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The study of glass forming ability of Fe-based alloy for welding processes

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Materials

ABSTRACT

Purpose: This paper tends to present the thermal analysis and structure of selected Fe-based bulk metallic glasses for welding processes.

Design/methodology/approach: The studies were performed on Fe-Co-B-Si-Nb alloy in form of plate and rod. Master alloy ingot with compositions of $Fe_{37.44}Co_{34.56}B_{19.2}Si_{4.8}Nb_4$ was prepared by induction melting of pure Fe, Co, B, Si and Nb elements in argon atmosphere. The investigated material was cast in form of plate with thickness 0.5 mm and rod with diameter 3 mm. The structure analysis of the studied materials in as-cast state was carried out using X-ray diffraction (XRD). The thermal properties: glass transition temperature (T_g), onset crystallization temperature (T_x) and peak crystallization temperature (T_p) of the as-cast alloys were examined by differential scanning calorimetry (DSC) and melting temperature (T_m), liquidus temperature (T_l) by differential thermal analysis (DTA) methods. The parameters of glass forming ability included reduced glass transition temperature (T_{rg}), supercooled liquid region (ΔT_x), α, β, γ, δ and stability (S) were calculated.

Findings: The Fe-based bulk metallic glasses in form of plate and rod with good glass forming ability were produced by die pressure casting method. The investigation methods revealed that the studied as-cast bulk metallic glasses were amorphous. These materials exhibit good glass-forming ability. The calculated GFA parameters indicated that the slightly best glass-forming ability has $Fe_{37.44}Co_{34.56}B_{19.2}Si_{4.8}Nb_4$ alloy in form of rod. It is confirmed that these parameters could be used to determine glass forming ability of tested amorphous alloy for welding processes.

Research limitations/implications: It is difficult to obtain a bulk metallic glasses in form of plate and rod with large sizes. Various empirical parameters have been proposed to specify the glass forming ability of bulk metallic glasses. Several GFA indicators have been determined by measuring the characteristic thermal parameters. A few simple criteria were calculated to explain the GFA of tested alloys.

Practical implications: These obtained values of GFA parameters can suggest that studied alloys are suitable materials for further practical application at welding process.

Originality/value: The success formation and investigation of the casted Fe-based bulk metallic glasses. The chemical composition of $Fe_{37.44}Co_{34.56}B_{19.2}Si_{4.8}Nb_4$ alloy were tested first time.

Keywords: Metallic glasses; Bulk metallic glasses; Glass-forming ability; Bulk metallic glasses welding process

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1. Introduction

Recently, the diameters and thickness of homogeneous bulk metallic glasses have been too small for structural applications. Therefore, the development of joining processes for bulk metallic glasses materials is desirable [1, 2].

The weld of bulk metallic glasses is composed of weld metal, the heat affected zone and the base weld [3].

Recently, a lot of bulk metallic glasses have been developed but the materials of high glass forming ability and high phase stability are required during welding and other engineering processes. In this regard, the successful welding of BMG is primarily dependent on the suppression of crystallization in the weld. The welding parameters, structure and thermal properties of materials have influence on quality of obtained weld [3].

In this article the structure and thermal parameters of Fe-based alloy were studied.

The heat affected zone is more easily susceptible to crystallization then weld metal because the time of the solid-heating time-temperature-transformation (TTT) diagram of BMG is shorter than the melt-cooling time. Moreover, the structural relaxation of BMG weld could occur, then the phase is not changed but the mechanical properties can be changed by the effects of thermal annealing below crystallization temperature (T_p). Because of it, it is very important to know all thermal parameters of joined materials. The thermal parameters determination is necessary to determine and select welding parameters [2, 4].

Glass stability of BMG is determined among other things by chemical composition.

The crystallization of molten liquid of BMG and that of solid-state BMG are two utterly different processes. For the molten liquid BMG, crystallization is dependent on whether the cooling rate is lower than a critical cooling rate. Meanwhile, heating thermal cycle as well as cooling thermal cycle affect solid-state crystallization of BMG. Therefore, material aspects and process aspects should be taken into consideration in order to understand phase evolutions in the BMG weld [5, 6].

This studied alloy will be appropriate to first tests of BMG joining process in Poland.

