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STUDY THE MATERIALS AND MECHANICAL PROPERTIES OF NI-25%WT TA ALLOY

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A B S T R A C T

Nickel and Tantalum alloys have a wide range of capabilities biomedical applications due to its high degree of biocompatibility, Favorable mechanical properties and high corrosion resistance The possibility of Osseointegration. In this study, all the alloys were prepared by powder metallurgy Then the alloying element (indium as a binder with different structural composition) in different groups (0.6, 0.7, and 0.8 wt.%) to the main alloy (75 wt.% Ni-25wt% Ta) for to study the effect of these elements on microstructure characterization (XRD, SEM, EDS, XRF and light optical microscopy) and mechanical properties (compression, hardness, Wet sliding corrosion tests) for this alloy. The compact pressure was determined as 800MPa and the green alloyed sintered at 700 oC for 5h in inert gas (Argon), then the samples cooled in the furnace.

1. INTRODUCTION

Shape memory alloys (SMAs) are metallic substances with the capacity to regain their original shape in response to outside stimuli. Due to their high melting points and exceptional resistance to extreme climatic conditions, binary Ni-Ta alloys have drawn attention. This work examined the impact of various Ta contents on the structural, morphological, and transformation characteristics of the binary Ni-Ta high-temperature SMA system (Koksal, 2019). Powder metallurgy is a method of alloy preparation in which metal powders are pulverized to produce the appropriate forms, then heated by a process called sintering to bind the particles together to form a cohesive mass (solid block) at specific pressure levels (Abtan and Hussein, 2016; Novák, 2020). Using a press machine with a number of costly custom-made and engineered components, such as a die and piston, and then sintering at a temperature below the melting point of the base metal. NiTa shape memory alloys are highly useful in biological and technical applications because to their formability and shape memory characteristics. Because these alloys are difficult to produce by casting because their constituents are immiscible in liquid form or difficult to melt, powder metallurgy has gained popularity in recent years (Koehler, 2015). Because of the rapid industrial development, materials scientists have been pushed to find alternatives to materials used in essential industries, such as complex NiTa alloys, which allow microstructure manipulation and thus critical alloy features like high elastic behavior and transition temperatures (Altug-Peduk et al., 2018).

1.1 Ball milling

For powders to have the necessary fineness, milling is one of the most important and widely utilized processes.

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Materials that are malleable and ductile metals as well as friable, friable, tough, and hard materials are all included in this category. It involves applying force to the material that needs to be atomized (Wu et al., 2013). For at least 8 hours, wet mixing was done (Kumar et al., 2020). The NiTa alloy is churned in a cylindrical pod with the help of a large number of balls made of a solid substance that is resistant to erosion, as shown in the drawing of a simplified planetary (spherical) mill. The powder produced is also less polluted as a result of the minimal wear on the balls and mills.

Figure 1. Ball milling

Drums for rotating mills are frequently made of stainless steel or steel that has been lined with sturdy alloy plates (Alnomani et al., 2017). Steel or a strong alloy is used to make the balls. Because grinding using other methods will cause the final powder to be polluted with Iron (not less than 0.5%) due to the occurrence of corrosion of the inner surface of the pods with the balls.

2. EXAMINATIONS

2.1 Light microscopy examinations

2.1.1 X-Ray diffraction Analysis (XRD)

Powder XRD was performed for both nickel and tantalum for the purpose of compatibility, after that an XRD test was performed for the selected core sample before and after sintering and as shown in the figures 2-5.

