

The Effect of Heat Treatment to Tensile Properties of Intermetallic Nickel Aluminide

Halida Hanim Hafiz Afandi, T. Joseph Sahaya Anand*, Intan Sharhida Othman, Sivarao Subramonian

Fakulti Kejuruteraan Pembuatan, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.

*Corresponding e-mail: anand@utem.edu.my

Keywords: Tensile; intermetallics; nickel aluminide

ABSTRACT – Intermetallic Nickel Aluminide are having good electrical and mechanical properties. The current material that is used in wheel hub requires heat related influence. Intermetallic aluminides can be consider to replace this annealed at suitable temperature to replace the existing material. The sample are tested for mechanical properties with respect to various heat treatment. The result shows that intermetallic aluminides is a good candidate material for wheel hub application. The annealing temperature used specifically 400°C, 500°C and 600°C provide or maintain the strength to weight ratio. Result show that as the value of Young's Modulus are 0.0758 MPa at room temperature, 0.0819 MPa at 400°C, 0.0956 MPa at 500°C and 0.078 MPa at 600°C. The value of tensile strength are 96.44 MPa, 71.01 MPa, 63.72 MPa and 59.98 MPa as the temperature increase. Lastly, the value of tensile strain are 2.16 at room temperature sample, 1.48 at 400°C, 1.00 at 500°C and 1.27 at 600°C. This shows that heat treatment samples affect its mechanical properties.

1. INTRODUCTION

Wheel hub plays an important role in tyre mechanism. Studies had concluded that spokes region are the most risky for failure of hub. Furthermore, when there is an excessive force acting on the tyre, the spokes of the tyre may able to break, thus the hub will also break causing the wheel to be immediately instable [1]. Material and design plays an important role for wheel hub performance. Aluminium is a lightweight material, unfortunately its physical strength is relatively small which will affect the hub structure and performance. Hence, to overcome this issue, a light weight material and good in other properties is needed.

Intermetallic aluminides are not only lightweight but also possess superior properties such as resistant to corrosion, less fuel emission, high physical strength etc. [2]. This proves that the intermetallic aluminides has appeared to be as one of the material having high potential for a wide range of technological application in some of the essential areas.

Heat treatment involves the heating and cooling process through time of metal without altering the specimen shape. This process affect the mechanical properties thus microstructure of the material after heat treatment process can be observe. Based on the literature [3], one of the function of heat treatment is to improve the performance and properties of the materials. This process consists of different stages which mainly includes annealing, tempering and quenching.

Tensile testing is essential in mechanical testing as it can provide many result that shows the materials' characteristics and mechanical behaviour. In applying material for wheel hub in simulation, tensile test result are needed as the input data for finite element analysis. For this testing, the material is held on universal testing machine (UTM) and pulled until it breaks. This procedures can give a result of stress-strain curve. From this curve, results such as Young Modulus, yield strength, ultimate tensile strength and more can be obtained. Hooke's law is about the relationship between stress and strain of material. This property of material is called linearly elastic [4]. In stress and strain curve, the phase can be divided into elastic and plastic.

2. METHODOLOGY

2.1 Material

Nickel Aluminide plate had been casted into 200mm × 140mm × 6mm with the composition of 75% nickel and 25% of aluminium.

2.2 Heat Treatment

The procedure starts with heat treatment of the samples by using furnace. The temperature were set at 400°C, 500°C and 600°C. The reason those temperature were selected because temperature during a collision can increase up to 500°C. Thus, 400°C and 600°C is the upper and lower value of the above state. For annealing on alloy material the sample need to soak for 1 hour.

2.3 Tensile Test

For tensile testing, the sample had been cut into dog bone shape following ASTM E8 Standard Test Methods for Tension Testing of Metallic Materials. Figure 1 shows the Nickel Aluminide samples that had been cut by using water jet machine.



Figure 1 Tensile test sample

3. RESULT AND DISCUSSION

Figure 2 shows the stress-strain curve for all the four parameters. Each shows similar curve pattern but different limit of stress and strain values.

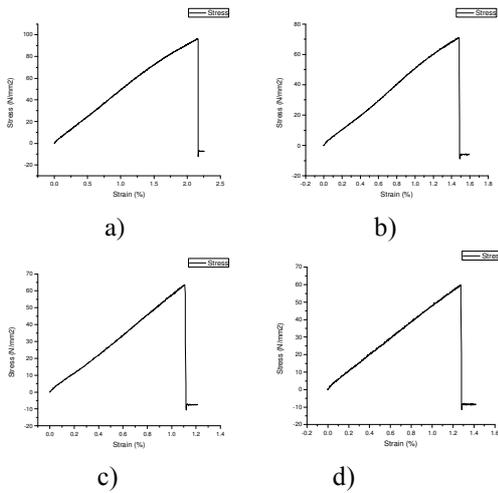


Figure 2 Stress and strain curve for a) non-heat treated b) 400°C c) 500°C d) 600°C