Bulk metallic glasses are characterized by exceptionally high glass forming abilities which allow them to obtain amorphous samples with considerable geometric dimensions [7]. The glass forming ability is very important parameter to design new bulk metallic glasses which characterize unique physical-chemical and mechanical properties. Different experimental parameters to estimate glass forming ability were proposed [8, 9]. The most often used parameters are reduce glass transition temperature (T_{rg}) and γ indicator. The glass transition temperature value is calculated according to the pattern: $T_{rg}=T_g/T_l$ (where: T_g – glass transition temperature; T_l – melting temperature) [10]. The slowing down of crystallization process was observed for alloys with T_{rg} equal 2/3. The alloys which are characterize by such a reduced glass transition temperature values are easily obtained by supercooling. One should apply high cooling rate. In the consequence of this the amorphous structure is obtained [11, 12].

But γ parameter is defined with the help of formulae: $\gamma=T_x/T_g+T_l$ (where: T_l – liquidus temperature) [13]. These indicators are most often applied because they can be easily determined with the help of calorimetric tests. Thermal analysis allows to observe of glass transition temperature, melting temperature and liquidus temperature existence. There have been shown that T_{rg} and γ parameter values could not properly determine glass forming ability of BMG in many experiments. The main indicator of GFA alloy is critical cooling rate (R_c). The obtained structure of metallic alloy depends on just critical cooling rate. R_c value depends on alloy chemical composition. R_c value of pure metals is equal 10^{10} K/s but R_c of chosen palladium based alloys is equal even 0.1 K/s. Therefore, the critical cooling rate is required. The minimum cooling rate of the metallic liquid to cast in bulk metallic glasses form is necessary. The R_c value of selected alloy is determined by experimentation and estimation of heat flow [11, 13]. In this work the R_c was not estimated. It was constant. The next glass forming ability parameter is maximum sections thickness of plates or maximum rods diameters. These parameters are easily measurable but they need doing a lot of research. That is why simple and effective new glass forming ability appraisal of bulk metallic glasses have been searched [9, 13]. In article [11] a discussion about a new glass forming ability parameter which are based on nucleation theory and nucleus of crystallization growth was made. Based on classical nucleation theory, homogeneous nucleation rate (I) and nucleus of crystallization growth rate (U) were determined with the help of formulas. Taking into consideration that formation of BMG proceed at glass transition temperature and that the glass forming ability of metallic liquid is proportional to converse of I and U. It was found that $GFA \sim T_g/T_l - T_m$, following $GFA \sim T_x/T_g$ (where: T_x – onset crystallization temperature). Finally, new expression was created, which combines glass forming ability alloy with characteristic temperature: T_g, T_x, T_l. In this article [11], next, new criterion of GFA was proposed: $\delta=T_x/T_l-T_g$.

Inoue and co-authors exhibited that width of super cooled liquid region is a very good GFA measure. Super cooled liquid region is presented as $\Delta T=(T_x-T_g)$ [13]. It results from basic research that when range of temperature ΔT_x is larger, GFA is higher. ΔT_x criterion is acknowledged through researchers in this field.

Last parameter is called the stability parameter [13, 14] and it is defined in the following way: $S=\frac{(T_p-T_x)(T_x-T_g)}{T_g}$ (where: T_p – crystallization peak temperature).

Besides, Inoue formulated three empirical rules connected with bulk metallic glasses' production:

1. Multicomponent alloy;
2. Significant difference in atomic size of main elements alloy;
3. Negative heat of mixing between main alloy elements.

Fulfilment of these rules results in capacity to create multi-component short-range interaction, forming new atomic configuration and fraction increase of densely packed structure in alloy. Finally, it ensures high glass forming ability and large stability of super cooled liquid [14, 15].

All glass forming ability indicators exhibit relationship with respect to the maximum thickness D_{max} or maximum diameter $Ø_{max}$ indicating that all these parameters can reflect the GFA of tested alloys.

These criteria are useful in selecting ultimate alloy compositions that could be easily formed into glasses [15]. The thermal parameters, the maximum sample diameters and calculated GFA parameters of the Fe-based system alloys are listed in Table 1.

