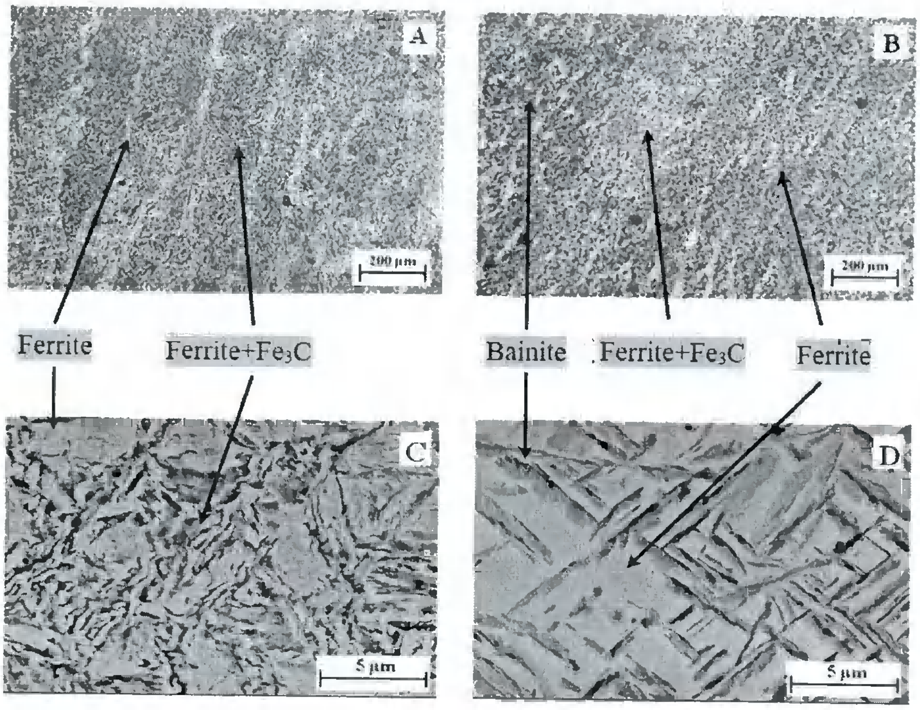

Fig. 3 Microstructure in welding zone (WZ) by optical microscope (OM) from welding by electrodes (A) E110-16G and (B) E1-UM-350 with 500X Magnification, and by Scanning Electron Microscope (SEM) from welding by electrodes (C) E110-16G and (D) E1-UM-350 with 10,000X Magnification

From the investigation of microstructure in heat-affected zone (HAZ) of the welding with E110-16G, the microstructure consisted of ferrite phrase (white), combined with pearlite structure (α+Fe_3C). The martensite structure (M) occurred and constantly dispersed due to the rapidly cool-down in heat-affected zone. The structure was changed to martensite [3,13] as illustrated in Fig. 4A and 4C, with no occurrence of defect. Moreover, the martensite structure occurred from the welding with E1-UM-350 as shown in Fig. 4B and 4D since the large amount of Carbon and Chromium (Cr) in electrode affected the martensite structure occurrence and porosity was dispersed thoroughly in the heat-affected zone [14]. This structure decreased the ability of vibration resistance because of the strong structure and a great number of porosity, resulting from expansion of cracks on the surface of the rail. [10]. However, it was highly recommended to maintain the vibration resistance properties in railway welding [6,15].