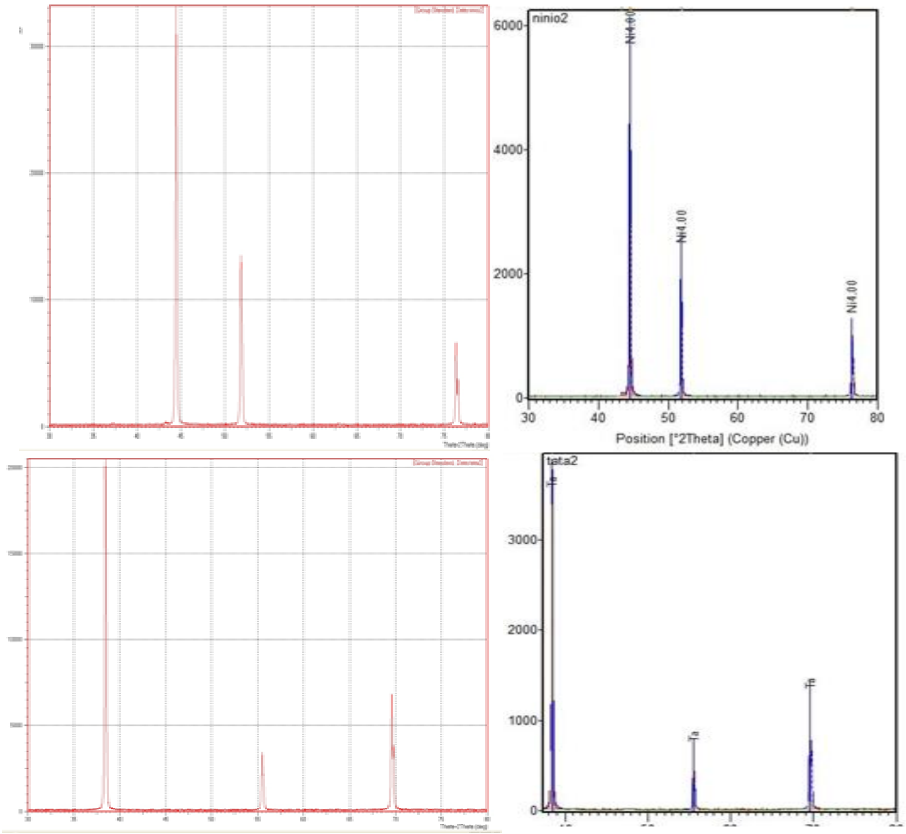


Figure 2. XRD Analysis of Ni and Ta powders

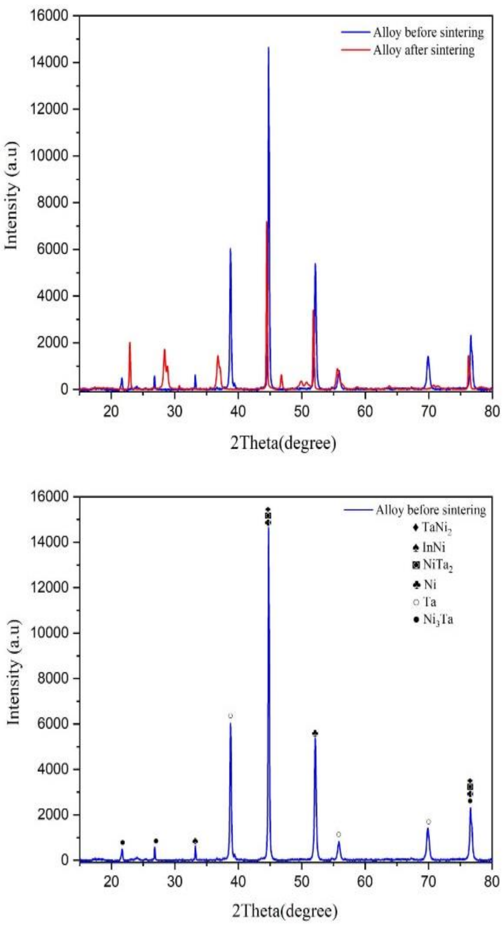


Figure 3. XRD Pattern for Ni-25Ta Alloy before and after Sintering Process

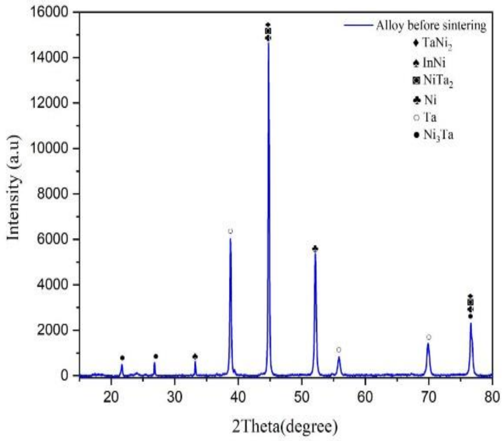


Figure 4. XRD Pattern for Ni-25Ta Alloy before Sintering Process

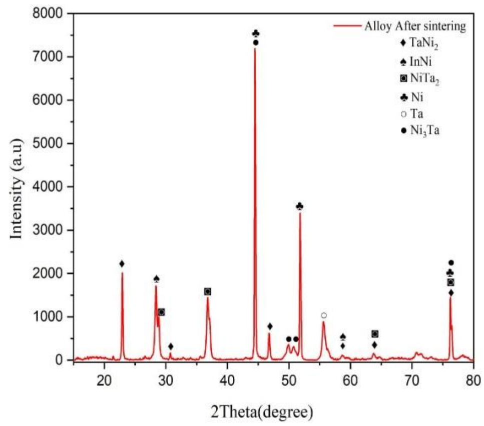


Figure 5. XRD Pattern for Ni-25Ta Alloy after Sintering Process

X-ray diffraction (XRD) characterization represents a potent analytical method employed to investigate the crystallographic arrangement, composition, and phase details within materials. Illustrated in **Figures (3,4,5) ** are XRD patterns for sample Ni-25Ta, both prior to and following the sintering process. It is evident that the XRD pattern of the alloy, prior to sintering, exhibits distinct and well-defined peaks corresponding to various multiphases, including TaNi2, Ta2Ni, Ta, Ni, Ni3Ta, and InNi. Post-sintering, new sharp peaks emerge at 22.9 and 46.7, representing TaNi2, at 28.39 and 36.8, signifying NiTa2, and at 49.9 and 50.73, denoting Ni3Ta phases.

2.1.2. Scanning Electron Microscope-Energy Dispersive spectroscopy Analysis (SEM-EDS)

