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Analysis of structural properties of aluminium skeleton castings regarding the crystallization kinetics

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ABSTRACT

Purpose: The aim of this research was the definition of technological parameters influence and modification treatment on structural properties of closed skeleton castings. Approach obtained maximal refinement of structure and minimal structure diversification.

Design/methodology/approach: Skeleton castings were manufactured in acccordance to elaborated production technology. The subject of the research was the microstructural analysis of non - monolithic castings. Analisys of metallographic specimens and quantitative analysis of silicon crystals and secondary dentrite-arm spacing analysis of solution α were performed. Studies were executed for typical regions of skeleton castings. The regions were diversified regarding the cooling rate.

Findings: Technological condictions and modification treatment were determined on advantageous structural properties (the great homogeneity and the greatest degree of fineness of microstructure). On basis of the reserach autors confirmed that in applied condictions of solidifiaction advantageous structur of AlSi11 alloy was obtained.

Research limitations/implications: In the future autors will pursue to define influence of different modifiers (than antimony) on structural properties of skeleton castings. The modifiers are generally applied to refinement the structure of eutectic aluminium alloys. The aim of future resarch will be also to define optimum technological parameters which generate the best structural properties.

Practical implications: This article shows method of structure design of AlSi11 alloys skeleton castings. This is essential with regard on usable properties of skeleton castings in future technical applications.

Originality/value: Value of article is the elaborated manufacturing technology of skeleton castings and two methods of structure design of non – monolithic constructions with complicated geometry. The first method depended on elaborated parameters technological guidelines and advantageous technological condictions which enables to obtain the best structural properties. The second method depended on use of modifier which improve castability of AlSi11 alloys and enables to obtaine good filling of core channels of skeleton castings with more homogeneous structure.

Keywords: Casting; Skeleton casting; Solidification; Structure; AlSi11 alloy

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MATERIALS MANUFACTURING AND PROCESSING

1. Introduction

Skeleton castings belong to the modern group of constructions material and can find application for: pressure vessels for gaseous and liquid media for example hydrogen, ozone; zones of controlled adsorpcion of kinetic energy at cars for example fenders, longerons, frames and bearing elements of transport agent, frames of machine tool, suporting structures of machines, military armours, elements of anti – radar shield.

These innovative castings executed on basis of heat-insulating and hydrophilic core sand with cristobalite and aluminosilicate matrices. Thermal properties of core material should be well-fitting. Beyond obtain of desirable geometry of casting is necessary obtain of required microstructure of casting. Obtain of minimum is a differentiation of microstructure in whole volume of castings basic problem.

The achievement of required mechanical properties requires designing the geometry of skeleton, which is closely connected with geometry of the core.

Methods of manufacturing of cores are: composing cores with single elements, which reproducing the elementary cells; composing layers which reproducing the required number of cells;or direct execution of the whole core.

2. The aim and domain of study

The aim of research was the definition influence technological parameters and modification treatment on structural properties of closed skeleton castings. Approach obtained maximal refinement of structure and minimal structure diversification. Virtual model of casting is shown in Fig. 1.

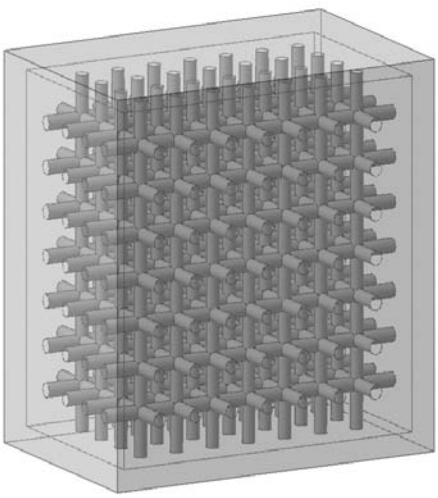


Fig. 1. Virtual model of skeleton casting

3. Experimantal procedure

Experimental test were realized according to Hartley's experiment plan. Basic experiment plan includes performance of 11 experiments (Fig. 2), in which input factors are:

1. Pouring temperature (range 953 - 1013 K)
2. Temperature of the mould (range 293 - 373 K)
3. Height of the gating system (range 230 – 300 mm)

Output factors of process are:

