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Fabrication and Characterization of Binary Fe_{60} –Co_{40} Alloy by Powder Metallurgy Method

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ABSTRACT

Binary pure powders Fe_{60} –Co_{40} (wt%) fabricated by powder metallurgy technology ,compacted at 10Mpa and heat treated at 850,950 and 1050°C for (1hr)sintering time, then slow cooling to RT. The aim of this paper to study and characterize the effect of heat treatments on the structural , microstructural and magnetic properties using x-ray diffraction (XRD), Scanning Electron Microscopy(SEM)coupled with Energy Dispersive x-ray spectroscopy (EDX) and the Vibration Sample Magnetometer (VSM).The structural results show that two face centered cubic (FCC) for Fe and Co respectively ,with a third phase of hexagonal(HCP) for Co element are observed clearly at all treated temperatures. The composition of elements in the Fe_{60}-Co_{40} alloy are also detected from EDX analysis. The SEM resulted morphology shows the aggregation as cluster of spherical particles size at 1050°C . The magnetic properties are increasing significantly with increasing the heat treatment until 1050°C and above that at 1150°C treated ,dropped suddenly.

Keywords: Fe-Co alloy ,Heat Treatment, Powder Technology, Structural properties, Magnetic behavior, Magnetic materials

I. INTRODUCTION

The 3d transition materials such as Ni, Cr, Fe, Co, Mn …..etc have been become the most interest and promising materials for several potential applications of technological scopes such as electrons, magnetic data storage, structural components and devices of motors ,generators, transformers[1,2].The magnetic materials have a marketable properties like, coercivity force (H_c), saturation magnetization (M_s), ordering temperature and the permeability [3,4].Several methods were possible to prepare the magnetic materials such as sol gel, powder metallurgy ,casting metal plasma reaction and mechanical alloying (MA)[5,6].The Fe-Co alloy system is competitive candidates materials as Fe-Ni , Co-Ni alloys, because of high curie temperature , high permeability , low coercivity ,which make them very useful for application at high temperatures [7,8].Indeed ,really there are agreed of interesting works to focus in this field of magnetic materials and there is still posses a lot of work .Therefor we, focused in this research is to study the effect of heat treatment on the structural, Microstructure and magnetic properties of Fe_{60} – Co_{40} alloy system by using powder technique method.

II. METHODS AND MATERIAL

Commercially pure Iron and Co powders (≥ 99.90%, www.nanokar.com **Istanbul/Turkey**)were used as raw materials. The materials were mixed in appropriate weight ratio to obtain Fe_{60}-Co_{40} alloy , using powder metallurgy technique. A total amount of (5g) was mixed by using powder technique method for(1hr), which is sufficient to obtain(50μm).The final mixture then was cold pressed at 10 Ton using die of (15mm) diameter and height of (5mm) .The compacted samples then heat treatment sintered at(850,950,1050) °C for $\frac{1}{2}hr$, using the Furnace Germany type (Magma2300). The samples after treatment are ready for tests .The samples analyzed by x-ray diffraction (XRD) for examining the phase structure as a function of heat treatment degrees. The x-ray diffraction equipment type Philips diffractometer was used ,with parameters(Cu-kα)filter with ($\lambda = 0.15406nm$), ranging used with 2θ from 10^o to 80^o . The magnetic properties was measured using vibrating sample magnetometer (VSM)type() with a maximum applied field(H) in the (0-15000)Oc rang .SEM morphology for compacted samples after heat treatments were performed using a JEOL JSM-5800LV microscope supplied with energy dispersive spectrometer (EDS).

III. RESULTS AND DISCUSSION

3-1 Structural Analysis:

XRD patterns of with various heat treatment temperatures of (850,950,1050) °C at 1(hr) sintering for the sample (Fe_{60} –Co_{40})is displayed in fig-1(a-b-c). At 850°C heat treatment ,the sample shows presence clearly of several peaks related to the face center cubic cobalt (F-Co) and hexagonal close paked cobalt (H-Co) and also the third phase of face centered cubic Iron (F-Fe) was observed .

The main (FCC) peaks are indicates clearly by the plans of (111),(200),(220)and (220) for fcc phase for Co and Fe .Also at 850°C ,the second phase with plans of (100),(002)and(101)for hcp phases are observed as shown in Fig-1(a).alloy after heat treatment at 850,950 and 1050°C were showed in Figure(1-a-b-c).