Table 1.
Thermal stability of the selected bulk glassy Fe-based alloys [11, 16-22]

No.	Alloy	Dimension Ø, mm	Thermal stability								
			T_c, K	T_g, K	ΔT_x, K	T_g/T_l	T_x	T_p	T_l, K	γ	δ
1	$[(Fe_{0.9}Co_{0.1})_{0.75}B_{0.2}Si_{0.05}]_{96}Nb_4$	2	610	832	45	0.570	877		1460	0.383	1.397
2	$[(Fe_{0.8}Co_{0.2})_{0.75}B_{0.2}Si_{0.05}]_{96}Nb_4$	2.5	642	830	50	0.580	880		1431	0.389	1.464
3	$[(Fe_{0.7}Co_{0.3})_{0.75}B_{0.2}Si_{0.05}]_{96}Nb_4$	3.5	668	828	50	0.586	878		1413	0.392	1.501
4	$[(Fe_{0.6}Co_{0.4})_{0.75}B_{0.2}Si_{0.05}]_{96}Nb_4$	4	678	825	50	0.586	875		1407	0.392	1.503
5	$[(Fe_{0.5}Co_{0.5})_{0.75}B_{0.2}Si_{0.05}]_{96}Nb_4$	5	692	820	50	0.587	870		1397	0.392	1.508
6	$[(Fe_{0.6}Co_{0.1}Ni_{0.3})_{0.75}B_{0.2}Si_{0.05}]_{96}Nb_4$	3	554	792	60	0.608					
7	$[(Fe_{0.6}Co_{0.2}Ni_{0.2})_{0.75}B_{0.2}Si_{0.05}]_{96}Nb_4$	4	598	800	65	0.611					
8	$[(Fe_{0.6}Co_{0.3}Ni_{0.1})_{0.75}B_{0.2}Si_{0.05}]_{96}Nb_4$	4	643	813	65	0.613					
9	$Fe_{60.75}Co_{6.75}Nb_4Gd_{3.5}B_{25}$	3		852	53	0.569	905	962			
10	$Fe_{54}Co_{13.5}Nb_4Gd_{3.5}B_{25}$	3.5		851	56	0.570	907	959			
11	$Fe_{47.25}Co_{20.25}Nb_4Gd_{3.5}B_{25}$	4		855	54	0.575	909	958			
12	$Fe_{40.5}Co_{27}Nb_4Gd_{3.5}B_{25}$	4		853	57	0.577	910	963			
13	$Fe_{33.75}Co_{33.75}Nb_4Gd_{3.5}B_{25}$	5		854	102	0.589		956			
14	$Fe_{80}P_{12}B_4Si_4$			753	36						
15	$Fe_{76}Al_4P_{12}B_4Si_4$			738	46						
16	$Fe_{74}Al_4Ga_2P_{12}B_4Si_4$			737	49						
17	$Fe_{56}Co_7Ni_7Zr_{10}B_{20}$	2		814	73	0.60					
18	$Fe_{56}Co_7Ni_7Zr_8Nb_2B_{20}$	2		828	86						
19	$Fe_{61}Co_7Ni_7Zr_8Nb_2B_{15}$	2		808	50						
20	$Fe_{56}Co_7Ni_7Zr_8Ta_2B_{20}$	2		827	88						
21	$Fe_{60}Co_8Zr_{10}Mo_5W_2B_{15}$	6		898	64	0.63					
22	$[(Fe_{0.5}Co_{0.5})_{0.72}B_{0.192}Si_{0.048}Nb_{0.04}]_{96}Y_4$			898.2	55.4		953.6	959.0			
23	$[(Fe_{0.6}Co_{0.4})_{0.72}B_{0.192}Si_{0.048}Nb_{0.04}]_{96}Y_4$			911.5	51.0		962.5	969.5			
24	$[(Fe_{0.7}Co_{0.3})_{0.72}B_{0.192}Si_{0.048}Nb_{0.04}]_{96}Y_4$			901.2	45.4		946.6	281.86			

2. Materials for research and work methodology

The aim of this work is the presentation of the thermal analysis and structure of selected Fe-based bulk metallic glasses for welding processes.