1. Filled space of mould
2. Geometrical characteristic of casting microstructure
3. Mechanical properties of casting

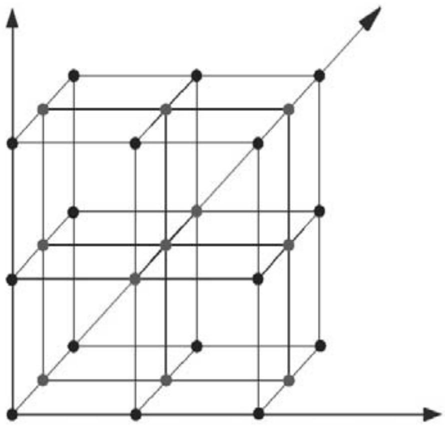


Fig. 2. Hypercube of Hartley's experiment plan three – levels

Experiment plan assumes three levels of controlling factors X: minimal (-1), central (0) and maximal (1). These factors are the estimate according to formulas:

$$\check{X} = \frac{X - \bar{X}}{\Delta X} = \frac{2\alpha \cdot (X - \bar{X})}{X_{max} - X_{min}} \quad (1)$$

$$\Delta X = \frac{X_{max} - X_{min}}{2\alpha} \quad (2)$$

$$\bar{X} = \frac{X_{max} + X_{min}}{2} \quad (3)$$

where:

$\check{X}$ – controlling factor of modeling,

$\bar{X}$ – central value of factor on actual scale,

X – factor on actual scale,

ΔX – variation of controlling factor,

$\alpha = 1$, experiment design based on hypercube.

1. Computation of the central value (computation of input factors on the level 0) on the pouring temperature, temperature of the mould and height of the gating system:

$$\bar{X}_{Tzal} = \frac{1013\ K + 953\ K}{2} = 983\ K$$

$$\bar{X}_{Tformy} = \frac{373\ K + 293\ K}{2} = 333\ K$$

$$\bar{X}_{h} = \frac{300\ mm + 230\ mm}{2} = 265\ mm$$

2. Computation of variability units on pouring temperature, temperature of the mould andheight of the gating system:

$$\Delta X_{Tzal} = \frac{1013\ K - 953\ K}{2 \cdot 1} = 30\ K$$

$$\Delta X_{Tformy} = \frac{373\ K - 293\ K}{2 \cdot 1} = 40\ K$$

$$\Delta X_{h} = \frac{300\ mm - 230\ mm}{2 \cdot 1} = 35\ mm$$

3. Coding of factors on pouring temperature, temperature of the mould and height of the gating system:

$$\check{X}_{Tzal} = \frac{X - 983\ K}{30\ K} = x_1$$

$$\check{X}_{Tformy} = \frac{X - 333\ K}{40\ K} = x_2$$

$$\check{X}_{h} = \frac{X - 265\ mm}{35\ mm} = x_3$$

Pouring temperature, temperature of the mould and height of the gating system were perfomed with symetrical condition on all three levels of controlling factor. Experiment plan matrix was shown in Table 1.

Table 1.
Experiment plan matrix based on hypercube

Lp.	x_1	x_2	x_3
1.	+	+	+
2.	+	-	-
3.	-	+	-
4.	-	-	+
5.	+	0	0
6.	-	0	0
7.	0	+	0
8.	0	-	0
9.	0	0	+
10.	0	0	-
11.	0	0	0

Core with matrix aluminosilicate (λ = 0.037 W/m·K) was used for making cores of the experimental skeleton castings. In comparison to traditional castings skeleton castings have large self cooling surface, therefore heat-insulating materials were used. In core was the reproduction channels on circular section (r = 2.5 mm). The circular section was reproduction on three planes.

Model of the core was shown in Fig. 3.

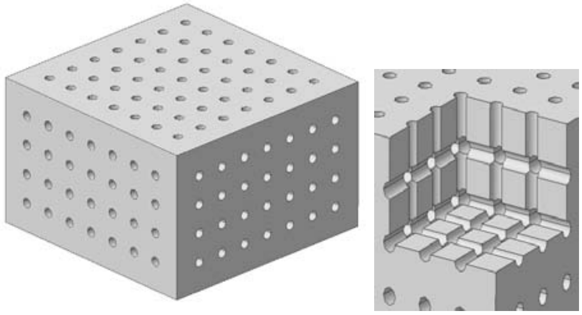


Fig. 3. Model of core

The eutectic aluminum alloy AlSi11 with antimony was used for making of experimental casting, because this alloys crystallizes forming fine grained structures. Antimony belong to the group of the chemical elements which modify structure of Al-Si alloys. Application of antimony as modifier is often unsatisfactory.

In presented research antymony was applied in order to decrease surface tension of liquid alloy to minimize production of Al_2O_3 oxides on stream front and to maximize the castability of the alloy. Application antimony as a modifier of structure was assumed in the background.

Experimental castings were manufacturing on the following condictions:

- dimension of the casting: 125x65x125 mm;
- thickness of external walls: 6 mm;
- lower ingate (5x50mm);
- size of elementary skeleton cell a = 15 mm;
- connector of skeleton radius 2.5 mm;

Technological parameters of experimental castings manufacturing are shown in Table 2.

