www.dergipark.gov.tr
ISSN:2148-3736
El-Cezerî Fen ve Mühendislik Dergisi
Cilt: 4, No: 3, 2017 (349-354)

El-Cezerî Journal of Science and Engineering
Vol: 4, No: 3, 2017 (349-354)

ECJSE

Research Paper / Makale

Investigation of Mechanical Properties of Fe-Doped Intermetallic NiAl

İsmail YILDIZ[1], Ayhan EROL[2]

[1]Afyon Kocatepe University, Iscehisar Vocational School, Afyonkarahisar/Turkey
[2]Afyon Kocatepe University, Technology Faculty, Afyonkarahisar/Turkey
[1]iyildiz@aku.edu.tr

Received/Geliş: 15.03.2017 **Revised/Düzeltme:** 12.06.2017 **Accepted/Kabul:** 20.06.2017

Abstract: Last few decades intermetallic materials such as NiAl are mechanical and physical properties for high temperature practice. Especially high melting point, excellent oxidation resistance and high hardness properties draw the attention in that intermetallics. It is known that Ni-Al intermetallics are commonly used in various application fields with the addition of Fe, in particular as well as elements such as Ti, Cr, Mo and Co which are related to this group for improving properties thereof. It is especially determined that Fe additive provides positive results in terms of moderate intensity, high strenght and corrosion resistance in the produced intermetallics. Sintering process was used in this work, NiAl powder mixture and Fe powder were sintered at different temperatures. Scanning electron microscopy imaging, EDX line analysis tests performed respectively to sintering samples.

Keywords: Sintering, intermetallics, powder, sample.

Fe Katkılı NiAl İntermetaliklerin Mekanik Özelliklerinin İncelenmesi

Özet: Son yıllarda NiAl gibi intermetalik malzemeler, yüksek sıcaklık uygulamalarında iyi mekanik ve fiziksel özellikler göstermektedir. Özellikle yüksek erime noktası, iyi oksidasyon direnci ve yüksek sertlik bu intermetaliklerin en dikkat çeken özellikleri arasındadır. NiAl intermetalikler, Fe katkılı malzemenin yanında Ti, Cr, Co ve Mo gibi malzemelerin katkısıyla çeşitli uygulamalarda kullanım alanına sahiptir. Özellikle Fe katkılı intermetalikler, yoğunluk, yüksek dayanım ve iyi korozyon direnci gibi özellikler sergilemektedir. Bu çalışmada NiAl toz karışımı ile Fe tozu farklı sinterleme sıcaklığında sinterlenmiştir. Sinterlenen numunelere sırasıyla SEM ve EDX analizleri gerçekleştirilmiştir.

Anahtar kelimeler: Sinterleme, intermetalik, toz, numune.

1. Introduction

The NiAl intermetallics have attracted industry's attention an exceptional combination of high strengt hand low weight, low intensity, good oxidation/corrosion resistance, thermal stability and high fracture toughness combined with its ability at high temperature. Nevertheless, low conductivity and brittle fracture is a serious obstacle its application [1-4]. The B2 additions could critically prove the ductility of NiAl at atmospheric and high temperatures [5]. Ni–Fe alloys have been worked broadly because in the power generation, automobile and petrochemical industries at temperatures higher than the creep limit for ferritic-martensitic steels or the oxidation–corrosion limit for austenitic stainless steels [6,7]. These improved alloys are intented to their theoretical limits of alloying elements for ideal unification of diverse alloy features. [8,9].

How to cite this article
Yıldız, İ., Erol, A., "*Investigation of Mechanical Properties of Fe-Doped Intermetallic NiAl*" El-Cezerî Journal of Science and Engineering, 2017, 4(3); 349-354.

Bu makaleye atıf yapmak için
Yıldız, İ., Erol, A., *"Fe Katkılı NiAl İntermetaliklerin Mekanik Özelliklerinin İncelenmesi"* El-Cezerî Fen ve Mühendislik Dergisi 2017, 4(3); 349-354.

The aim of this work is to define the sintering capability of compound changed Fe–Ni–Al alloys and to study the microstructural development of this multi-phase alloys owing to thermo-mechanical treatment [10-12]. A broadly of conversion and magnetic progression temperatures can be ordered in these alloys by changing the Al ingredient lightly [13,14].