Fe-based master alloy ingot with compositions (Table 2) of $Fe_{37.44}Co_{34.56}B_{19.2}Si_{4.8}Nb_4$ was prepared by induction melting of pure Fe, Co, B, Si, Nb elements (Table 3) in argon atmosphere. Applied ingot was melted one at a time. The alloy composition represent nominal atomic percentages.

Table 2.
Chemical composition of $Fe_{37.44}Co_{34.56}B_{19.2}Si_{4.8}Nb_4$ alloy

No.	Elements	mass., %	at., %
1	Fe	43.23	37.44
2	Co	42.11	34.56
3	B	4.29	19.20
4	Si	2.68	4.80
5	Nb	7.69	4.00

Table 3.
Purity and shape of used elements

No.	Elements	Purity, %	Shape
1	Fe	99.97	pieces
2	Co	99.99	briquette
3	B	99.5	pieces
4	Si	99.99	lump
5	Nb	99.8	pieces

The studies were carried out on bulk metallic materials as plate and rod, too. The investigated material was cast in form of plate with thickness 0.5 mm and rod with diameter 3 mm. From the master alloy, plate and rod samples were prepared by the pressure die casting method in an argon atmosphere. The master alloy was melted in a quartz crucible using an induction coil and pushed in a copper mould by applying an ejection pressure.

The microstructure characterization and thermal analysis of the $Fe_{37.44}Co_{34.56}B_{19.2}Si_{4.8}Nb_4$ bulk metallic alloy using XRD, DTA and DSC methods were carried out.

Glassy structures were examined by X-ray diffraction (XRD) using a Seifert – FPM XRD 7 diffractometer with Co Kα radiation at 35 kV. The data of diffraction lines were recorded by means of the stepwise method within the angular range of 30° to 90°. The counting time in the measuring point was 3 s.

The thermal properties: glass transition temperature (T_g), onset crystallization temperature (T_x) and peak crystallization temperature (T_p) of the as-cast alloys were examined by differential scanning calorimetry (DSC) method using DSC822 Mettler Toledo at a constant heating rate of 40 K/min.

The melting temperature (T_m), liquidus temperature (T_l) were determined by differential thermal analysis (DTA) method using STA 449 F3 Jupiter by NETZSCH factory thermal analyser.

The parameters of glass forming ability included reduced glass transition temperature (T_{rg}), supercooled liquid region (ΔT_x), α, β, γ, δ and stability (S) were calculated in the following way [11, 13, 15]:

1) $T_{rg} = \dfrac{T_g}{T_l}$

2) $\Delta T_x = T_x - T_g$

3) $\alpha = \dfrac{T_x}{T_l}$

4) $\beta = \left(\dfrac{T_x}{T_g} + \dfrac{T_g}{T_l}\right)$

5) $\gamma = \left(\dfrac{T_x}{T_g + T_l}\right)$

6) $\delta = \left(\dfrac{T_x}{T_l - T_g}\right)$

7) $S = \dfrac{(T_p - T_x)(T_x - T_g)}{T_g}$

3. Results of researches

3.1. X-ray analysis

The bulk metallic glasses samples in rod and plate form were produced and investigated. The structure of as-cast $Fe_{37.44}Co_{34.56}B_{19.2}Si_{4.8}Nb_4$ alloy in form of rod with diameter 3 mm and plate with thickness 0.5 mm was examined by X-ray diffraction method.

The Fe-based samples of determined chemical composition consist of a single glassy phase as was evidenced from a main halo peak without crystalline peaks in their X-ray diffraction patterns. One of the obtained halo peak of $Fe_{57.6}Co_{7.2}Ni_{7.2}B_{19.2}Si_{4.8}Nb_4$ glassy alloy in form of rod is presented in Figure 1.