Table 2.
Variables technological condictions studies

AlSi11+ 0.4%Sb			
number of casting	pouring temperature [K]	temperature of mould and core [K]	height of gating system h [mm]
1.	1013	373	300
2.	1013	293	230
3.	953	373	230
4.	953	293	300
5.	1013	333	265
6.	953	333	265
7.	983	373	265
8.	983	293	265
9.	983	333	300
10.	983	333	230
11.	983	333	265

Closed aluminium skeleton casting was shown in Fig 4.

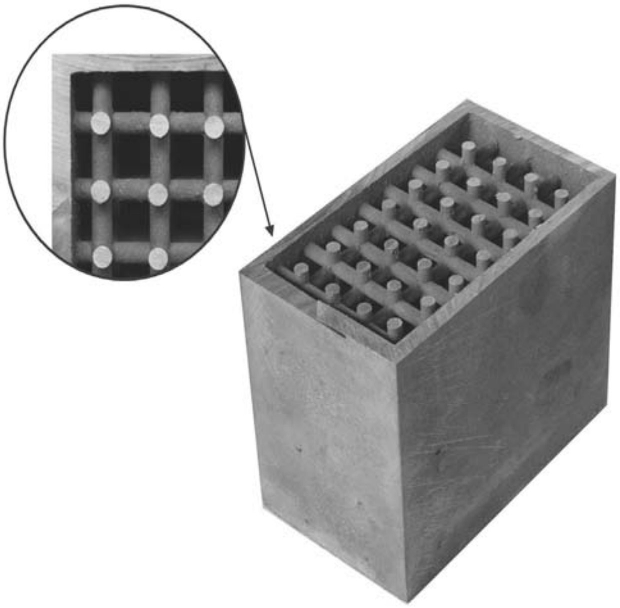


Fig. 4. Example of closed aluminum skeleton casting with eliminate external upper wall, modified AlSi alloy, 125x70x125 mm, T_{pour} 953 K, T_{mould} 293 K, (height of gating system above casting level = 105 mm)

3.1. Structural analysis

Qualitative and quantitative microstructural analysis of studied skeleton castings was conducted. Metallographic specimens were not etched.

Typical regions in which authors compared microstructure were shown in Fig. 5.

Structural constituent of alloy is: solution α of silicon in aluminium and crystals of eutectic (α + Si) silicon in interdendritic regions.

Microstructures particular elements of consecutive skeleton casting were shown in Fig. 6. Numerical designation in the right upper corner meet a description in Fig. 5. Sequence of micrograph meet the increase of dimension of structural constituent.

Metallographic photos of microstructure were analysed. Variability of stereological parameters was studied: surface (P), perimeter (A), width (B) and lenght (L) of silicon crystals. Maximal and minimal and average values of stereological parameters for all analysed regions research castings were determined. On basis on values of stereological parameters refinement degree was determined. Values of stereological parameters for selected sample were shown in Table 3.

(B/L) and (P/A) factors and *Na* parameter were determined. *Na* parameter determine silicon crystals number on 1 mm^2 surface.

a)

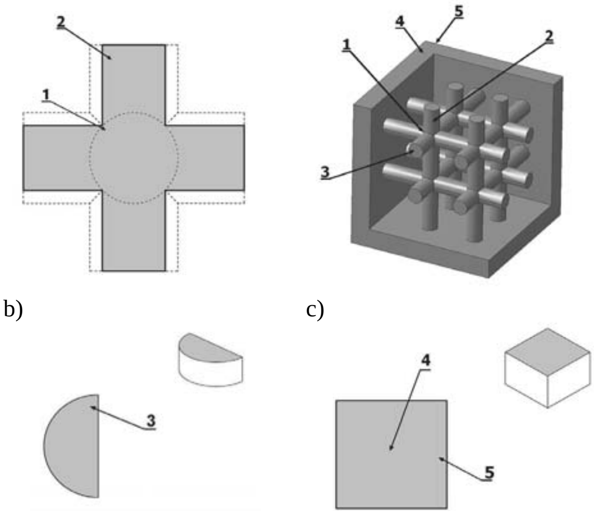


Fig 5. Typical regions in which author compared microstructure: 1 - skeleton node corner; 2 - longitudinal section; 3 - cross-section; 4 - central elements of corner wall which closed the skeleton; 5 - external surface of corner wall which closed the skeleton [13]

