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Microstructure and mechanical behaviour of hot rolled V- Microalloy Steel

Harish Kumar Sharma[1], Ashutosh Pratap Singh[2]
[1]GLA University Mathura, Uttar Pradesh, India

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Abstract:
In this study, microstructure of still air cooled hot rolled V-microalloy steel was under observation, micrograph shows the refine primary structure of ferrite and pearlite. SEM images show the nucleation of /second phase particles. Tensile test carried out on Instron testing machine. Test shows improved yield strength without any significant decrement in ductility of alloy. The attempts were made to study Microstructure and mechanical behaviour of hot rolled V- microalloy steel subjected to the pre chosen thermo mechanical treatment schedule. Thermo mechanical simulation was carried out to impose the prechosen deformation on to steel and then the microstructure and mechanical properties were monitored by elaborate microscopic studies.

***Keywords**: Hot rolled, Microstructure, Pearlite, Yield strength.*

1. Introduction

Micro-alloy Steel is a type of alloy steel that contain small amount of alloying element (.05 to 0.15%). Standard alloying element include: niobium, vanadium, titanium, molybdenum. They are known for refine grain refinement and precipitation hardening. Micro-alloying exercised initially, in the 1960 and 1970, to flat-rolled, low-carbon steel for higher strengths, in which low-temperature controlled rolling inhibit austenite recrystallisation and promotes very fine ferrite grain sizes with excellent combinations of toughness and strength[1]. Many researchers attempt to change the microstructure either by cooling rate or by changing the chemical composition of microalloying element. Primary microstructure of micro alloy steel consist ferrite pearlite microstruture that can be modified by such practices [2].

Vanadium is mostly added for precipitation hardening. The precipitation strengthening increases the Strength up to 50 to 100 MPa. Vanadium precipitates during austenite ferrite transformation at the interphase boundaries. This precipitation density can be further increased by refinement of Vanadium Precipitate, and in the recent time refinement is done by increasing the percentage of nitrogen in steel [3-4]. It is also evident that by increasing the amount of nitrogen content in the steel the precipitation of vanadium can be promoted and greater precipitation strengthening effect can be achieved. In Present research work Precipitation sites are generated by the thermo mechanical processing. During thermo mechanical processing, the dislocation density increases which generate more nucleation sites for the V(C,N) precipitates. It is also reported by many workers that Vanadium carbonitrides is relatively less stable and dissolved in solid solution at relatively lower temperature as compared to the vanadium carbide and vanadium nitride [5]. This makes V an eminent choice for strong and easily controllable precipitation strengthening. Further higher solubility of vanadium carbonitrides in austenite reduce the tendency towards hot cracking in structural steel.

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Microalloying elements such as V, Nb and Ti used over conventional low alloy steels to improve the strength and ductility simultaneously[6].In this research work is thermomehanical treatment is carried at 800°C temperature so that large number of nucleation sites created for the strain induced precipitations that results into the strengthening effect.

This is why the attempts are made to study Microstructure and mechanical behaviour of hot rolled V- microalloy steel subjected to the pre chosen thermo mechanical treatment schedule. Thermo mechanical simulation is carried out to impose the prechosen deformation on to steel and then the microstructure and mechanical properties is monitored by elaborate microscopic studies.

2. Alloy Preparation and experimental procedure

Alloys is prepared through casting with a prechosen composition of Vanadium and . Alloy consist 0.067 wt % of V and 90 ppm of nitrogen as given in table-01.

Table.1 Elements of Alloy

C	Mn	Si	V	N(ppm)
0.20	1.46	0.35	0.067	90

Alloy of prechosen composition heated within the furnace at a heating rate of 3°C/s upto the holding temperature of 1000°C. Alloy kept at a temperature of 1000°C up to an hour for uniform austenization. Upon leaving from the furnace Alloy was hot rolled in rolling mill by thickness reduction of 60% at 800°C. Subsequently Alloy was normalised. The schematic diagram of thermo-mechanical processing is shown in Fig.1.