The x-ray spectrum for the alloy the heat treated at 850 °C was show the presence of several peaks belong to the face center cubic cobalt (FCC-Co) and hexagonal close packed cobalt (HCP-Co)and centered cubic Iron (FCC-F_e) . The main(FCC)peaks are indicates clearly by the plans of (111) ,(200) and (200) , while fcc phase for Co and Fe was indicated by(220) plane ,in addition , hcp phases hcp phases were indicated by (100),(002)and (101)plans as shown in figure (1-a).After increasing the heat treatment to 950 °C ,all hcp peaks are disappear and the intensity of peak(111)starts to increase gradually although their width increases with increase the heat treatment ,indicating that can be due to attributed to the dissolution of Co into Fe lattice or reverse all otropic phase conversion of Co from hcp phase to fcc phase as shown in Fig- 1(b)[9]. This transformation of Co during the increasing heat treatment also has been reported by other researchers by using study the effect of mechanicall milling preparation on the structural properties[10,11].

They considered that Co phase is ameto stable structure[12]. For longer heat treatment at 1050 °C, a significant (Fe-Co) stabilizes to the one fcc-phase structure as shown in Fig-1(c) ,which shows the transformation clearly takes place at treatment temperature close to 1050 °C. The effect of continuous increase of heat treatment of (Fe_{60} –Co_{40}) alloy will decrease the grain size as shown in table (1) , the increase of temperature will prevent the growth and aggregation of the grains , the grain size of (Fe_{60} –Co_{40})

alloy that treaed at 850°C was 21.52135 nm then the grain size decrease to 10.49949 nm and 9.384395 nm for the alloy that treated at 950°C and 1050°C respectively table (1).

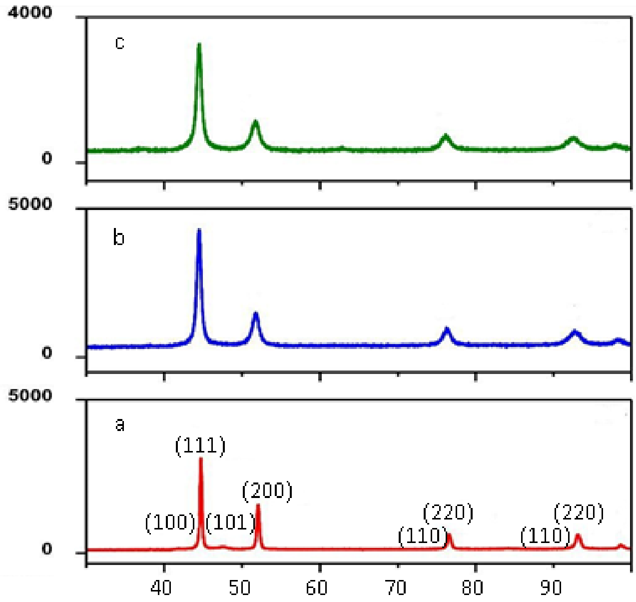

Figure (1) XRD pattern of $Fe_{60}-Co_{40}$ treated at different temperatures (a) 850°C (b) 950°C(c) 1050°C

Table (1) the average grain size variation with heat temperature

Heat temperature °C	2-Theta (θ)	FWHM [°2Th.]	D nm	Average grain
1050	44.5	0.5123	16.75526624	9.384395
	52	1.1657	7.582464558	
	76.5	1.5361	6.584545552	
	93.5	1.7521	6.61530292	
950	44.5	0.4953	17.33035109	10.49949
	52	0.9524	9.28063727	
	76.5	1.2492	8.096798289	
	93.5	1.5899	7.290189475	
850	44.7	0.2538	33.84500731	21.52135
	52.2	0.3216	27.50750848	
	76.8	0.8397	12.07032046	
	93.6	0.9162	12.66254593	

Scanning electron microscope (SEM) image of ($Fe_{60}-Co_{40}$) ally treated at 850°C showed in figure (2). The images show that the average grain size was about (31.6nm) and this agree with XRD results .