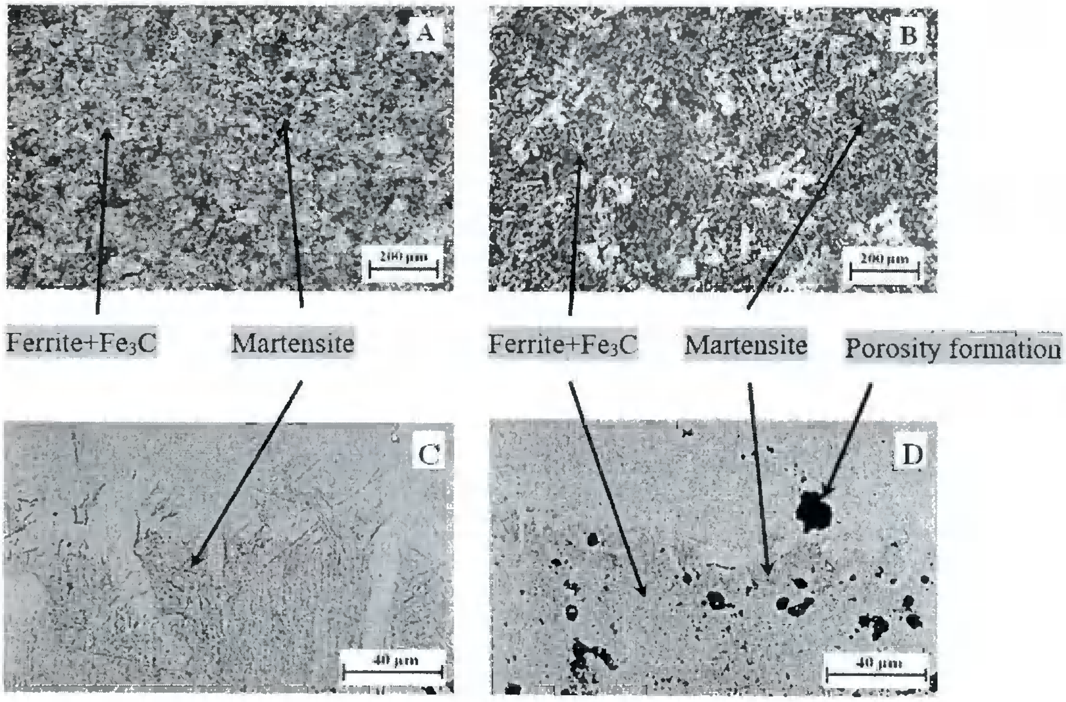

Fig. 4 Microstructure in heat affected zone (HAZ) by optical microscope (OM) from welding by electrode (A) E110-16G and (B) E1-UM-350 at Magnification 500X and Scanning Electron Microscope (SEM) from welding by electrode (C) E110-16G and (D) E1-UM-350 at Magnification 1,200X

4. Experimental Conclusion

The objective of this research was to study metallurgical structure using high-level analytical technology (SEM) from welding of 70 ponds/yards rail surface for repair with E110-16G and E1-UM-350 welding wires. Comparison of results was done to choose the best variables for rail surface repair work for the Khon Kaen Permanent way of the Maintenance Division of State Railway of Thailand. Results of the study could be summarized as follows:

In the macrostructure, the welding zone in welding with E110-16G had deeper permeation than welding with E1-UM-350 because Silicon (Si) in the electrode affected the ability of welding and permeation.

In the microstructure, the welding zone consisted of ferrite phrase combined with pearlite structure. From the welding with E110-16G, the ferrite phrase was alternating lengths with pearlite structure in the welding zone because of Silicon and Manganese. From the welding with E1-UM-350, the bainite structure dispersed consistently in the weld and causing a risk to crack after welding.

In the microstructure heat-affected zone, it was found that the microstructure consisted of ferrite phase mixed with pearlite structure from the welding with E110-16G. The martensite structure occurred and dispersed consistently without any defect. The martensite structure occurred from the welding with E1-UM-350 while the porosity dispersed mainly in heat-affected zone. This structure would cause the decrease of vibration resistance and not suitable for welding repair of railway's surface.

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References

[1] T. Khrueaphue, "Comparative Study of Hard-facing Weld Metal Properties on Grade 900 Railway Steel using H450R and E120-18G SMAW Electrodes," Journal of Engineering, RMUTT, Vol. 18, No. 1, 2020, pp. 111-120.

[2] A. Chanpahol, "The Study of Metallurgy Structure of 50-Pound Sized of Railway Hard Surfacing Welding by Shielded Metal Arc Welding Process," KKU Research Journal (Graduate Studies), Vol. 19, No. 3, 2019, pp. 28-35.

