

The determination of the hydrogen content in the aluminium alloys casted by tekcast method

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ABSTRACT

This research publication presents the method of centrifugal casting TEKCAST for the selected aluminium alloy AlSi10Mn STN 42 4383. The aim is the research and determination of hydrogen content depending on a rotation rate of mold during false centrifugal casting. Then it is an observation of the changes in mechanical and structural properties depending on the changes caused by increased content of hydrogen.

Key words: *TEKCAST method, centrifugal casting, hydrogen content, Silumin AlSi10Mn*



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Introduction

Tekcast method of false centrifugal casting is one of the most modern ways of castings' production. By this method, we can manufacture the high quality castings of different shapes from zinc alloys when casting into vulcanized silicone rubber. The production itself is operative and suitable for large-scale production. The system of this method with all advantages of centrifugal castings fully complies with the requirements for production of prototypes, not only of functional machine parts, but also of medals, badges and decorative items. The disadvantage of this method of casting from lead alloys and silumins mainly is that it is still in experimental stage, even though it has good premises in foundry industry.

The most commonly used material for castings are alloys of zinc, tin and lead. US producer of the device TEKCAST offers the production of silicone rubber molds marked BLUE which is used for casting of thin-walled aluminium alloys, silumins mainly. This method of castings of aluminium alloys into silicone rubber molds is not used in Slovakia and Czech Republic, so far. Neither there is available information about using TEKCAST method of casting aluminium alloys in other European countries. During the rotation, the centrifugal force eliminates negative effects which can occur as e.g. in casting of polyurethane solidifying liquids or melts of the aluminium alloys in order to remove the hydrogen bubbles formed during the cooling and solidification of aluminium alloys.

Casting of Aluminium Alloy AlSi10Mn STN 42 4383

Induction furnace VC 1000D, which was used during the experiment, is vacuum-pressurized pouring device designed for melting in the electromagnetic induction field under a protective atmosphere. The device allows the melting of the metal in standard conditions, in vacuum or in a controlled atmosphere (N₂), and the subsequent casting into a preheated skillet. The melting temperatures can be reached faster with induction heating because the heat is generated directly in the melting material and crucible. Moreover, the metal during melting process is thoroughly mixed by magnetic induction and hence it is possible to achieve homogeneous mixing also when producing the alloys. (Fig.1)



Figure 1. Induterm VD1000 device and Tekcaster Series 100-A device

The casting temperature was set to 720 °C for aluminium alloy (AlSi10Mn). The device was automatically turned on and the melting process was started after setting the temperature. The time interval between melting and overheating was set to seven minutes.

The casting of the molten alloy was performed after temperature stabilization of the melting by the means of a solenoid valve device. When Tekcaster Series 100-A device was prepared for operation, the closed mold treated with the separation product and which was pressed with the mold by the help of a gas pump, was put inside the device.

Afterwards, when the tools for a casting were preheated and temperature of furnace was balanced, we fitted a refractory funnel to Tekcaster Series 100-A device and launched it.

Preheated skillet for casting was placed under the drain of Induterm VD1000 furnace.

The controlled amount of melt was poured into the preheated skillet by using a solenoid valve and then manual casting into the device Tekcaster Series 100-A was followed immediately. The whole process of pouring and dosing lasted about 10 seconds. The casting is effected at a speed of 350, 400, 450, 500, 550, 600 r/min. The contact pressure of air cylinder was 0.6 MPa. Sixty sample castings of blasting rods from aluminium alloys (AlSi10Mn) were produced by this procedure which underwent the tensile test together with the determination of the hydrogen content. The view of the open form is shown on Fig. 2. [2]