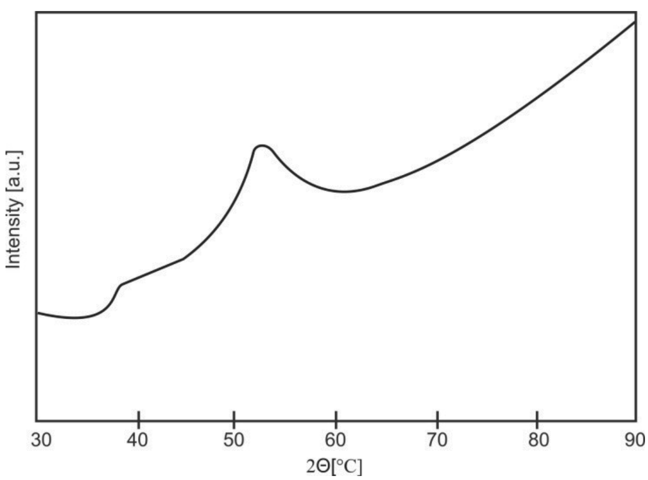

Fig. 1. X-ray diffraction pattern of the $Fe_{37.44}Co_{34.56}B_{19.2}Si_{4.8}Nb_4$ alloy rod with diameter of 3 mm

The diffraction pattern of the second studied $Fe_{57.6}Co_{7.2}Ni_{7.2}B_{19.2}Si_{4.8}Nb_4$ alloy in form of plate shows the broad diffraction halo characteristic for amorphous structure of Fe-based glassy alloys, too. The diffraction record of $Fe_{57.6}Co_{7.2}Ni_{7.2}B_{19.2}Si_{4.8}Nb_4$ alloy plate is shown in Figure 2.

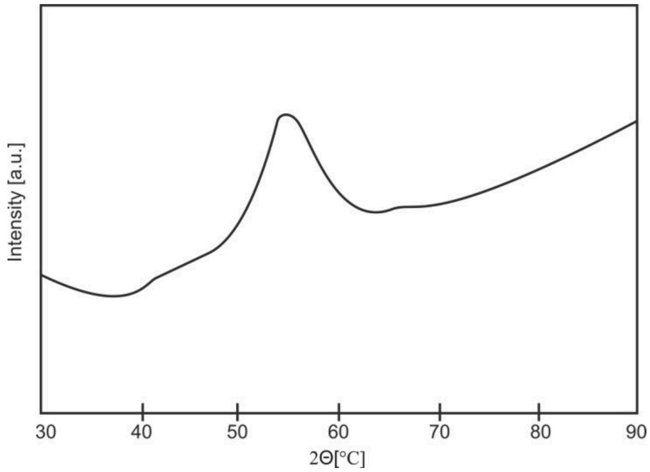

Fig. 2. X-ray diffraction pattern of the $Fe_{57.6}Co_{7.2}Ni_{7.2}B_{19.2}Si_{4.8}Nb_4$ alloy plate with thickness of 0.5 mm

In all tested samples the amorphous state was created.

3.2. Thermal analysis

Figure 3 shows a double melting process. The first peak is not so sharp but the second one is bigger and sharper. Figure 3 shows a two-step melting process which indicates that the alloy is off-eutectic.

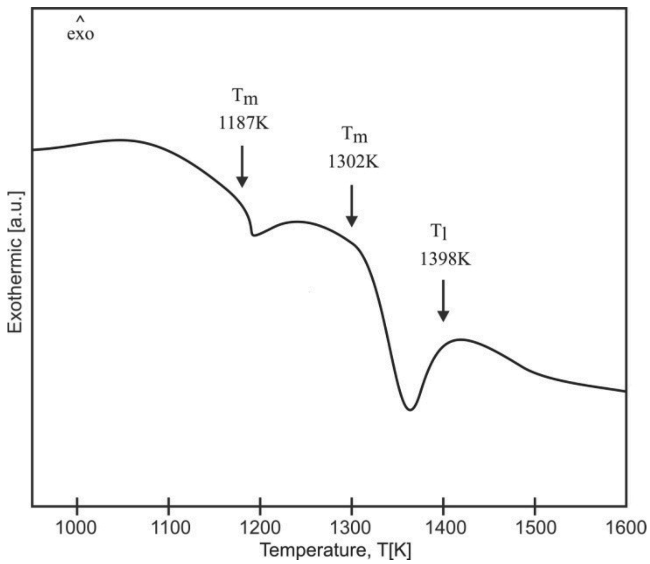

Fig. 3. DTA curve of $Fe_{57.6}Co_{7.2}Ni_{7.2}B_{19.2}Si_{4.8}Nb_4$ alloy as master-alloy

For estimating the reduced temperature (T_{rg}), melting point (T_m) and liquidus temperature (T_l) of $Fe_{37.44}Co_{34.56}B_{19.2}Si_{4.8}Nb_4$ alloy were measured by differential thermal analysis. The T_m and T_l are the onset and the end temperature of the melting curve on the DTA diagrams which are presented in Figure 3. Liquidus temperature of melting alloy equals T_l=1398 K.