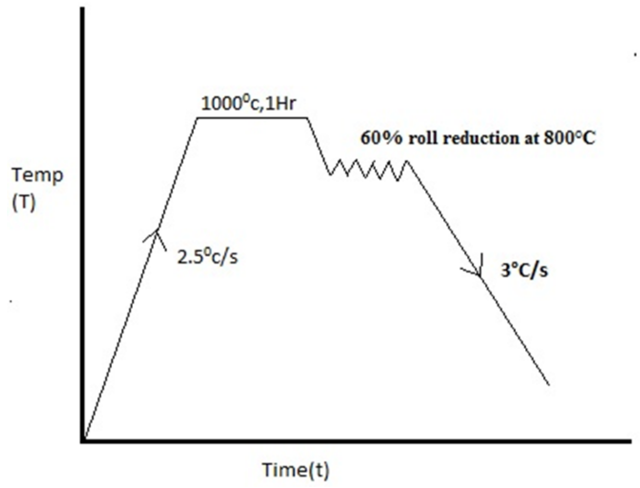

Figure 1.Schedule of Thermomechanical Treatment

3. Results and discussion:-

3.1.Optical study:-

Optical micrograph study of the 60% rolled alloy reveals the bimodal grains up to some extent that contains the ferrite and pearlite phase shown in Fig.02. In other words fine ferrite grains present with the coarser grain. The pearlite phase reuced significantly due to the strain induced precipitation of vanadium carbonitrides[7-8]. Comparative study of cast alloy and hot rolled alloy also shows that the amount of white phase is increases with the deformation. The notches of layered structure of pearlite are crack propagation sites, that reduced the mechanical properties such as impact strength toughness and ductility significantly [9-10]. There are many ways to reduced the formation of pearlite such as increase cooling rate [11], varying the composition by adding the microalloy element such as vanadium, niobium and titanium. But varying chemical composition becomes effective when it is associated with thermo mechanical processing. Vanadium posses strong affinity towards carbonitrides and produces vanadium carbonitrides V(C,N)[12-13]. The coarsening of austenite grain is restricted by the vanadium carbonitrides results in grain refinement of ferrite[14].

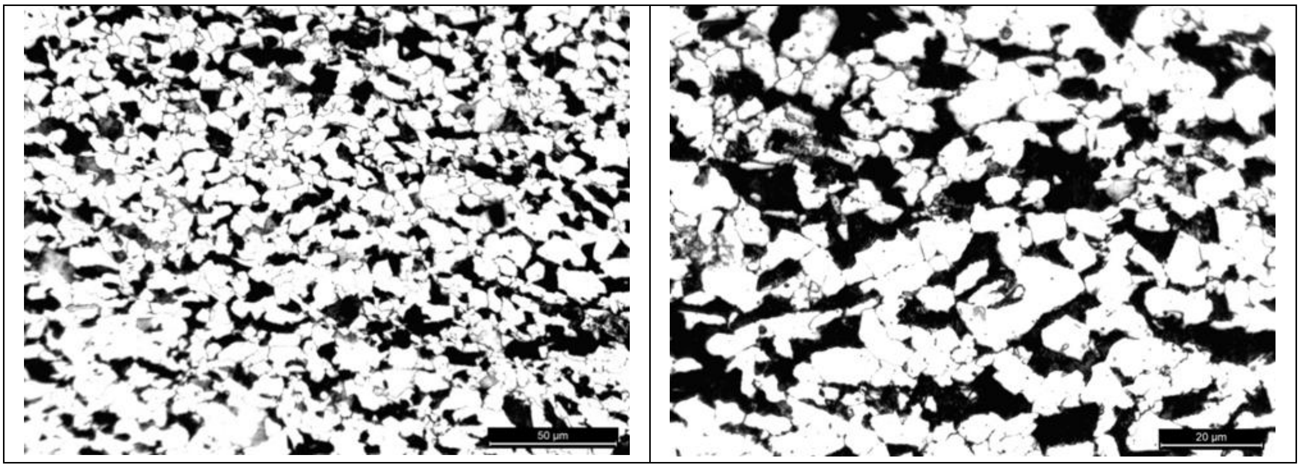

Figure.2 Optical micrograph study of the 60% hot rolled alloy.

3.2.SEM Study:-

The details microstructure reveals in scanning electron micrograph shown in Fig. 3. SEM micrograph confirms the presence of fine ferrite surrounded by coarse grain structure. SEM images also show some retained austenite surrounded by pearlite grains[15-16]. There is significant reduction in the amount of pearlite this is due to thermo-mechanical treatment of alloy. Thermomechanial treatment provides large number of nucleation sites for the vanadium carbide and nitrides[17-18]. Reduction in pearlite phase is the lear evidence of increase in mechanical properties of hot rolled.