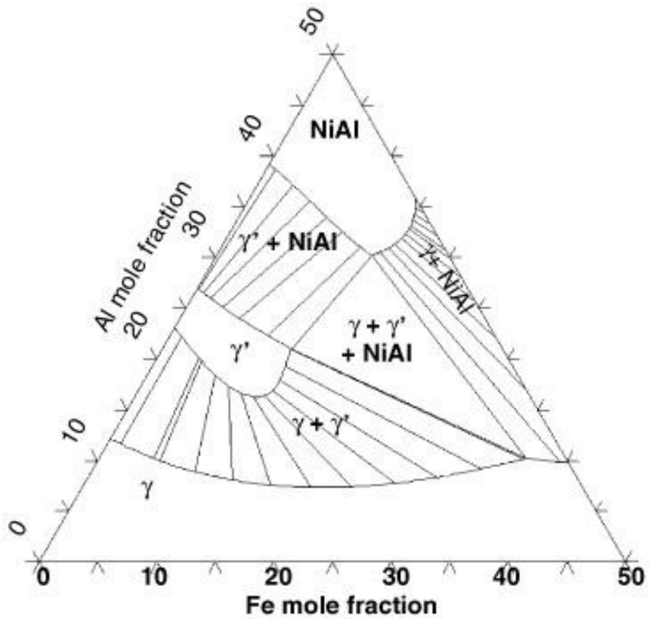

Figure 1. Ni-Al-Fe ternary phase diagram [15].

The aim of this work is to make NiAl-Fe intermetallic by sintering at 585 °C. The intermetallics acquired with supplement of Fe have fall weight, maximum strenght, and high temperatures. This information the mechanic properties of acquired Fe coped NiAl will be examined.

2. Experimental Method

For obtaining intermetallic pattern Al and Fe as well as Ni material were mixed equally for 24 hours in specific proportions for produce a Ni based intermetallic. For this process the crude material powders mixed in mixer. The mixture was shaped by cold hydraulic pressing. In forming process the pressing pressure is 300 atm. Pressed patterns have spended sintering for 2 h. 585 °C in a tube furnace within Ar gas atmosphere. The purpose of sintering process is packaging the particle of raw materials by the way increasing the hardness of patterns by heat treating. Patterns with air-cooled after sintering were tested for rigidity, intensity and shear strength, respectively. Also XRD and SEM were practicaled to patterns.

3. Empiric Results

3.1 Intensity

The intensity of the patterns acquired after sintering were calculated by intensity formula (Figure 2). Here m is the bulk of sintered pattern; v is the measure of sintered pattern, calculated volumetrically. When Figure 2 is investigated maximum intensity is in 40% Fe added mixture as 4.71 gr/cm^3 and the minimum intensity has 4,44 gr/cm^3 values in 20% Fe added blend. According to these rates, intensity values also increased depending on Fe ratio.

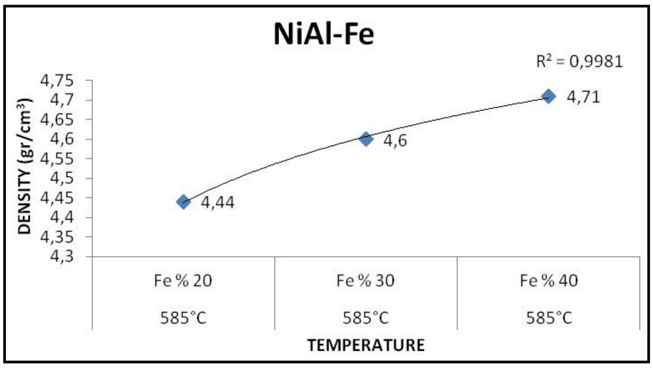

Figure 2. Density graphic of NiAl-Fe composite materials

3.2 Hardness

The hardness values of the patterns were measured in Brinell depending on the sintering effect (Figure 3). 10 mm diameter spherical balls were used in the brinell test measurement. The proximate data has taken that performed any 3 places on pattern. This is done to find the average hardness value.

When Figure 3 is explored while the top values was acquired in 40% Fe added blend as 186 HB, the minimum values was acquired in 20% Fe added blend as 171 HB. The cause for hardness rates to be very high in 40% Fe added intermetallic material is proposed to be that Fe ratio can be increased depending on the effect of sintering.

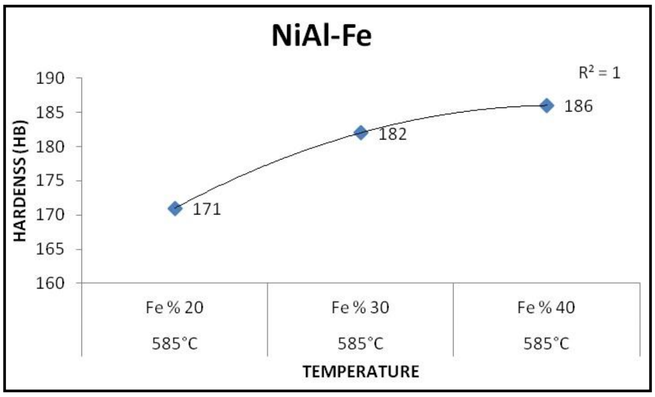

Figure 3. Hardness graphic of NiAl-Fe composite materials

3.3 Volumetric Change

The volumetric changes of NiAl-Fe composite material after sintering were calculated by using (d=m/V) calculation formula (Figure 4). The volumetric change in the patterns before and after sintering was measured by the principle of Archimedes.

