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THE IDENTIFICATION OF HAZARDS IN THE PROCESS OF PRODUCTION AND EXAMINATION OF BULK METALLIC GLASSES WITH FERROUS MATRIX

Abstract: In this article hazards connected with production and examination of bulk metallic glasses with ferrous matrix were described. Bulk metallic glasses were produced by the use of high-pressure casting to copper mould cooled with water. The sample structure examination was carried out with the use of X-ray analysis (XRD), light microscopy and scanning electron microscopy (SEM). Thermal properties were tested with scanning differential calorimeter (DSC). Test and casting stands underwent occupational risk assessment with the use of Risk Score method.

1. Introduction

Bulk metallic glasses show series of extraordinary properties connected with their structure. These are non-crystalline alloys formed because of high cooling speed (in the range of 10 K/s). The solidification speed decreases with the increase of cross-section width. The material of amorphous structure is considered as bulk, only when the cast cross-section width is at least 1 mm. Attractiveness of these materials, compared with typical crystalline alloys, makes that they are very useful and desirable. They are used apart from others for IT elements, sports or medical devices. In practice you can get metallic glasses using different methods of production. But using the equipment at test stands of these materials is connected with a slight hazard, which has to be assessed. The aim of occupational risk assessment is hazard effect prevention and risk reduction and elimination. Residual risk that cannot be eliminated should be controlled, but the knowledge of risk and hazard should be passed to the employees.

2. Fe-Co-B-Si-Nb alloy formation with the use of pressure casting

At the first stage the basic alloy of proper atom composition with Fe,Co, B,Si and Nb elements was formed. To homogenize the structure double induction remelting was used. Next, comminuted ingot was molten in a quartz crucible with the use of an induction heater. Molten material was cast under pressure into a copper mould. The material was cast in the form of two 20x10x1mm plates.

3. The examination of bulk metallic glasses in the form of plates

The experiment carried on the created plates allowed to draw unique conclusions. Both X-ray and calorimetric testing together with microscopic observations showed that the sample number 1 is crystalline, whereas the second one is amorphous and crystalline. Series of diffraction lines of such intermetallic components as Fe_2B,Co_3B,FeSi were discovered on diffraction pattern.

The observations with the use of light microscope revealed a lot of precipitates, crystallites, non-metallic inclusions and microcracs on the crystalline plate. On the other hand there is a small number of little precipitates and uniform area on the amorphous plate. SEM images show that in the amorphous plate sample cross-section two sections can be observed, those comprising “plain” areas and characteristic patterns (resembling rivulets). Exothermic peak on DSC curve for the second sample confirms the presence of crystallization process. The peak crystallization temperature equals 899.23K, whereas the temperature of vitrification is 830.08K.

4. Occupational risk assessment

Occupational risk assessment is connected first of all with work process risk and hazard establishment. The term hazard means any factor occurring in the work environment which can suddenly and violently create dangerous events causing accidents and potential accidents, failures and technical damages. Risk is the occurrence of harmful factors in work environment, which because of longer exposure on human organism can cause occupational diseases, semi-occupational diseases (occupational illness) or employee`s temporary efficiency decrease.

According to PN80/Z08052 (Polish norm) dangerous and harmful factors are the physical, chemical, biological and psychophysical factors.

Occupational risk assessment means detailed hazard and risk identification at the work place. On its basis it is possible to assess occupational risk on a given position and compare risk assessment with risk acceptance criteria and define reduction actions.

The occupational risk assessment by Risk Score method was carried out on the following posts: sample preparation stand, stand equipped with X-ray diffractometer, to make microsections and observations with the use of light microscope and finally posts equipped with SEM and DSC. Risk Score is a popular method of risk indicator. In this method three-factor-formula is used:

- P- the probability of event occurrence,
- E- hazard exposure,
- S- the probable hazard effects.

Calculations of the final hazard index can be presented in the following way: WR=P*E*S. The carried out occupational risk assessment (Fig.1) showed that most hazards on research stands are on acceptable level.

The greatest danger on the alloy preparation stand is the induction heater, which not only emits harmful electromagnetic radiation, but can also be the source of burns or metal chips. A major hazard during the use of X-ray diffractometer is X-ray radiation. During microscopic observations the decrease of eyesight organ efficiency and bone-muscular system load used by a forced body position. These hazards are also applicable as far as the stand which is equipped with scanning differential calorimeter are concerned. What is more on the research stands with light microscope and devices for making microsections, the caustic substances and moveable elements of machinery and devices create danger. The work with scanning electron microscope causes exposure to electromagnetic radiation. All stands (apart from the one for massive amorphous alloys casting) possess a computer which is the source of electromagnetic radiation and such hazards as: movement organ overloading and eyesight perception overloading.

