Conference Paper

The Improvement of Impact on Manganese Steel for Bucket Tooth Product

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Abstract

The bucket tooth is one of an excavator components made of manganese steel used to dig and load land into a truck or elsewhere. The impact of the bucket tooth product needs to be increased so that it has longer lifetime. The objective of this research is to know the right composition of manganese in order to obtain the optimal impact strength. Varying the composition of manganese from 11,2% to 15,1% wt Mn are carried out in an induction furnace. Mechanical tests carried out include microstructure observation, impact and hardness testing. The structure of austenite dominates manganese steel with an average grain size of 60 μm (11,2% Mn) and increases up to 45% for the contents of 15,1% Mn. The lowest impact strength (0,08 J/mm^2) in specimens with 11,2% Mn, increases up to 42% (0,142 J/mm^2) in specimens with 15,1% Mn. The increase of impact strength is affected by grain size and austenite stability. The hardness of manganese steel with 11,2% Mn (330 VHN) increases up to 376 VHN with 15,1% Mn.

Keywords: bucket tooth, manganese steel, impact

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Received: 20 July 2019
Accepted: 22 August 2019
Published: 29 August 2019

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the ICTSD 2018 Conference Committee.

1. Introduction

Bucket tooth is one of excavator components that is used to dig and load land into a truck or somewhere else. Bucket tooth is usually made of manganese steel which has wear resistance and high impact. Bucket tooth replacement is usually done because of wear, yet there are some cases that are replaced because of broken. The enhancement of the bucket tooth mechanical properties can be conducted with variations of manganese composition and heat treatment. The increase of material strength occurs due to the stability of the austenite structure increased.

Bucket tooth made by one of the metal casting industries contains 11 to 12% Mn, but it often fractures when used. The research was carried out with variations of Mn to obtain the optimal mechanical properties.

2. Literature Review

Manganese steel has high wear resistance and impact toughness. Manganese steel has a primary alloy of 12% Mn with austenite structure at room temperature, which is tough, high strain and paramagnetic (Katila, 1994). The improvement of mechanical properties are obtained by heat treatment and work hardening (Clauser and Henry, 1975). Manganese steel is an alloy steel with high wear resistance which has the composition of carbon, manganese, silicon, cromium, molybdenum, and tungsten as shown in Table 1. Manganese steel is widely used for stone crusher, excavator buckets, and loader sholver, since it has impact and high wear resistance.

TABLE 1: Manganese steel composition (JIS G5131, 1991).

Class	Symbol	Composition						
		C	Si	Mn	P	S	Cr	V
1	SCMnH1	0,9-1,3	-	11,0-14,0	0,1 max	0,05 max	-	-
2	SCMnH2	0,9-1,3	0,8 max	11,0-14,0	0,7 max	0,04 max	-	-
3	SCMnH3	0,9-1,3	0,3 max	11,0-14,0	0,5 max	0,035 max	-	-
4	SCMnH11	0,9-1,3	0,8 max	11,0-14,0	0,7 max	0,4 max	1,5-2,5	-
5	SCMnH21	1,0-1,35	0,8 max	11,0-14,0	0,7 max	0,4 max	2,0-3,0	0,4-0,7

The addition of manganese steel composition around 1,65% - 1,90% increases tensile strength, hardness and heat ability. The manganese also improves the response of steel toward heat treatment. The optimum mechanical properties in manganese steel are obtained by heat treatment. Hardening and tempering improve the mechanical properties. Normalizing increases the impact strength and it is often applied to forging and casting products (Rajan, 1997).

Hadfield steel is a high manganese steel used for commercial purposes. Hadfield steel contains 1,1 – 1,4% carbon and 11-14% manganese. Heat treatment with austenization followed by quench of water will produce austenitic structures that increase toughness and wear resistance. Formation of manganese steel carbide (Mn_7C_3) for AISI 3401 steel occurs with annealing at 950°C. Silicon carbide (SiC) is formed at temper of 200°C, 500°C and 700°C with nodular and intergranular shapes surrounded by ferrite matrix. Hardness decreased along with the increase of tempering temperature (Hussen and Sadino, 2012).

The hardness and wear resistance improvement of austenitic manganeese steel occur due to dislocation density and stacking fault with high austenite stability. Austenitic manganeese steel increases its hardness (60% - 120%) and wear resistance

(50% - 140%) when compared with hadfiled steel (Zhen et al, 2003). The austenite microstructure of manganese steel showed the grain size of 10 to 17 μm when the solution heat treatment was carried out at temperature up to 1000°C. The grain size increased up to 50 μm when the solution heat treatment was carried out with temperature above 1000°C (Dobrzanski et al, 2008).

