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Influence of Vibrations During Crystallization on Mechanical Properties and Porosity of EN AC-AlSi17 Alloy

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Abstract

Today's industry aims at such situation, where number of defective products, so called defects shall approach to zero. Therefore, one introduces a various changes in technology of production, introduces improvements which would help in accomplishment of this objective. Another important factor is introduction of different type of testing, which shall help in assessment which factor has significant effect on quantity of rejects, and which one could be neglected. Existence of casting rejects is unavoidable; therefore a new ideas, technologies and innovations are necessary in the entire widely understood foundry branch, in order to minimize such adverse effect. Performance of tests aimed at unequivocal determination of an effect of vibrations during crystallization on mechanical properties and porosity of the EN AC-AlSi17 alloy was the objective of the present work. To do this, there were produced 36 castings from EN AC-AlSi17 alloy. All the castings underwent machining operations. Half of the casting was destined to strength tests, the other half served to determination of an effect of vibrations on porosity of the alloy. The specimens were divided into 12 groups, depending on amplitude of vibrations and tilt angle of metal mould during pouring operation.

Keywords: Fundamentals of foundry processes, Crystallization, Structural constituent, Porosity, ATD

1. Introduction

For the testing one prepared 36 specimens from EN AC-AlSi17 alloy, the specimens were poured in foundry laboratory of University in Bielsko – Biala. As the first sequence there were cast 18 specimens destined to determination an effect of vibrations during crystallization on phenomenon of porosity. Subsequently, one poured next 18 specimens destined to the testing aimed at determination of an effect of vibrations during crystallization on mechanical properties.

The tests were performed with not modified alloy, refined in temperature of 720^{0}C. In the process of refinement one used Rafa1 rafinator (hexachloroethan) in quantity 0,05%wt. of mass of the metallic charge.

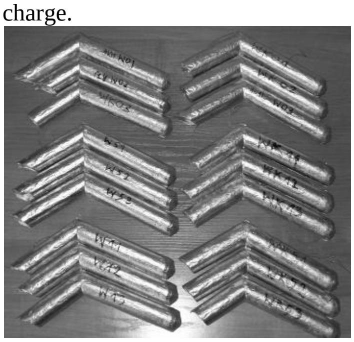

Fig. 1. Batch of poured specimens

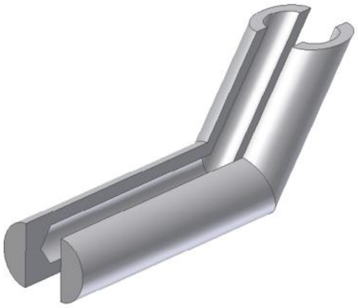

Fig. 2. Metal mould used to pouring of the tested specimens

The metal mould had a possibility of installation of a thermocouple, which served to permanent registration, in real time, of temperature of solidifying specimen. With use of measuring station of the ATD method one registered runs of crystallization for individual specimens. Results of the registration were presented in graphic form on crystallization diagrams from the ATD method [7, 8, 9,10]. The tests were performed in fixed conditions. One poured specimens of the investigated alloy in the following conditions: without vibrations, with 50% amplitude of the vibrations (0,4 mm), with 100% amplitude of the vibrations (0,8 mm), frequency of vibration of 50Hz, temperature of metal mould of 250^0C, temperature of the alloy of 760^0C. Half of the specimens (18) were poured in horizontal position, whereas the second half of the specimens were poured in metal mould tilted with 20^0 (Fig. 3). Three pieces of specimens for each series were produced. [12, 13]

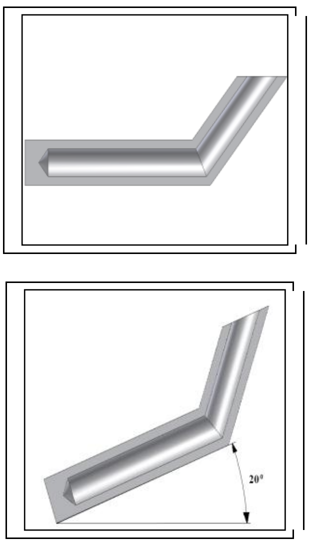

Fig. 3. Positioning of the metal mould during pouring

2. Methodology of the investigations

The paper presents test results of an effect of metal mould vibrations on crystallization of the investigated EN AC-AlSi17 alloy. The Table 1 below presents method of marking of the specimens. In the Fig4. is shown an exemplary result of registration with use of the ATD method of the given specimen.