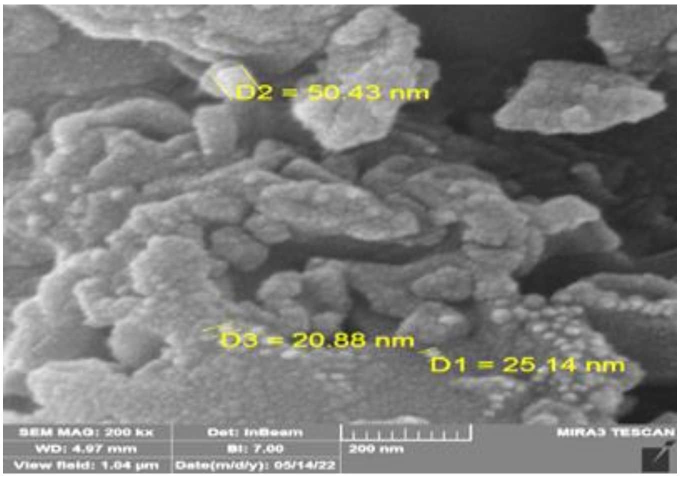

Figure: (2) Show SEM images of (Fe_{60} –Co_{40}) treated at 850°C

3-2 Magnetic Characterization:

In order to examine the effect of heat treatment on the magnetic properties of the (Fe_{60}-Co_{40})sample, the hysteresis loops have been recorded as shown in Fig-2(a-b-c). The result indicates from the hysteresis loops are typical soft behavior of ferromagnetic order materials possess with a small coercive filed (H_C)due to the narrow hysteresis loops ,as shown in Fig-2(a-b-c)[13].

The measured M-H curves of (Fe_{60}-Co_{40}) binary alloy in the external magnetic field ranging from -10 to 10 KO_e are shown in this figure. The magnetization filed M-H loops have been used to determine the values of the saturation magnetization (M_S)and the coercive filed (H_C)at various heat treatment (RT,850,1025)°C temperatures .

The results show that increases the M_S but the coercivity very small change due to the incorporation of high magnetic moment of Fe atoms in Fe_{60}-Co_{40} alloy [14].The maximum saturation magnetization and the minmum coercivity estimated from M-H to be (105.30)emu/gr and (57.21)Oe respectively ,as shown in Fig-2(a-b-c).By the way, the curie point (Tc)of Iron (Fe)is around(1041) °C and this degree is so important in magnetic materials ,in which above that the magnetic behavior are drastically changed from ferromagnetic strong behavior to paramagnetic state sample ,not attracted by a magnetic field again [15,16].

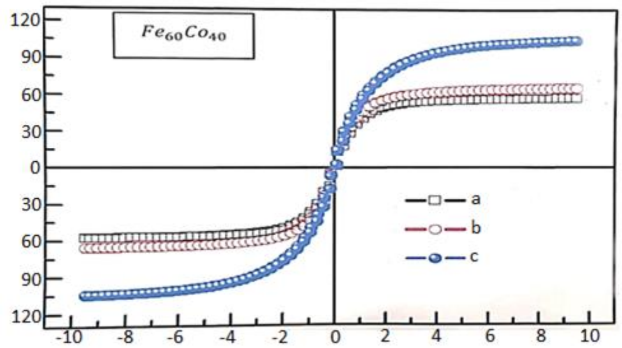

Figure: (2) hysteresis loops for Fe_{60} – Co_{40} alloy as function of temperature (a)RT, (b) 950°C and (c) 1050°C

IV. Conclusion

The x-ray spectrum for the (Fe_{60} –Co_{40}) alloy the heat treated at 850 °C was show the presence of several peaks belong to the face center cubic cobalt (FCC-Co) and hexagonal close packed cobalt (HCP-Co). The heat treatment temperature at 950°C will lead to disappearance of hcp peaks accompanied by an increase in both intensity and width of (111)peak , while the increasing of heat treatment temperature to will 1050 °C will result a significant (Fe-Co) stabilizes to the one fcc-phase structure .The x- ray spectrum show also the decrease of the grain size with the continuous increase of heat treatment of (Fe_{60} –Co_{40})

alloy will. Finally , the hysteresis loops show that the hysteresis loops are typical soft behavior of ferromagnetic order materials possess with a small coercive filed (H_C)

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VI. REFERENCES

[1]. Suryanarayana, C. (2001). Mechanical alloying and milling. Progress in materials science, 46(1-2), 1-184.