3. Methods

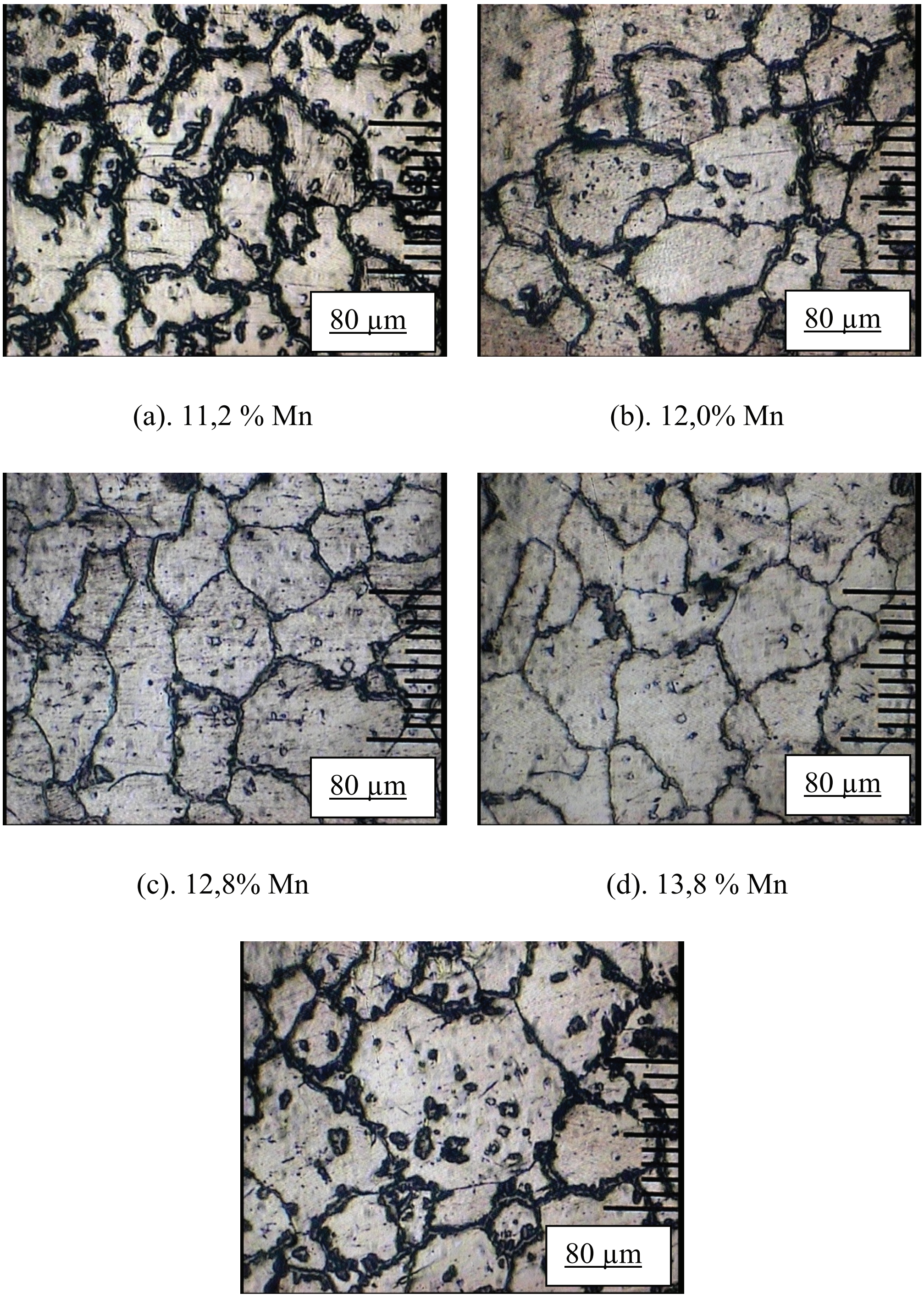
The impact resistance improvement of manganese steel is carried out with variations in the manganese addition. The addition of manganese was done in an induction furnace with a composition of 11,2; 12,0; 12,8; 13,8 and 15,1% Mn. Variations in the addition of Mn were carried out to improve the stability of the austenite structure, thereby it increased the impact of bucket tooth product from manganese steel. Test specimens made are impact, hardness and microstructure specimens. Materials and tools used include: manganese steel, HNO_3, autosol, induction furnace, metallurgical microscope, impact tester, and hardness tester.

4. Results and Discussions

Microstructure observation showed that the austenite dominated the structure. The addition of Mn composition could increase the grain size (Figure 1). The grain size of austenite with 11,2% Mn composition was 60 μm and increased by 25%; 33%; 40% and 45% respectively for the contents of 12; 12,8; 13,8 and 15,1% Mn. The grains size of the austenite spread evenly which made it more stable and stronger.

The impact strength of manganese steel tended to increase along with the improvement of Mn content (Figure 2). The lowest impact strength (0,08 J/mm^2) in specimens with 11,2% Mn, increased up to 42% (0.142 J/mm^2) in specimens with 15,1% Mn. The improvement of impact strength was effected by the grain size and the stability of austenite so that it was more resilient and stable (Zhen et al, 2003).

The hardness of manganese steel tended to increase along with the improvement of Mn content (Figure 3). The hardness of manganese steel with 11,2% Mn (330 VHN) increased up to 376 VHN (12%) with 15,1% Mn.