Aluminum industry has a great contribution to world-wide economy. Nowadays, aluminum is the second (after steel) the most popular and the most often used metal in the world [1]. For a few last decades its production has grown nearly ten times and is still growing. The aluminum owes its popularity to properties like corrosion resistance or thermal and electric conductivity. However, ratio of the strength to mass is the main property. Except advantages, the aluminum also features a disadvantage like the price is. Alloys of aluminum with silicon (so called silumins), which are characterized by good mechanical properties, find broad applications in electro-engineering, automotive, aircraft, precise, household equipment industry, and in many other industrial branches [2, 3, 4]. Contemporary tendencies striving after minimization of mass of structures should increase field of the application. [14]

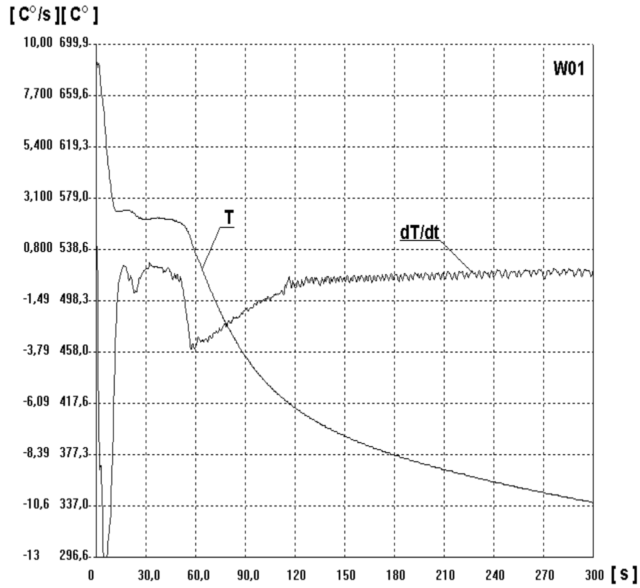

Fig. 4. The ATD diagram of the 1113 specimen

Test bed to investigation of porosity of the alloy consisted of the NEOPHOT 32 metallographic microscope equipped with high resolution camera connected to computerized system of image analysis. Next, with use of the *MULTISCAN* program there were performed photos of the investigated specimens (Fig. 5). Successive stage consisted on generation, with use of the image analyzer system, an image of specimens' photos showing areas of porosity and contraction cavities only, on base of which the software could calculate surface area of the porosities and contraction cavities. [15]

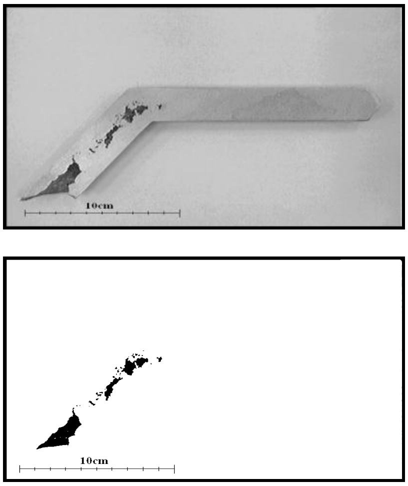

Fig. 5. Exemplary view of 01specimen together with generated by the image analyzer system surface of porosity

Table 1.
Marking of the specimens

Marking of the specimen	Vibrations[%]	Tilt angle of metal mould [deg]	Number of specimen in the series
1101	0	0	1
1102	0	0	2
1103	0	0	3
1151	50	0	1
1152	50	0	2
1153	50	0	3
1111	100	0	1
1112	100	0	2
1113	100	0	3
K1101	0	20	1
K1102	0	20	2
K1103	0	20	3
K1151	50	20	1
K1152	50	20	2
K1153	50	20	3
K1111	100	20	1
K1112	100	20	2
K1113	100	20	3

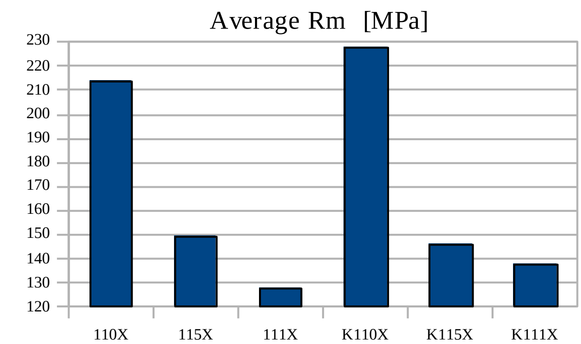

Fig. 6. Results of strength tests of the EN AC-AlSi17 alloy

Results of the porosity tests are summarized in the Table 2.