When Figure 4 is studied it can be considered that reduces in volumetric changes of composite materials consist of against proportional to increases in intensity rates when compared to pre-sintering. While the maximum volumetric change was acquired in 40% Fe added mixture with 1.85 cm^3, the minimum volumetric change was 2,16 cm^3 in 20% Fe added mixture.

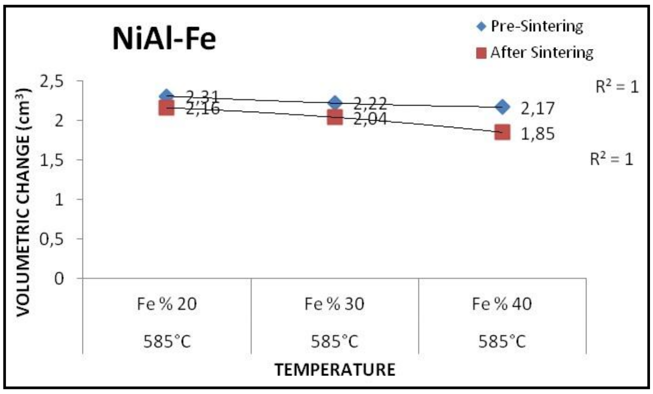

Figure 4. Volumetric change graphic of NiAl-Fe composite materials

3.4 Xrd Analysis

XRD analyzes were performed on the samples after sintering.(Figure 5 and Figure 6). While studiying Shimadzu XRD-6000 XRD device was handled. Cu K (alpha) was preferred as X Ray. However, the scanning step occurred at the speed of 0,02 °/min and the scanning angle was assessed as 2 Theta. To state the values of phase, XRD-6000 V4.1 program was used. When the analysis conclusions were acquired, the maximum peak rate was watched in Fe phase among the sintered composite materials. NiAl phase has the other maximum peak rate. It is expected that NiAl peak rate point out the effect of Fe with Al within the intermetallic material.

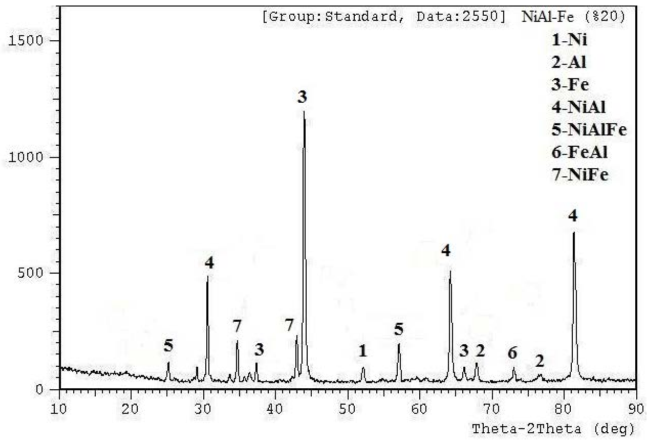

Figure 5. XRD graphic of Ni-Al-20% Fe composite material

The XRD analysis conclusion of 40% Fe added blend is observed in Figure 6. As it is observed in the Figure too, Fe phase has the maximum rate. It is observed that NiAl phase follows this phase. It is expected that this case point outs that Ni element perhaps composed within the intermetallic material.

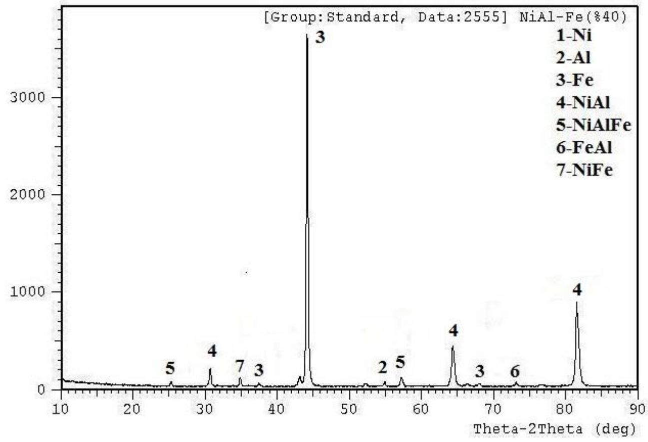

Figure 6. XRD graphic of Ni-Al-40% Fe composite material

When Figure 5 and 6 are investigated it is observed that intermetallic phase created in Ni-Al-Fe compound after sintering is Ni, Al, NiAlFe, NiAl, FeAl, Ni, NiFe.