It is often suggested that the deepest eutectic composition has the best GFA. However, many successful metallic glass compositions are shifted away from the eutectic composition. It was noticed that optimum compositions, close to the eutectic ones are often shifted. The shift direction and the magnitude depend on the system [23]. In this article it is said that thermodynamic considerations of liquid state stability point to the deepest eutectic composition having the best GFA. A shift away from the eutectic composition may result from kinetic consideration.

The authors of articles [23] propose that such a shift is caused by the composition dependence of the glass transition temperature (T_g) and of the supercooled liquid in the vicinity of the eutectic composition. Their proposal implies that the optimum composition is shifted from eutectic composition in the direction of increasing glass transition temperature.

Figures 4 and 5 show DSC curves of $Fe_{37.44}Co_{34.56}B_{19.2}Si_{4.8}Nb_4$ alloy with rather high glass forming ability. Each of the sample shows a glass transition process. The crystallization of the alloys in the form of rod and plate exhibits one step process.

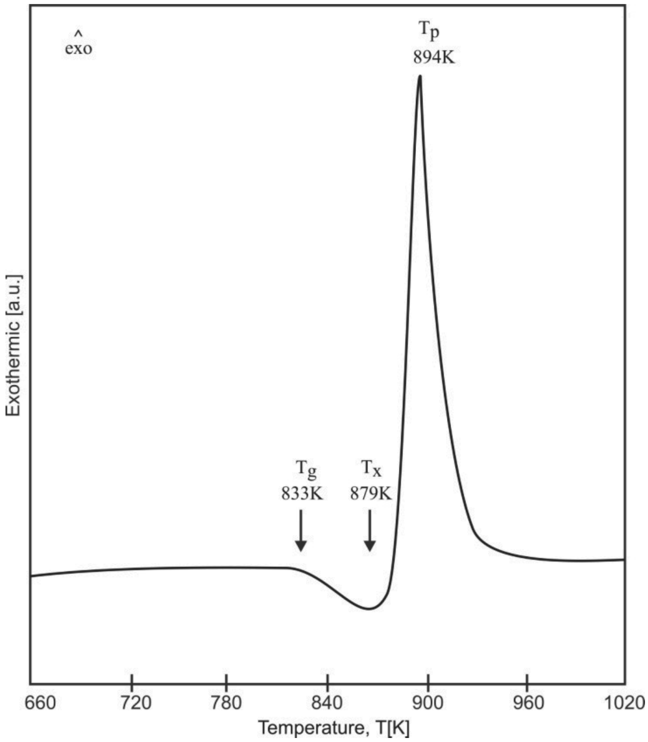

Fig. 4. DSC curve of $Fe_{57.6}Co_{7.2}Ni_{7.2}B_{19.2}Si_{4.8}Nb_4$ alloy in as-cast state in form of rod with diameter of 3 mm

The thermal stability temperatures: glass transition temperature, onset crystallization temperature, crystallization peak temperature and calculated glass-forming ability parameters of studied bulk metallic glasses in form of rod and plate are listed in Table 4 and Table 5.