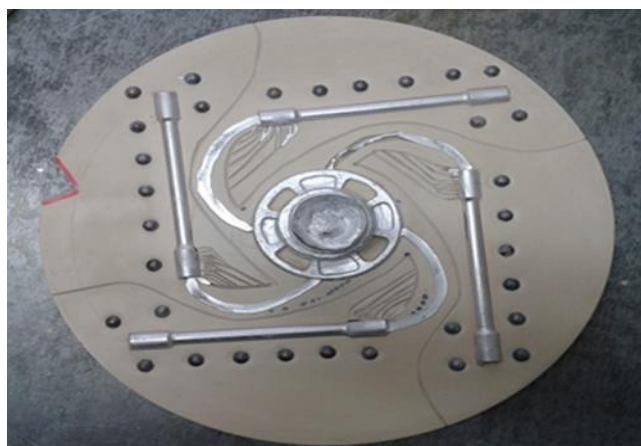


Figure 2. Castings of steering rods from AlSi10Mn alloy situated in open bottom half of the mold

Determination of Hydrogen Content

Hydrogen content was determined by means of the Galileo G 8 device

which is designed for fast and precise analysis of oxygen, nitrogen and hydrogen in the various types of the solid samples, e.g. in steel, non-ferrous metals, aluminium, titanium and its alloys, metals dust, soil, ceramics, glass, cement, and many others. Concentration of oxygen, nitrogen or hydrogen is determined according to a basic gas by a melt extraction with the help of IR detector or TCD (thermal conductivity detection) (Figure 3). [7]



Figure 3 Galileo G8 device for measuring hydrogen content

Main advantages of the analyser are

A short analysis' time, automatic procedure, easy operation,

A programmable pulse furnace temperature to 2400 ° C (refrigerated holder crucible to 2900 ° C), contactless temperature measurements and its precise regulation,

An easy change of the analysed gas with a help of the software for simultaneous measurement of oxygen and nitrogen for the determination of hydrogen. Optionally, the unit can be equipped with an external furnace for the determination of the diffused hydrogen.

The procedure and the evaluation of the determination of hydrogen content

The sample is melted in a pulse furnace in a graphite crucible under a stream of inert (main) gas. The graphite crucible, see. (Fig. 4) functions also as a melting element between the two water-cooled electrodes of the pulse furnace. The lower electrode is pneumatically operated and moves up for the closure of the furnace. Freely programmable temperature of the pulse furnace is monitored by a contactless sensor. Temperature can also be controlled by the help of current or power control. [7]



Figure 4 The graphite crucible

The high temperature of the oxygen in the sample, which is present in the oxide mostly, reacts with a free-occurring carbon to CO. Thermally conductive detector is used to measure nitrogen and hydrogen. Thermal conductivity of the two gases is measured by the thermistors, which are connected in a bridge configuration. The measuring principle is based on a thermal conductivity change of the basic gas due to the gas released from the sample in a comparison with pure carrier gas. The signal is proportional to the concentration of measured gas in the primary gas. Helium of purity 99.996% is used as the basic gas for the analysis of oxygen and nitrogen, the nitrogen purity of 99.999% is used for the analysis of hydrogen. Argon may be used for the analysis of oxygen in some special applications. The measuring signal is displayed on the screen during measurement. The concentration of oxygen, nitrogen and hydrogen is calculated based on the known weight of sample and calibration observed under certified materials or by calibration using a gas calibration. The company which conducted the measurement is called Inoval, Žiar nad Hronom and owns the device G-8 Galileo for the measurement of hydrogen content (H / ppm) only, excluding other gasses. Samples for measurement on the device G8 GALILEO from castings alloy (AlSi10Mn) were produced by turning on a lathe TOS Trenčín SUI 32 device. The final samples have a cylindrical shape with a diameter \varnothing 8 mm and with length $l = 16$ mm (Fig. 5)



Figure 5. Sample for measuring hydrogen content (H/ppm)

Treated samples were prepared for measuring the hydrogen content on Galileo G8 device. Samples were taken from the inlet and the tip of a sample (A-Inlet, B-Tip of the sample). It was measured under the protective atmosphere of nitrogen (N_2). The sample in a graphite crucible was put into a furnace and melted (heating lasted approximately 30 seconds). Samples were selected based on rotations per minute. Subsequently, the amount of hydrogen was analysed in the units for about 1 minute (ppm- parts per million) which express the low concentration, approximately to a concentration of 1 mg in 1 litre of solution.

In Tab. 1 are shown the values for the alloys of hydrogen AlSi10Mn and they are pictured in Fig. 6.