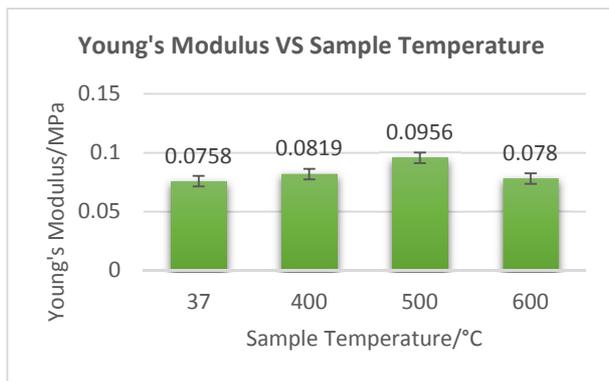


Figure 3 Young's Modulus of heat treated and non-heat treated Nickel Aluminide sample

Referring to the results obtain from Figure 3, the value of Young's Modulus is generally increase as the temperature of the heat treated samples increase. Since Elastic modulus means the rate of elasticity of the material, this indicates that the Nickel Aluminide tend to be more elastic as the temperature increase.

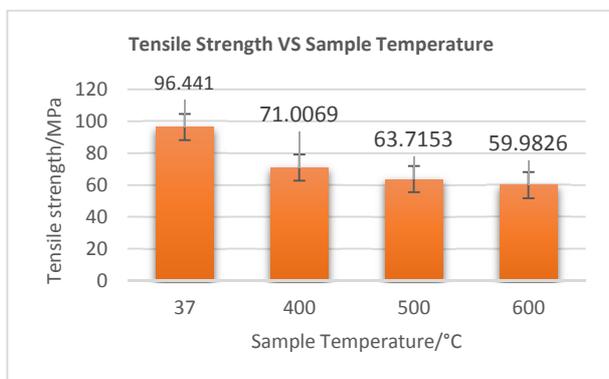


Figure 4 Tensile strength of heat treated and non-heat treated Nickel Aluminide sample

Based on Figure 4 the results shows the tensile strength tend to decrease the temperature of the sample went higher. The higher the value of tensile strength shows the harder the material.

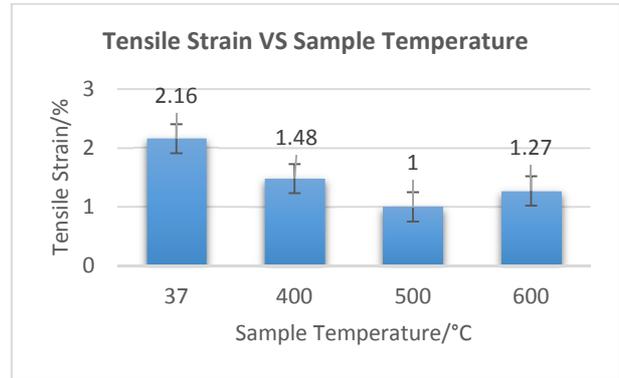


Figure 5 Tensile Strain of heat treated and non-heat treated Nickel Aluminide sample

Figure 5 displays the tensile strain pattern that is decreasing with temperature. As the temperature increase the material expand less or in other words less elongation.

4. CONCLUSION

Different temperature of annealing shows different mechanical performance. As the temperature of the sample increase, the Young's Modulus increase, the tensile strength and strain decrease.

ACKNOWLEDGEMENT

Authors are grateful to Universiti Teknikal Malaysia Melaka for the financial support through PJP/2017/FKP/HI15/S01549.

REFERENCES

- [1] A. Pandya and S. Thakkar, "Research Paper on Design Modification and Analysis of Automobile Wheel Rim Using Finite Element Analysis," *International Journal for Scientific Research & Development*, vol. 3, no. 3, pp. 3027-3030, 2015.
- [2] N. Jacob Mathew, D.K. Sahoo and E. Mithun Chakravathy, "Design and Static Analysis of Airless Tyre to Reduce Deformation," in *IOP Conference Series: Materials Science and Engineering*, Chennai, India, 2017.
- [3] D.A. Fadare, T.G. Fadara, O.Y. Akanbi, 2011 Effect of Heat Treatment on Mechanical Properties and Microstructure of NST 37-2 Steel, *Journal of Minerals & Materials Characterization & Engineering*, Vol.10, No.3, pp.299-308.
- [4] N.M. Ismail, N.A.A. Khatif, M.A.K.A. Kecik, M.A.H. Shaharudin (2016). "The Effect of Heat Treatment on the Hardness and Impact Properties of Medium Carbon Steel." *IOP Conference Series: Materials Science and Engineering 2016*, 2016, pp. 1-9.