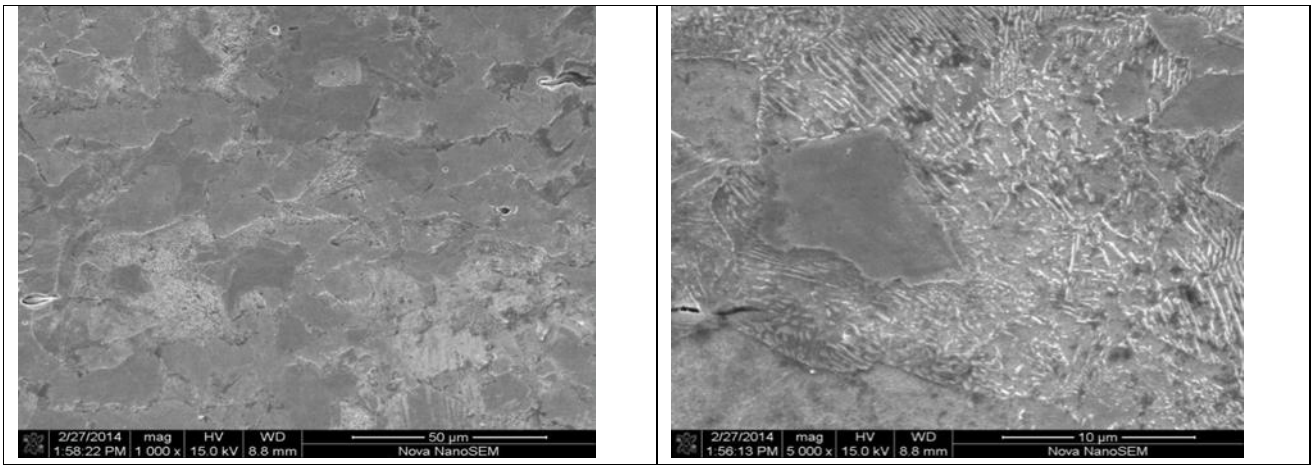

Figure 3.SEM micrograph study of the 60% hot rolled alloy

3.3.Tensile Test

The tensile test curve is shown in figure 3. The flat sample of gauge length 20mm was prepared. Total elongation after fracture is also measured. Test was conducted on Instron1126 testing machine. The tensile test curve shows ultimate tensile strength of 642MPa and yield strength of 502 MPa. Plot also shows that the total % elongation of alloy is 25%. It is clear from the tensile plot that alloy consist the combination of both strength and ductility.

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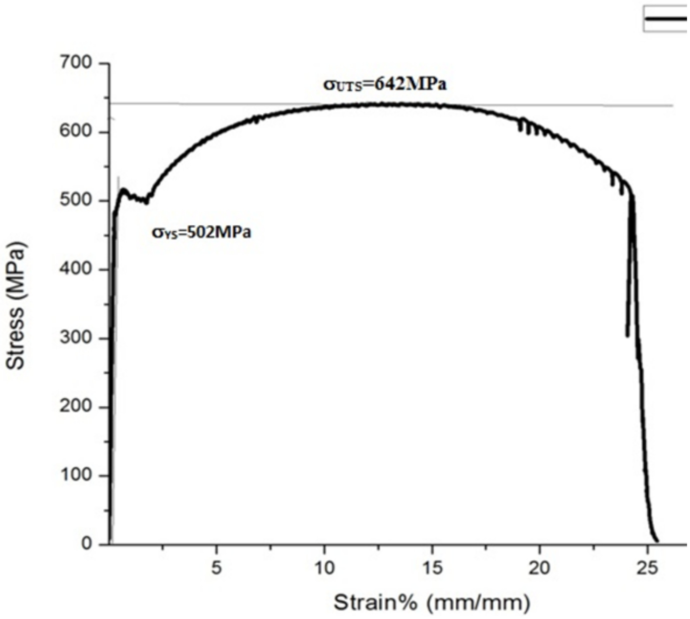

Figure 3. Tensile Test curve of Alloy.

4. Conclusion

Microstructure and mechanical behaviour of hot rolled V- microalloy steel was under observation following conclusion are derived.