(a). 11,2 % Mn

(b). 12,0% Mn

(c). 12,8% Mn

(d). 13,8 % Mn

(e). 15,1% Mn

Figure 1: The result of structure analysis.

5. Conclusions

The structure of austenite dominates manganese steel with an average grain size of 60 µm (11,2% Mn) and increases up to 45% for the 15,1% Mn composition. The lowest impact

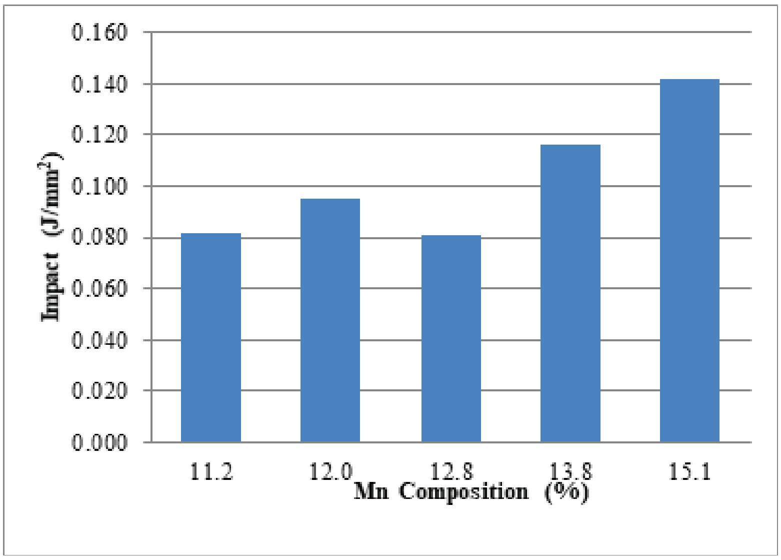


Figure 2: The result of impact test.

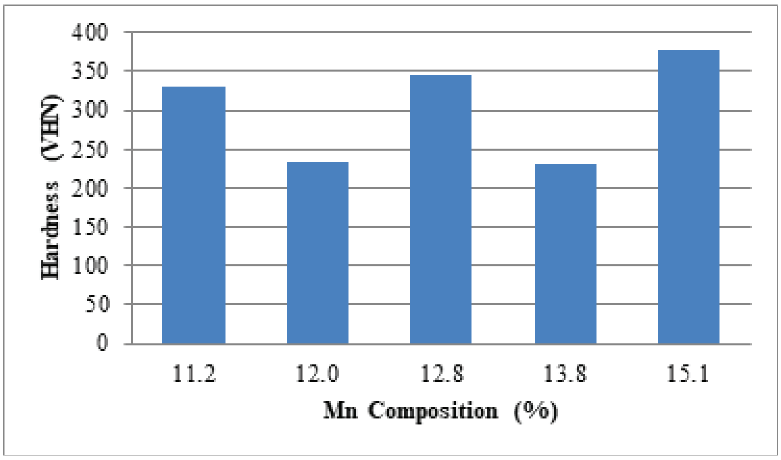


Figure 3: The result of hardness test.

strength (0,08 J/mm^2) in specimens with 11,2% Mn, increases up to 42% (0,142 J/mm^2) with 15,1% Mn. The impact strength increases because the grain size and the austenite stability increases as well. The hardness of manganese steel with 11,2% Mn (330 VHN) increases up to 12% with 15,1% Mn.

References

[1] Clauser, H. R., 1975, *Industrial and Engineering Materials.*, Mc. Graw-Hill. Inc

[2] Dobrzanski L.A., Grajcar, A., dan Borek., 2008., Influence of hot working conditions on a structure of high manganesee austenite steel, Journal of hot-deformed austenite steels., Materials Engineering., 795-798

[3] Hussen. C dan Sadino., 2012, Pengaruh Variasi Temperatur Tempering Terhadap Sifat Mekanik dan Struktur Mikro pada Baja Mangan Hadfield AISI 3401 Hammer Clinker Cooler PT Semen Gresik, Jurnal Teknik POMITS Vol. 1, No 1.

[4] Juqiang, C., 2007, *Development of Bucket Tooth Material of Hight Strength Cast Steel and Its Application*., Dept of Materials Science and Engeneering, Zhengzhou University, Zhengzhou 450002, China

[5] Katila R., 1994, *Austenit Wear Resistant Steel and Metods for Heat Treatment there of Patent 5308408*., United State

[6] Rajan, T.V, Sharman and Ashoe S.,1997, *Heat Treatment Principles and Techniques*, Revised Edition., Prentice Hall of India Private limited., New Delhi

[7] Zhen, M. H., Chuan, Q. J., Shao, B. F, and Jing, P. X., 2003., *Improved Work-Hardening Ability and Wear Resistance of Manganeese steel Under Non-serve Impact Loading Conditions.*, Departement of Metallic Materials Enggineering, Jilin Univrsity of Technology, Chanchun, China