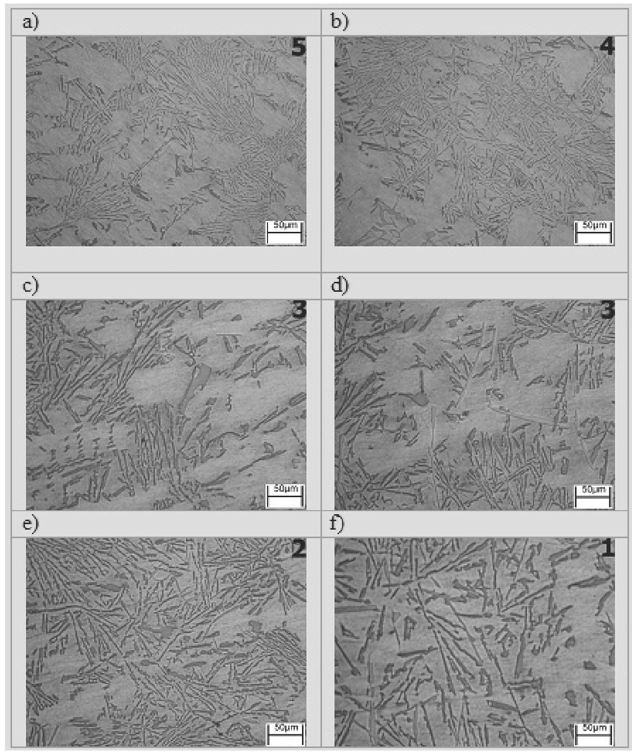


Fig. 6. Microstructures particular elements of skeleton casting (AlSi11, T_{pour} 953 K, T_{mould} 293 K, h – 300 mm): a- external surface of wall which closed the skeleton, b- central elements of wall which closed the skeleton, c,d,- longitudinal section of skeleton connector, e- cross-section of skeleton connector, f- corner of node, designation numerical (1-5) meet a description in Fig. 5

Table 3.
Values of measured and calculated stereological parameters of silicon crystals for research regions of consecutive castings –sample 5 (AlSi11, T_{pour} 1013K, T_{mould} 333K, h /265 mm)

Region		A[μm²]	L [μm]	B[μm]	P[μm]	$\frac{B}{L}\left[\frac{1}{1}\right]$	$\frac{P}{A}\left[\frac{1}{\mu m}\right]$
1	Average	35.70	31.33	15.21	10.92	0.50	0.47
	Max	3794.74	559.54	315.33	680.36	0.95	1.20
	Min	3.64	7.04	1.71	0.40	0.05	0.09
	Stand. dev.	2680.71	390.26	178.87	479.53	0.17	0.30
2	Average	28.77	29.44	14.79	9.98	0.52	0.47
	Max	961.44	377.85	204.94	299.41	1.00	1.19
	Min	3.71	7.29	1.71	1.93	0.10	0.14
	Stand. dev.	677.22	261.21	140.65	210.22	0.12	0.18
3	Average	23.31	25.07	12.43	8.64	0.50	0.52
	Max	1788.55	350.72	260.76	344.61	0.96	1.29
	Min	1.02	3.08	0.85	0.67	0.06	0.18
	Stand. dev.	1263.97	245.43	182.68	242.99	0.05	0.53
4	Average	28.96	27.75	13.73	9.56	0.51	0.49
	Max	1735.61	483.33	162.71	451.50	0.97	1.14
	Min	3.64	7.04	1.71	1.91	0.06	0.11
	Stand. dev.	1224.69	336.79	105.87	317.91	0.38	0.19
5	Average	19.61	26.10	11.08	7.99	0.45	0.54
	Max	920.74	252.15	171.65	220.84	0.96	1.23
	Min	3.71	7.29	1.21	0.48	0.07	0.02
	Stand. dev.	648.44	159.36	117.56	97.85	0.13	0.45