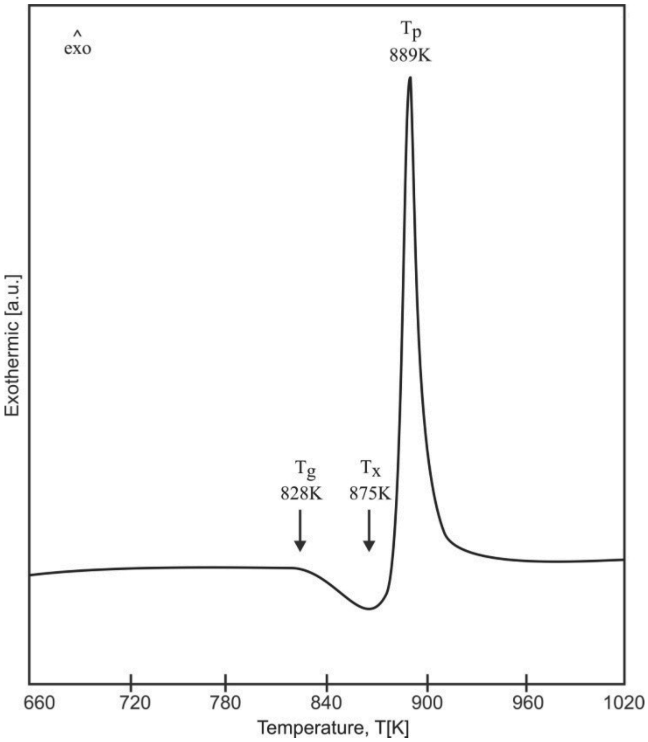

Fig. 5. DSC curve of $Fe_{57.6}Co_{7.2}Ni_{7.2}B_{19.2}Si_{4.8}Nb_4$ alloy in as-cast state in form of plate with thickness of 0.5 mm

Table 5 also shows reduced glass transition temperature (T_{rg}), supercooled liquid region (ΔT_x), the α, β, γ, δ and S parameter.

The higher value of T_g and T_x may extend the application temperature region of the bulk metallic glasses as engineering materials. Turnbull [13, 15, 24] suggests that large T_{rg} means excellent GFA, when T_{rg} is larger than 0.6, the nucleation and growth of crystalline phase in supercooled liquid are highly restricted. He maintained that ΔT_x can be used to represent the GFA for all bulk metallic glass forming alloys. It was proved that the GFA is higher if the value of ΔT_x is larger. According to Y. Zhang et al. [24] this phenomenon may be related to the microstructure difference between the BMG and conventional metallic glasses. Authors of article [24] maintain that the large ΔT_x of bulk metallic glasses originates from their microstructure characteristic.

Basing on conventional nucleation theory, the crystallization is determined by the nucleation barrier and atomic diffusion in the supercooled liquid state. Higher nucleation barrier or higher interfacial energy between liquid and solid phases will suppress the nucleation and growth of the crystalline phases. Lower diffusivity or higher viscosity in the supercooled liquid will suppress crystallization, too.

In Y. Zhang's opinion, the compact microstructure in the melt leads to an increase in interfacial energy and viscosity, and then the alloy inhibits the nucleation and growth in the supercooled liquid state. The conclusion was drawn that the supercooled liquid of the multicomponent alloy $Fe_{37.44}Co_{34.56}B_{19.2}Si_{4.8}Nb_4$ is much more stable opposing crystallization and has a high resistance to the nucleation and high stability in larger temperature range. The value of supercooled liquid region reflects the microstructure characteristics of bulk metallic glasses. In authors opinion this is the reason why ΔT_x can characterize the GFA of bulk glass forming alloys [24, 25].

As mentioned earlier, on the other hand, the width of the supercooled liquid region ΔT_x is an important parameter of amorphous alloys and corresponds to the stability of the supercooled liquid.

The width of ΔT_x is 47 K for plate and 46K for rod, indicating that the alloy possesses a sufficient stability of the supercooled liquid.

The DSC curves (at 40 K/min.) measured on amorphous rod of $Fe_{37.44}Co_{34.56}B_{19.2}Si_{4.8}Nb_4$ alloy with diameter of 3 mm in as-cast state is shown in Figure 4. The exothermic peaks describing crystallization process of studied bulk metallic glasses is observed. The crystallization effect of rod with diameter of 3 mm has onset crystallization temperature (T_x=879 K) and peak crystallization temperature (T_p=894 K). Figure 5 shows DSC curve of $Fe_{37.44}Co_{34.56}B_{19.2}Si_{4.8}Nb_4$ glassy alloy plate in as-cast state. For sample with thickness of 0.5mm the exothermic effect includes onset crystallization temperature at value of T_x=875 K and peak crystallization temperature at T_p=889 K.