In this research a device using Mira3Tescan (RMRC FESEM) was used. Made in Germany This device uses a focused beam of electrons to produce complex, high-magnification images to reveal the microstructure of NiTa powder and to describe the surface topography and porosity of the powder atoms.In addition, an energy-dispersive-ray spectroscopy (EDX) system (IMIX PGT X-ray Microanalysis) device, which is employed with SEM device, was used to provide an additional understanding of surface materials during the SEM analysis process SEM-EDS analysis is a great way to determine particle sizes and basic composition.

The microstructure of the samples after sintering is illustrated in (Figure 6). The microstructures after treatment were found to be cohesive and have high smoothing strength, and the environment is under they were designed to be very visible. It is shown in ** Figure (6) ** SEM images of the sample Ni-25%Ta. These SEM images clearly show nickel (Ni) in gray and black tones and tantalum (Ta) in white.

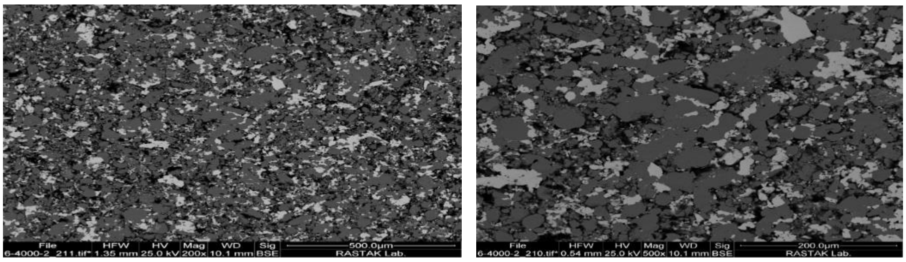
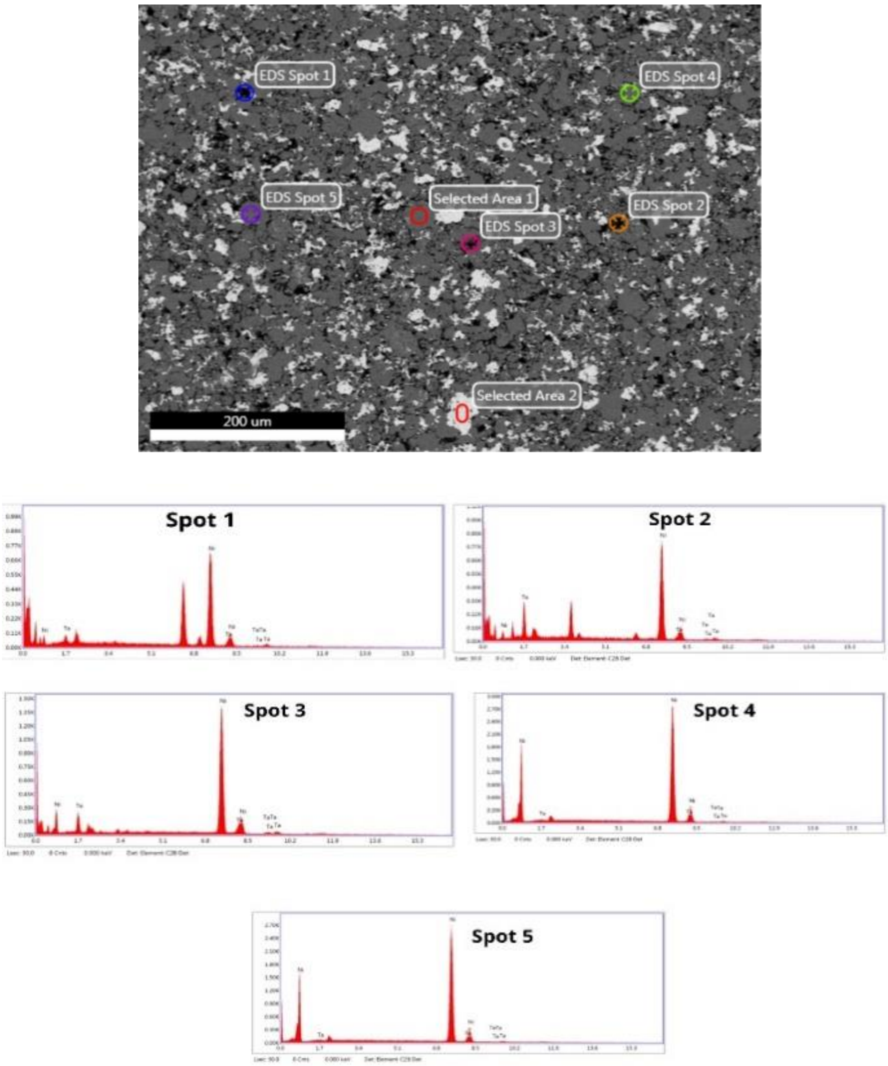