Table 4.
Dendrite arm spacing for select regions of skeleton castings

Sample	Measur. range	Dendrite arm spacing [μm]			
		min	maks	average	stand. dev.
1 T_{pour} 1013K, T_{mould} 373K, h – 300 mm	region 1	19.11	86.53	47.64	15.89
	region 5	19.11	86.65	51.60	15.36
3 T_{pour} 953K, T_{mould} 373K, h – 230 mm	region 1	120	350	188	67
	region 2	70.01	170.8	116.26	28
	region 4	70.04	200.1	132.44	36
	region 5	70.01	240	145.11	38
4 T_{pour} 953K, T_{mould} 293K, h – 300 mm	region 1	60.02	202	118	34
	region 2	62.10	180.3	109	31
	region 4	50.20	200.3	120	42
	region 5	78.73	118.7	96.62	11.69
5 T_{pour} 1013K, T_{formy} 333K, h – 265 mm	region 1	26.27	82.20	49.14	12.86
	region 5	22.52	86.06	50.28	13.88
6 T_{pour} 953K, T_{mould} 333K, h – 265 mm	region 1	13.51	95.57	44.10	17.40
	region 5	22.52	95.02	59.77	20.95
7 T_{pour} 983K, T_{mould} 373K, h – 265 mm	region 1	71.10	212.0	123	29
	region 2	90.05	250.3	164	41
	region 4	50.02	283.4	129.73	44
	region 5	71.20	173.3	117.02	25
8 T_{pour} 983K, T_{mould} 293K, h – 265 mm	region 1	22.97	82.20	52.26	14.94
	region 5	24.26	93.73	52.68	15.49
9 T_{pour} 983K, T_{mould} 333K, h –300 mm	region 1	16.24	96.40	53.31	20.36
	region 5	14.24	84.15	48.96	15.49
10 T_{pour} 983K, T_{mould} 333K, h – 230 mm	region 1	16.24	81.21	38.98	12.26
	region 5	20.14	91.87	49.40	16.16
11 T_{pour} 983K, T_{mould} 333K, h – 265 mm	region 1	16.24	85.47	51.37	16.61
	region 5	22.52	90.20	48.04	16.57

In Fig. 7 show histograms which describe silicon crystals number on 1 mm^2 surface for extreme regions of example skeleton casting.

Diagrams show values of (B/L) factors and (P/A) factors for typical regions of example skeleton casting (Fig. 8). (Designation numerical meet a description in Fig. 5).

Dendrite arm spacing of solution α was determined. (Numerical designation meet a description in Table 2). Samples were grinding and polishing and then samples was etching in 20% NaOH water solution during 30 seconds.Statement results dendrite arm sparing for samples with experiment plan is show in Table 4. (Numerical designation meet a description in Fig. 5)