[2]. Loudjani, N., Benchiheub, M., & Bououdina, M. (2016). Structural, thermal and magnetic properties of nanocrystalline Co 80 Ni 20 alloy prepared by mechanical alloying. Journal of Superconductivity and Novel Magnetism , 29 , 2717-2726.

[3]. Panday, S., Jeevanandam, P., & Daniel, B. S. (2013, February). Synthesis and magnetic properties of nanocrystalline Co-Ni alloys: A review. In Materials Science Forum (Vol. 736, pp. 229-240). Trans Tech Publications Ltd.

[4]. Aymard, L., Dumont, B., & Viau, G. (1996). Production of CoNi alloys by mechanical-alloying. Journal of alloys and compounds, 242(1-2), 108-113.

[5]. Hewa MK. Frage and Ismail k. Jassim (March 2022) . Magnetic and Structural Behavior of (Ni75-Co25 – Wt% Nario Co) powders Prepared by Mechanical Alloying. NeuroQuantology | Volume 20 | Issue 3 |Page 723-733| doi: 10.14704/nq.2022.20. 3.NQ22360.

[6]. Hewa.MK.F., Ismail.k.J., Jawdat.A.Y. (February, 2022).Synthesis and Characterization of Binary Ni75-Co25 Alloy by Mechanical Alloying. International Journal of Mechanical Engineering. Vol. 7 No. 2.

[7]. H.M.Abadul Majeed, I.K.Jassiaand A.S. Mahmood (2021) .Fabrication and Structural properties of Nis. Also Alley by Mechanical Alleying,Neuro Quantology, Vol 191.PP 110-114.

[8]. H.M. Abadul Majeed, I.K.Jassin and A.S. Mahmood () .Fabrication and Structural properties of Niso Also Allay by Mechanical Alloying. NeuroQuantology, vol 191 .PP 110-114.

[9]. Lendzion-Bielun, Z., Narkiewicz, U., & Arabczyk, W. (2013). Cobalt-based catalysts for ammonia decomposition. Materials, 6(6), 2400-2409.

[10]. H.M.Abdur Majeed, A.S.Mahmood and I.K.Jassim, Synthesis and Characterization of Binary 〖Ni〗_50 〖Al〗_50 Alloy Fabricated by powder Metallurgy Technique,Turkish.Online.Journal of Qualitive Inquiry (TO,QI),Vol12,pp 2081-2088(2021).

[11]. X.Yuan ,P.Zhang ,J.Wang …etc,Influences of Fe cotent and cold drawing strain on the microstructure and properties of powder metallurgy Cu-Fe alloy wire ,Materials ,vol 16,pp 5180(2023).

[12]. R.Anand Sekhar, S.Samal,N.Nayan…etc, Microstructure and mechanical properties of Ti-Al-Ni-Co-Fe based high entropy alloys prepared by powder metallurgy route ,Journal of Alloys and Compounds,vol 787,pp 123-132 (2019).

[13]. B.J.Brown,I.K.Jassim,K.U.Neuman,K.R.A.Z, ebeck, Neutron Scattering from invar alloy physica B ,Condensed Matter,vol 161,pp 9-16(1990).

[14]. I.K.Jassim,K.Uneumann,D.Visser,P.J.Webster,K RA.Ziebeck,The magnetic structure of the

Heusler alloyPd-Ag-Mn-In,physica B : Condensed Matter, vol 180, pp 145-146(1992).

[15]. A. Guittoum, A. Loyadi, A. Bourzani etc diffraction, microstructure) Mossing -Her and magnetization studies of nanostructures Feso Ni5o alloys journa of Magnetism and Magnetic Materials, 32017/PP 1385-1392 (2021).

[16]. Ishmaeel Khalil Jassim PhD Thesis, Magnetic and lattice interaction in 3D transitio metal Compounds Loughborough University of Technology, Ijnited Kingdom (1990).

[17]. I.K. Jassim, Kh. H. Erzaich M.A. Majeed, The effect of heal treatment on the Structural properties of the (Alnico -5] Alloy Prepared by Powder metallurgy method, European journal of Scientific Research, Vol 134 No 3, pp 378-389 (2015)

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