3.5 SEM Analysis

SEM analysis of the intermetallic materials obtained relying on sintering effect was performed (Figure 7). When SEM images were analyzed, it is observed that over homogeneous and less spongy structure 20, 30 and 40% Fe added materials. The reason of obtaining less- spongy structure is over sintering. It is considered that this condition indicates that Fe material in the intermetallic material could rise the sintering temperature by reacting with other materials.

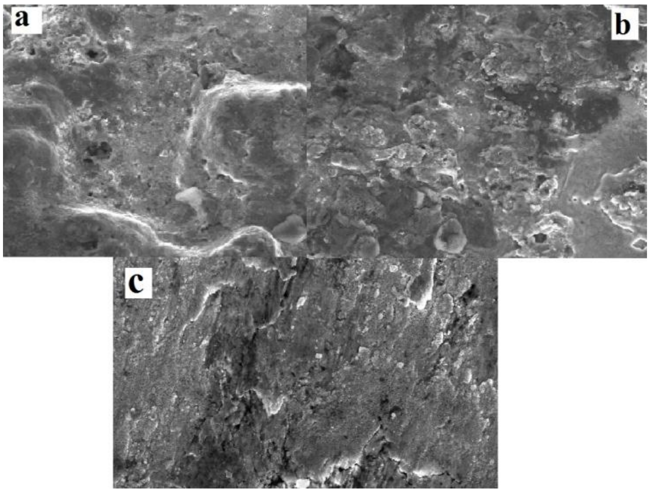

Figure 7 SEM images of NiAl-Fe composite materials, a) 20% Fe added composite material, b) 30% Fe added composite material, c) 40% Fe added composite material

4. Conclusion

The following results were obtained from the experimental findings;

- The highest density value was calculated in 40% Fe added composite material as 4.71gr/cm^3 (Figure 2).
- The highest hardness value was measured as 186 HB hardness in 40% Fe added composite material among the sintered composite materials.

- The highest hardness value in respect to intensity is inspected in 40% wt Fe composite material. The reason creates this hardness value is liquid phase in sintering media causing by high aluminum content.
- Hardness values have also increased in the density values. It is estimated that highest density value of the Fe composite caused by high hardness of pattern.
- When the SEM images of sintered patterns investigates it is clear that successfully created with 40% Fe added intermetallic material.

References

[1] Bochenek, K., Basista, M., "Advances in processing of NiAl intermetallic alloys and composites for high temperature aerospace applications", *Progress in Aerospace Sciences*, 79, 136–146, (2015).

[2] Morsi, K., "Review: Reaction Synthesis Processing of Ni–Al Intermetallic Materials", *Material Science Engineering*, 299, 1–15, (2001).

[3] Scheppe, F., Sahm, P. R., Hermann, W., Paul, U., Preuhs, J., " Nickel Aluminides: a Step Toward Industrial Application", *Material Science Engineering*, 329–331, 596–601, (2002).

[4] Liyang, Y., Guo, J., Zhou, L., Zhang, C., Lin, J., "Effect of overheating treatment on the microstructure of NiAl-based alloy", *Materials Letters*, 64, 1707–1709, (2010).

[5] Shekhar, R., Arunachalam, J., Das, N., Srirama Murthy, A. M., " Chemical and structural characterisation of nickel based superalloys doped with minor and trace elements", *Materials Science and Engineering A,* 435-436, 491-498, (2006).

[6] Elvira, G., Salvador, P., Elisa, V., *Electrochim. Acta*, 51, 146, (2005).

[7] Liping, W., Yan, G., Qunji, X., Huiwen, L., Tao, X., *Apply Surface Science*, 242, 326, (2005).

[8] Oikawa, K., Wulff, L., Lijima, T., Gejima, T., Ohmori, T., Fujita, A., et al. *Appl. Phys. Lett*. 79, 3290–2, (2001).

[9] Oikawa, K., Omori, T., Sutou, Y., *J Phys*. 112, 1017–20, (2003).

[10] Gazda, A., Čermák, J., " Diffusion in Ni_3Al-Co Intermetallic", *Metal*, 14-16, (2002).

[11] Kainuma, R., Ise, M., Jia, C. C., Ohatani, H., Ishida, K., *Intermetallics*, 4, S151–8, (1996).

[12] Oikawa, K., Ota, T., Gejima, F., Ohmori, T., Kainuma, R., Ishida, K., *Mater. Trans*. 79, 2472–5, (2001).

[13] Murakami, Y., Shindo, D., Oikawa, K., Kainuma, R., Ishida, K., *Acta Mater*. 50, 2173–84, (2002).

[14] Morito, H., Fujita, A., Fukamichi, K., Kainuma, R., Ishida, K., *Appl. Phys. Lett*. 81, 1657–9, (2002).

[15] http://www.nims.go.jp/htm21/documents/990705b.htm, (2010).