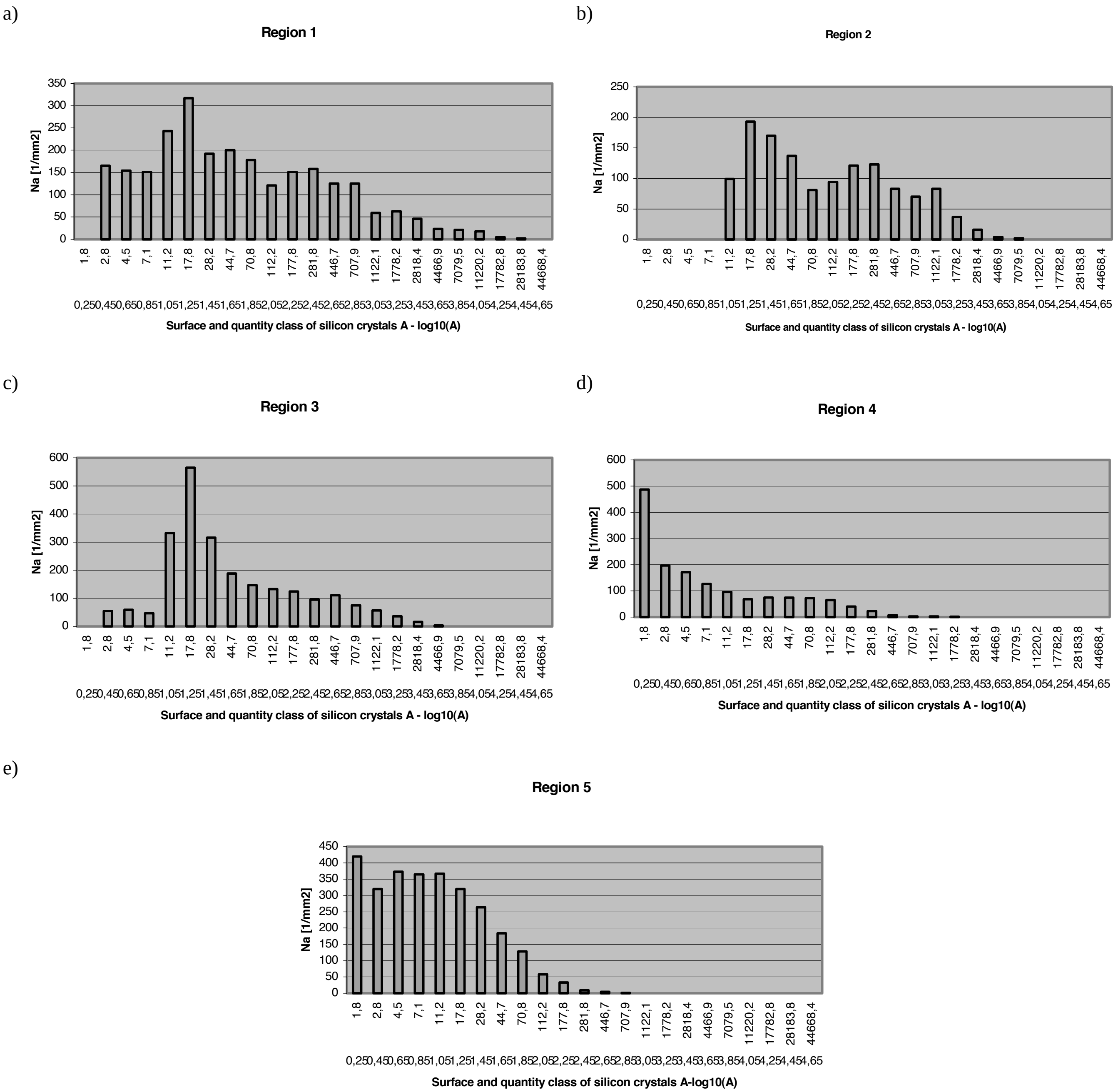


Fig. 7. Quantities Na of silicon crystals in classes of size their the surface (AlSi11, T_{pour} 953 K, T_{mould} 373 K, h – 230 mm)

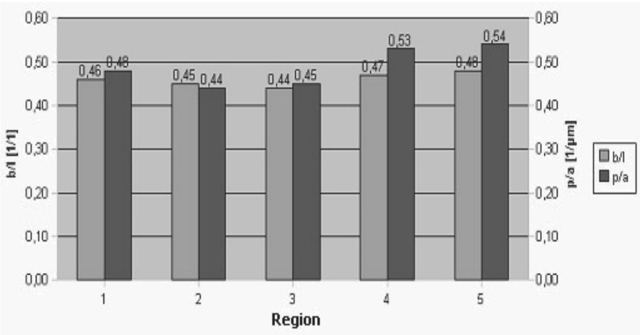


Fig. 8. Shape factor B/L and P/A for particular skeleton regions (1-5): sample 2 (AlSi11, T_{pour} 1013 K, T_{mould} 293 K, h – 230 mm);

Dendrite arm spacing of solution α was determined. (Numerical designation meet a description in Table 2). Samples were grinding and polishing and then samples was etching in 20% NaOH water solution during 30 seconds.Statement results dendrite arm sparing for samples with experiment plan is show in Table 4. (Numerical designation meet a description in Fig. 5)

Dendrite arm spacing in typical and extreme regions 1 and 5 was investigated. For regions 1 and 5 will provide the greatest diversification of DAS which connected with different cooling rate in this regions. The great scater of results in regions 1 and 5 for castings 3, 4 and 7 was observed.

Therefore for this castings in regions 2 and 4 autors executed studies additional. The aim of research was definition regions on least and greatest DAS.

Distributions of secondary dendrite-arm spacing diagrams for sample 5 were presented in Fig. 9.

Presented empirical distributions *DAS* for research regions remained approximate by function [14]:

$$F(X) = \frac{U \cdot Z \cdot \exp[Z \cdot (W - \log(X))]}{[1 + \exp(Z \cdot (W - \log(X)))]^2} \quad (4)$$

where:
U, W, Z – represents constans of approximation

Table 5.
Parameters function, which approximate of *DAS* distributions for regions on the least DAS of skeleton castings

Casting number	Function, which approximate of *DAS* distribution					
	Measured parameters function			Statistical parameters		
	U	W	Z	stand. dev.	correlation	Fisher's test
1	6.3754	1.7167	15.797	0.600	0.9948	114
5	6.5172	1.7327	13.711	0.455	0.9973	203
10	6.6365	1.7164	12.747	0.299	0.9989	436
11	7.0233	1.6806	11.978	0.463	0.9967	184

In Fig. 10 examples of approximate relation between objects quantity (y=F(x)) and DAS logarithm (log x) for regions on the least DAS of skeleton castings for different pouring temperature and temperature of mould.

In Table 5 parameters function, which approximate of *DAS* distributions for regions on the least DAS of skeleton castings were showed.

a)

b)