- Thermo-mechanical processing of vanadium microalloyed steel refines the ferrite-pearlite microstructure.
- Reduction in pearlite phase is an evidence of increase in impact strength of alloy.
- The ultimate tensile strength and yield strength of alloy are 642 MPa and 502 MPa respectively.
- The % Elongation of alloy is 25%.

References:-

1. Show, B. K., Veerababu, R., Balamuralikrishnan, R., & Malakondaiah, G. (2010). Effect of vanadium and titanium modification on the microstructure and mechanical properties of a microalloyed HSLA steel. *Materials Science and Engineering: A*, *527*(6), 1595-1604.
2. Okamoto, R., Borgenstam, A., & Ågren, J. (2010). Interphase precipitation in niobium-microalloyed steels. *Acta Materialia*, *58*(14), 4783-4790.
3. Da Silva, M. L. N., Regone, W., & Button, S. T. (2006). Microstructure and mechanical properties of microalloyed steel forgings manufactured from cross-wedge-rolled preforms. *Scripta Materialia*, *54*(2), 213-217.
4. Wei, S., & Zhu, J. (2006). Effects of vanadium and carbon on microstructures and abrasive wear resistance of high speed steel. *Tribology International*, *39*(7), 641-648.
5. Lagneborg, R., Siwecki, T., Zajac, S., & Hutchinson, B. (1999). The role of vanadium in microalloyed steels. *Scand. J. Metall*, *28*(5), 186-241.
6. Bepari, M. M. A. (1990). Effects of precipitates on strength and toughness of vanadium structural steels. *Materials science and technology*, *6*(4), 338-348.
7. Todić, A., Čikara, D., Todić, T., & Čamagić, I. (2011). Influence of vanadium on mechanical characteristics of air-hardening. *FME Transactions*, *39*(2), 49-54.
8. Lei, X. U., Wang, C. Y., Liu, G. Q., & Bai, B. Z. (2009). Hot deformation behavior of medium carbon VN microalloyed steel. *Transactions of Nonferrous Metals Society of China*, *19*(6), 1389-1394.
9. Singh, A. P., & Pant, G. (2020). Mechanical behaviour of vanadium microalloyed steel under control environment compression. *Materials Today: Proceedings*.
10. Singh, A. P., Singh, B., & Saxena, K. K. (2019). Precipitation Behaviour of Microalloyed Steel During Hot Deformation. *Materials Today: Proceedings*, *18*, 4821-4825.
11. Pant, G., Singh, A. P., & Sharma, H. K. (2020). Cooling rate characteristics of vanadium based micro alloyed steel. *Materials Today: Proceedings*.
12. Chun, X., Sun, Q., & Chen, X. (2007). Research on transformation mechanism and microstructure evolution rule of vanadium–

nitrogen microalloyed steels. *Materials & design*, *28*(9), 2523-2527.

13. Ceschini, L., Marconi, A., Martini, C., Morri, A., & Di Schino, A. (2013). Tensile and impact behaviour of a microalloyed medium carbon steel: effect of the cooling condition and corresponding microstructure. *Materials & Design*, *45*, 171-178.

14. Babakhani, A., Kiani-Rashid, A. R., & Ziaei, S. M. R. (2012). The microstructure and mechanical properties of hot forged vanadium microalloyed steel. *Materials and Manufacturing Processes*, *27*(2), 135-139.
15. Van Tyne, C. J, Matlock, D. K., & Speer, J. G. (2008). Microalloyed forging steels. *Colarado School of Mines, https://www. forging. org/uploaded/content/media/_376VanTyne_0_0. pdf*.
16. PAN, T., CUIYin-hui, S., & ZHANGYong-quan, Y. F. (2003). Effect of Vanadium on the Strength and Toughness of Wheel Steel at Different Reheat Temperatures. *High-tech Research and Development Program of China*, 161-165.
17. Caifu, Y. A. N. G., & Glodowski, R. J. Research, Production and Application of VN Microalloyed High Strength Reinforcing Bar for Building in China.
18. Adrian, H., & Staśko, R. (2008). The effect of nitrogen and vanadium on hardenability of medium carbon 0.4% C and 1.8% Cr steel. *Archives of Materials Science and Engineering*, *33*(2), 69-74.