Table 2.
List of superficial porosity test results

Marking of the specimen	Porosity surface area [cm^2]	Percentage share [%]	Porosity average surface area [cm^2]
1101	1,34	0,21	
1102	1,16	0,19	1,28
1103	0,97	0,15	
1151	2,07	0,33	
1152	0,93	0,16	1,42
1153	1,28	0,20	
1111	1,12	0,18	
1112	0,83	0,13	0,95
1113	0,91	0,14	
K1101	0,72	0,12	
K1102	0,75	0,12	0,77
K1103	0,83	0,13	
K1151	1,34	0,21	
K1152	0,97	0,15	1,18
K1153	1,23	0,2	
K1111	0,84	0,13	
K1112	0,83	0,13	0,86
K1113	0,92	0,14	

Table 3.
Results of strength tests of the EN AC-AlSi17 alloy

Specimen No.	Ø [mm]	F[kN]	Rm [MPa]	Average [MPa]
1101	15	40	240	
1102	14,9	36,5	206	**214**
1103	15	36	206	
1151	14,8	34	199	
1152	14,9	22,5	124	**149**
1153	15	22,5	125	
1111	14,8	19,5	112	
1112	15	28	159	**128**
1113	14,9	20,05	113	
K1101	14,8	40	240	
K1102	14,8	38,5	230	**228**
K1103	15	37,5	215	
K1151	14,9	25,3	145	
K1152	15	24,2	137	**146**
K1153	14,9	27,2	156	
K1111	15	25,5	145	
K1112	15	22,6	128	**138**
K1113	14,9	24,9	142	

3. Conclusions

Presented work shows impact of vibrations of casting mould in course of crystallization on porosity and mechanical properties of the EN AC-AlSi17 alloy.

Results of investigation of porosity's surface area are illustrated by the following figures:

Table 4.
Results porosity surface area of the EN AC-AlSi17 alloy

Comparison of the specimens	Porosity surface area
115X/110X	Reduction with 10%
111X/110X	Growth with 34%
111X/115X	Growth with 49%
K115X/K110X	Growth with 8%
K111X/K110	Growth with 11%
K1111X/K115X	Growth with 37%
K110X/110X	Reduction with 11%
K115X/110X	Growth with 8%
K111X/110X	Reduction with 33%
K115X/115X	Growth with 20%
K111X/111X	Growth with 10%

- Examining effect of vibrations on size of surface area of porosity we can conclude that vibrations have advantageous effect, because together with growth of vibrations we can notice reduction of size of surface area of porosity [table 2, table 4].
- Making comparison of porosity in specimens poured without vibrations and specimens poured with 0% amplitude of vibrations we can see 10% smaller surface area of porosity.
- If, additionally to vibrations we tilt the metal mould with 20^0 , the reduction amounts to as many as 33%.
- The smallest surface area of porosity was obtained for 0% amplitude of vibrations and tilt angle of 20^0.
- The experiments have confirmed that for the EN AC-AlSi17 alloy the highest growths of tensile strength occur at 0% amplitude of vibrations [table 5].
- Results of the experiments show, that the smallest porosity occurs at 0% amplitude of vibrations tilt angle of 20^0.

Table 5.
Results R_m tensile strength of the EN AC-AlSi17 alloy

Comparison of the specimens	Rm tensile strength
115X/110X	Reduction with 43%
111X/110X	Reduction with 88%
111X/115X	Reduction with 65%
K115X/K110X	Reduction with 56%
K111X/K110X	Growth with 3%
K111X/K115X	Growth with 6%
K110X/110X	Reduction with 4%
K50X/110X	Growth with 6%
K111X/115X	Growth with 55%
K115X/115X	Growth with 2%
K111X/111X	Reduction with 9%

- During crystallization, vibrations have also advantageous effect on mechanical properties.
- Amplitude of vibrations have also effect on R_m tensile strength. At 0% amplitude we can obtain a growth of the strength with about 11% (table 5).
- Tilt of the metal mould does not have so much strong effect on the strength as on porosity.

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