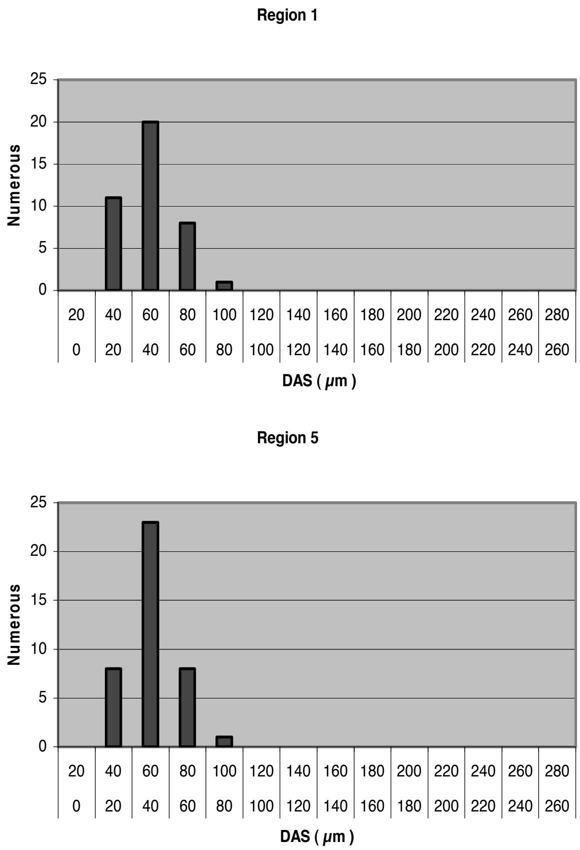


Fig. 9. Distribution of secondary dendrite-arm spacing for selected regions of casting -sample 5 (AlSi11, T_{pour} 1013K, T_{mould} 333K, h –-265 mm)

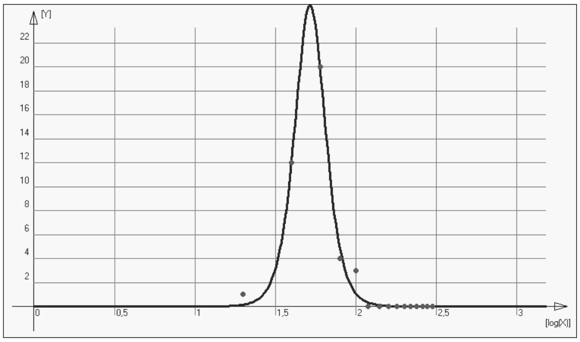
Approximation was investigated by higher value of correlation coefficient – *R* for analyse regions on the least DAS of skeleton castings.

4. Results and discussion

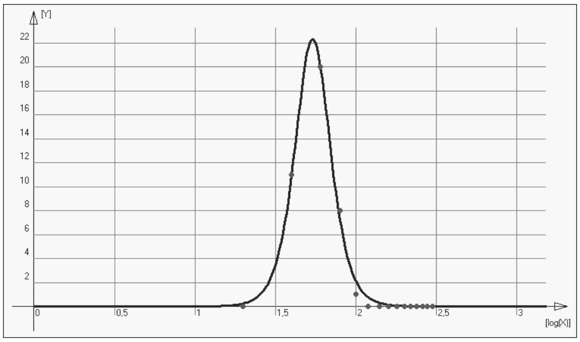
During crystallization of the casting diverse condictions of heat give up occurred. Structure of sections element connector of skeleton (Figs. 5 a,b point 2,3) and in corner of a node (Fig. 5 a point 1) and on wall which closed the skeleton (Fig. 5 c point 4, 5) were compared.

The highest averages of surface *A* of silicon crystals is in the region 1 (Table 3), which confirmed that the least refinement of skeleton casting structure was on the corner of node. The lowest average of surface *A* of silicon crystals is in the region 5 for all skeleton castings, which connected with occurrence the least refined eutectic silicon and rapidly heat give up occurred.

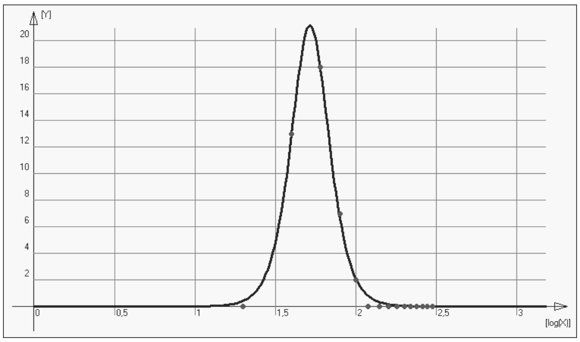
a)



b)



c)



d)

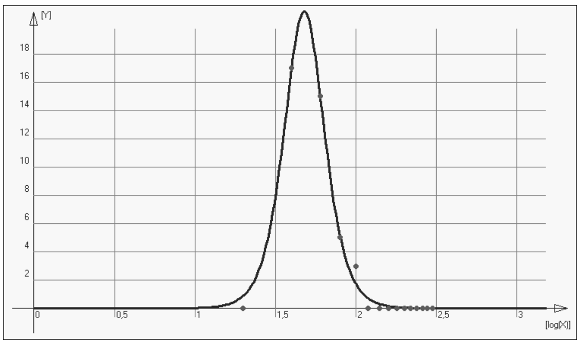


Fig. 10. Functional, approximation size of objects [1/1] related to logarith of measured DAS [μm] for regions on the least DAS of skeleton castings: a) sample 1 (T_{pour} 1013K, T_{mould} 373K, h – 300), b) sample 5 (T_{pour} 1013K, T_{mould} 333K, h – 265 mm mm; c) sample 10 (T_{pour} 983K, T_{mould} 333K, h – 230 mm; d) sample 11 (T_{pour} 983K, T_{mould} 333K, h – 265 mm