Table. 1 Measured value of hydrogen H/ppm AlSi10Mn

Rotation rate	A (H/ppm)	B (H/ppm)
350	48.58	16.94
400	34.28	14.72
450	28.82	13.34
500	23.36	11.52
550	17.82	9.71
600	15.27	6.92

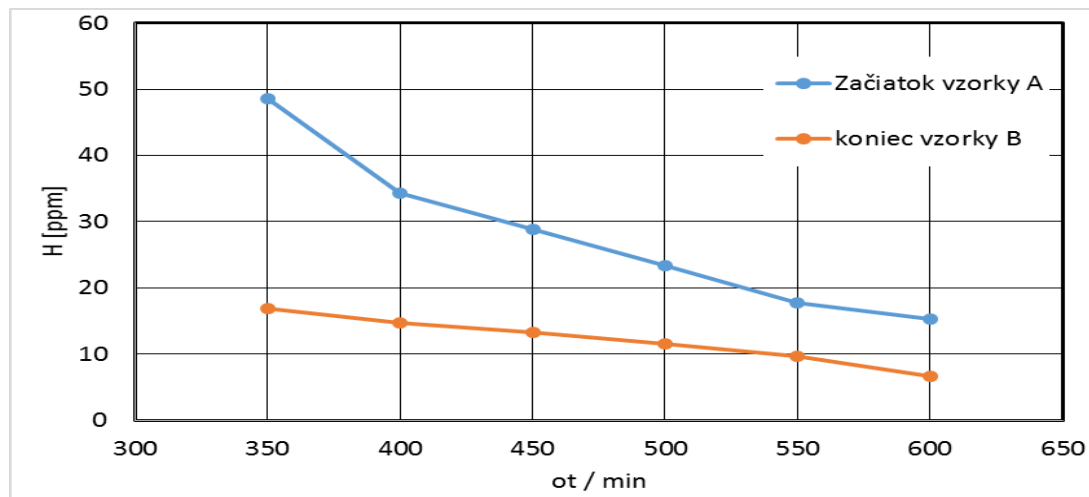


Figure 6. Measured value of hydrogen (H/ppm) for alloy AlSi10Mn

Conclusion

The main aim of this publication is to determine the appropriate rotation rates and compliance with the temperature of melts for alloy AlSi10Mn. The aluminium alloys are typically used in Slovak industry because their procedures together with welding are well scientifically examined. During the experiment, the special molds were designed with a thickness of 2.5 times to allow the heat dissipation through the mold which is needed unlike to the zinc alloys. Experiments have proven that the implementation of such process is an asset for the industry but only in compliance with the precise technology procedures. One of the great advantages is the usage of low temperature during the casting process. The aluminium alloys have in liquid state high capacity to absorb hydrogen which has a negative effect during the cooling and solidification of the castings, because it may cause the gas bubbles under the surface of the outer wall of the casting [8]. This was solved with this experiment by the use of centrifugal force during the casting process. The difference of the density of hydrogen and aluminium allows to decrease the hydrogen content with increasing centrifugal force, which is dependent on the radius of rotation and the angular velocity quadratic. Centrifugal casting has similar effects to the use of a protective gas in this case. The dependence of the decrease of hydrogen content was observed during this experiment on the test samples. The higher the rotation rates, the lower the hydrogen content, H/ppm (Fig. 6). On the inlet part of the test sample – tearing rod from alloy AlSi10Mn with 350 r/min, hydrogen content was decreased for e. g. from 48.58 to 15.27 ppm with 600 r/min. On the tip of the tearing rod with 350 r/min, the hydrogen content was decreased from 16.94 to 6.92 ppm with 600 r/min. The decrease of gas introduction confirms the advantage of centrifugal casting. The particles or gas bubbles, non-metallic impurities with low mensural weight were eliminated on smaller rotation radius in comparison with the particles and substrates with higher mensural weight [9]. All performed examinations were accompanied with the description and function of the used devices. The results are reproducible in order to be used in practice, in regard of the development of advanced aluminium-based alloys and new advanced types of materials.

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