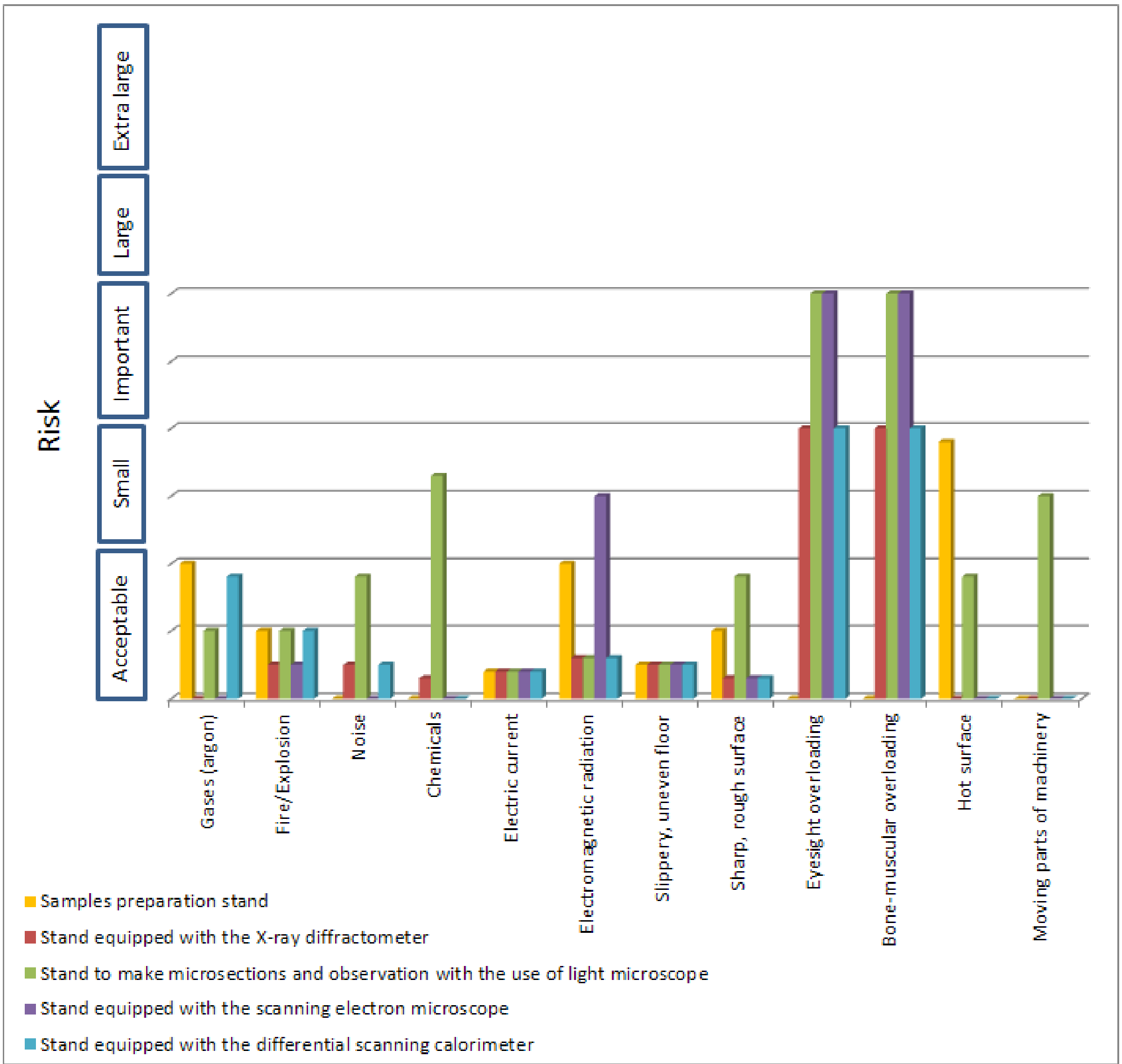

Fig.1 The result of Risk Score method occupational risk assessment on different research stands.

5. Summary

X-ray analysis, calorimetric research and microscopic observations showed that the first sample is crystalline whereas the second is amorphous-crystalline one.

Risk Score method occupational risk assessment proved that the majority of hazards occurring on research stands is on an acceptable level. So one should aim at minimizing the risk thanks to preventive measures.

On the microscopic observation stands an essential danger is eyesight and bone-muscular overloading. It is caused by a forced body position both during working with the computer and microscopic observations. Occupational risk assessment points at the elements creating hazardous situations or exposure during working process. Employers are obliged to obey Industrial Safety regulations and inform their employees about dangers. But the main aim of risk assessment is to allow the employer to take necessary measures to guarantee their employees safety and health protection such as:

- guarantee ergonomic workplace (chair, monitor, keyboard regulation, proper lighting, ventilation);
- equip in means of personal and collective protection(using protective gloves while working with hot surfaces and chips and using lead shields in the case of X-ray radiation);
- frequent measuring (using health physics membrane while working with X-ray diffractometer and measuring control);
- good work organization (good spatial organization, proper aisle width, order in the workplace, clean and non-slippery surfaces, cleanliness);
- the use of breaks at work (5 min. after each hour of work, employment contract guarantees 15-minute-break every 8 hours if the daily work time at the computer lasts at least 4 hours);
- good electrical system working condition.

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