[3] A. Chanpahol and B. Kongruang, "Comparative Study of H350R and E8016 Electrode in Surface Hard-Facing Welding of 100 pound/yard Railway by Shielded Metal Arc Welding," Industrial Technology Lampang Rajabhat University Journal, Vol. 12, No. 2, 2019, pp. 96-105.

[4] C. Chowda Reddy, K.M. Kenchi Reddy, C.T. Jayadeva, M.S. Satish and KM. Chandrashekar, "Some Studies on Shielded Metal Arc Welding Hard Facing on Mildsteel," International Journal of Innovative Research in Science, Vol. 7, No. 7, 2018, pp. 241-245.

[5] M. Morcillo, D. La Fuente, I. Díaz and H. Cano, "Atmospheric Corrosion of Mild Steel," Revista De Metalurgia, Vol. 47, No. 5, 2011, pp. 426-444.

[6] E. Viyanit, S. Kaewkamsai, and S. Oumnan, "Metallurgy and Rail Tracks in Mass Rapid Transit," Articles of National Metal and Materials Technology Center (MTEC), Pathumthani, 2014, 54 [Online], Available: https://www2.mtec.or.th/th/e-magazine/admin/upload/290_49-55.pdf [14 December 2020].

[7] U.P. Singh, B. Roy, S. Jha and S.K. Bhattacharyya, "Microstructureand Mechanical Properties of as Rolled High Strength Bainitic Rail Steels," Journal of Materials Science & Technology, Vol. 17, No. 1, 2001, pp. 33–38.

[8] V.E. Buchanan, P.H. Shipway and D.G. Mccartney, "Microstructure and Abrasive Wear Behavior of Shielded Metal Arc Welding Hard-Facings used in the Sugarcane Industry," Journal of Materials Science, Vol. 263, No. 1–6, 2007, pp. 99–110.

[9] D. López, W. Schreiner, S. Sánchez and S. Simison, "The Influ-Ence of Carbon Steel Microstructure on Corrosion Layers: an XPS and SEM Characterization," Applied Surface Science Journal, Vol. 207, No. 1–4, 2003, pp. 69–85.

[10] O. Hajizad, A. Kumar, H. Petrov and R. Dollevoet, "Influence of Microstructure on Mechanical Properties of Bainitic Steels in Railway Applications," MDPI - Publisher of Open Access Journals, Vol. 9, No. 7, 2019, pp. 1-19.

[11] K.M. Kenchi Reddy and C.T. Jayadeva, "Abrasive Wear Behavior of Hardfaced Fe-Cr-C Alloy and Mild Steel Under Two Body Conditions," Global Journal of Engineering Science and Researches, Vol. 4, No. 2, 2015, pp. 32-40.

[12] K.M. Kenchi reddy and C.T. Jayadeva, "A Study on Microstructure and Abrasive Wear Behavior of Fe-Cr-C Based Hard Facing Alloys Deposited by Smaw Processes," International Journal of Engineering Science and Innovative Technology (IJESIT), Vol. 3, 2014, pp. 344-349.

[13] L. Hee-jin and L. Hae-woo, "Effect of Cr Content on Microstructure and Mechanical Properties of Low Carbon Steel Welds," International Journal of Electrochemical Science, Vol. 10, No.10, 2015, pp. 8028-8040.

[14] M. Santofimia, L. Zhao and J. Sietsma, "Microstructural Evolutionof a Low-carbon Steel During Application of Quenching Andpartitioning Heat Treatments After Partial Austenitization," Metallurgical and Materials Transactions, Vol. 46, No. 40, 2008, pp. 46–57.

[15] E. Mortazavian, Z. Wang and H. Teng, "Repair of Light Rail Track Through Restoration of the Worn Partof the Railhead using Submerged Arc Welding Process," International Journal of Advanced Manufacturing Technology, Vol. 107, No.10, 2020, pp. 3315-3332.