Figure 6. SEM Micrographs of specimen Ni-25Ta

For in-depth elemental analysis within specific regions of the alloy, energy dispersive X-ray spectroscopy (EDS) was used. This analytical technique shown in Figure (7) was applied to four distinct domains selected from each sample.



Position No.	Weight %		Atomic %	
	Ni	Ta	Ni	Ta
Spot 1	89.54	10.46	96.35	3.65
Spot 2	88.37	11.63	95.90	4.10
Spot 3	85.08	14.92	94.62	5.38
Spot 4	94.28	5.72	98.07	1.93
Spot 5	95.47	4.53	98.48	1.52

Figure 7. EDS Micrographs for the main sample.

3. MECHANICAL PROPERTIES

3.1 Wear Resistance Test

The samples with a diameter of (13) mm under a pressure of 800 MPa, the sintering time is 5 hours. It is subjected to a dry abrasion test under neath different load 10 and 20 N for different times (5, 10, 15, 20, 25, 30) minutes. A constant load and different times were chosen according to several experiments. The result is shown in (Figure 8).

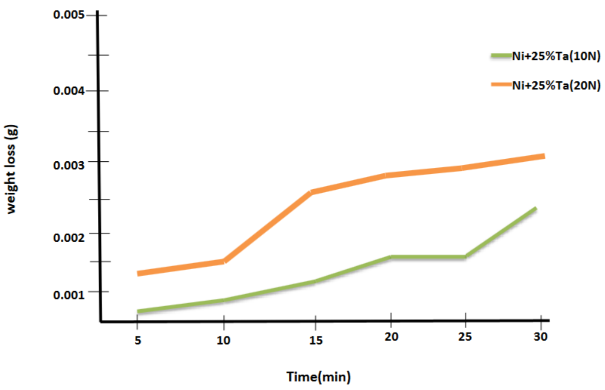


Figure 8. The relation between weight loss during wet sliding wear with time for tantalum alloy used in this work at normal load of 10 N and 20N

Figure (8) shows the relationship between the weight loss of the NiTa alloy. Against the time under a different load (10 and 20 Newtons) than this figure, the weight loss is obvious It increases gradually and slowly with increasing time, regardless of the chemical composition, and the microstructure of the alloy, due to the increase in friction in surface with increased load.

In addition, the increase in wear rate with time for all samples is due to more friction time causes more material to be removed from the surface. It can be seen weight Curve Behavior Over time, weight loss initially increases.

4. CONCLUSION

Although mineral powder technologies are easy to use, they come with a number of issues that need to be considered first. Some of these issues include mixing time, soaking time during sintering, and maximum sintering temperature.

Eight hours of mixing time used in this research was sufficient to produce a homogeneous mixture of nickel and tantalum at a ratio of Ni-25%Ta.

Argon gas with vacuum is used as the medium for sintering procedures.

The maximum sintering temperature of NiTa ingot should be 700 °C.

The hardness of the material was measured and it was found that the hardness of NiTa increased significantly.

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