Results of DSC investigations for rod and plate exhibited that peak crystallization temperature of rod is higher than the peak crystallization temperature of plate.

Table 4.
Thermal properties of $Fe_{37.44}Co_{34.56}B_{19.2}Si_{4.8}Nb_4$ glassy alloy in form of rod and plate

amorphous alloy	Dimension, mm	T_g, K	T_x, K	T_p, K	T_l, K
$Fe_{37.44}Co_{34.56}B_{19.2}Si_{4.8}Nb_4$	rod, diameter 3	833	879	894	1398
$Fe_{37.44}Co_{34.56}B_{19.2}Si_{4.8}Nb_4$	plate, thickness 0.5	828	875	889	1398

Table 5.
Glass-forming ability parameters of $Fe_{37.44}Co_{34.56}B_{19.2}Si_{4.8}Nb_4$ bulk metallic glasses in form of rod and plate

amorphous alloy	Dimension, mm	T_{rg}, K	ΔT_x, K	α	β	γ	δ	S
$Fe_{37.44}Co_{34.56}B_{19.2}Si_{4.8}Nb_4$	rod, diameter 3	0.5958	46	0.6287	1.6510	0.3939	1.5557	0.8283
$Fe_{37.44}Co_{34.56}B_{19.2}Si_{4.8}Nb_4$	plate, thickness 0.5	0.5922	47	0.6258	1.6489	0.3931	1.5351	0.7947

The calculated GFA parameters indicated that the insignificant best glass-forming ability has $Fe_{37.44}Co_{34.56}B_{19.2}Si_{4.8}Nb_4$ alloy in form of rod.

The value of ΔT_x increases from 46 K for $Fe_{37.44}Co_{34.56}B_{19.2}Si_{4.8}Nb_4$ alloy of rod with diameter of 3 mm to 47 K for $Fe_{37.44}Co_{34.56}B_{19.2}Si_{4.8}Nb_4$ alloy of plate with thickness of 0.5 mm. The reduced glass transition temperature is higher for rod then for plate. T_{rg} is going to achieve a value of 0.6 and increases from 0.5922 for $Fe_{37.44}Co_{34.56}B_{19.2}Si_{4.8}Nb_4$ alloy in form of plate to 0.5958 for $Fe_{37.44}Co_{34.56}B_{19.2}Si_{4.8}Nb_4$ alloy in form of rod.

The glass-forming parameters are slight higher for rod then for plate. As a result of this as T_{rg} is increased, values of α, β, γ, δ and S parameter also increase. The insignificant highest value of calculated parameters is obtained for rod with diameter of 3 mm for studied $Fe_{37.44}Co_{34.56}B_{19.2}Si_{4.8}Nb_4$ alloy.

4. Conclusions

The Fe-based bulk metallic glasses in form of plate and rod with good glass forming ability were produced by die pressure casting method. These obtained values of GFA parameters can suggest that studied alloys are suitable materials for further practical application at welding process. The crystallization process during welding of bulk metallic glasses occurs when the welding heat approaches to crystallization temperature (T_x) or when the temperature of heat effected zone stays long enough in the temperature region of supercooled liquid (T_x-T_g). That is why, it was necessary to determine thermal properties and glass forming ability parameters of studied alloy.

The experimental results have shown us that it can be successfully cast into plate and rod for the forming $Fe_{37.44}Co_{34.56}B_{19.2}Si_{4.8}Nb_4$ alloy.

The investigation performed on the samples of tested alloy in form of rod and plate allowed to formulate the following statements:

- The X-ray analysis exhibits that the studied Fe-based bulk metallic glasses are amorphous;
- The glass-forming parameters were calculated, as a result this proposal was put forward that the value of ΔT_x increases from 46 to 47, T_{rg} parameter increases from 0.5922 to 0.5958. The highest values of δ and S indicators are obtained for rod with 3 mm for $Fe_{37.44}Co_{34.56}B_{19.2}Si_{4.8}Nb_4$ alloy;
- It is evident that the above enumerated parameters could be used to determine glass-forming ability of studied joining process-oriented materials.
- The success of Fe-based bulk metallic glasses production in form of plate and rod with obtained sizes is important for future progress in joining research of this group of materials.

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