Empirical analysis of distributions Na=f(A) was shown, that the most of silicon crystals in the highest classes their surface were in skeleton node corner which is confirmation lowest refinement. The least of silicon crystals were in higher classes of size their the surface *A*. In the highest classes of size their the surface weren't of silicon crystals. The most of silicon crystals are in lowest classes of size their the surface *A* for external surface of wall which closed the skeleton for all castings which is confirmation greatest refinement.

B/L factor (Table 3, Fig. 8) determine degree of extension of silicon crystals. The lower value of factor the more elongated silicon crystals are. Values of B/L factor are similar for all analysed regions each research skeleton castings. Whereas P/A factor determine surface development of silicon crystals. For all analysed regions P/A factor the greatest values is in region 5, next in region 4, which connnected with rapidly heat give up occurred in this regions.

The least averages dendrite arm spacing (table 4) for castings for which in four regions autors investigated the research is for castings 4 and 7 in regions 5, whereas for casting 3 in regions 2. The greatest averages values of DAS are for casting 3 in region 1 and for casing 4 in region 4 and for casting 7 in region 2.

For castings 1, 5, 6, 8, 9, 10, 11 for which average DAS authors measured in typical and extreme regions research provide numerical influence cooling rate on refinement degree of structure. The least averages dendrite arm spacing for castings 9 and 11 are in region 5. For castings 1, 5, 6, 8, 10 dendrite arm spacing the least values are in region 1. Values DAS in region 1 and 5 for this castings achieves are similar (Table 4).

On basis diagram of distribution dendrite arm spacing for sample 5 (Fig. 9) numbers DAS are similar in highest and lowest class of distribution DAS for 1 and 5 region. It is connected with diversification insignificant of structure in extreme regions of skeleton castings in respect of cooling rate.

Fig. 10 indicate, that dendrite numer increases influence by higher pouring temperature. At higher pouring temperature dendrite numer increase of 20%, with DAS increased of 8.5%.

Radius of circular section element of skeleton is to 3 mm. Authors pursues minimization dimensions of cells and dimensions of circular of connectors (elements which composes skeleton). Therefore important is the crystallization kinetics. For thin walls of classical casting and especially in thin – walled castings applying heat-insulating moulding materials improves the ability of mould cavity. Then walls of casting crystallizes on considerable cooling rate, which is not on classical castings and universally applied moulding materials.

ATDG method authors applied to assessment cooling rate and another crystallization parameters. Equations (5-7) [14] stepwise regression were determined. On basis equations (5-7) autors estimates crystallization parameters in range of temperature from T_{pour} to T_{lik}. This range of temperature causes forming microstructure on degree of dispersion which was defined by dendrite arm spacing of silicon crystals of α solution.

On basis equations (8-10) autors determined: changes ranges of cooling rate (v_c) [K/s], gradient increase rate (v_G) [K/(cm s)] and v_c / v_G ratio (p_T=v_c/v_G) [cm] for received (table 6), for chosen technological condictions (castings 7-11 according to experiment design) for constant pouring temperature T_{pour}=983 K.

$$DAS = 103{,}89 \cdot v_c^{-0{,}5768} \text{ [µm]}; \quad v_c = \frac{\Delta T}{\Delta t} \text{ [K/s]} \quad (5)$$

$$DAS = 80{,}587 \cdot v_G^{-0{,}3845} \text{ [µm]}; \quad v_G = \frac{dT}{dz \cdot \Delta t} \text{ [K/cm·s]} \quad (6)$$

$$DAS = 94{,}79 \cdot p_T - 156{,}33 \text{ [µm]}; \quad p_T = \frac{v_G}{v_c} \text{ [cm]} \quad (7)$$

Transformation formulas (5-7):

$$v_c = 0{,}001\ DAS^{-1{,}734} \text{ [K/s]} \quad (8)$$

$$v_G = 0{,}0124 \cdot DAS^{-2{,}6} \text{ [K/cm·s]} \quad (9)$$

$$p_T = 0{,}0106 \cdot (DAS + 156{,}33) \text{ [cm]} \quad (10)$$

Table 6.
Values of cooling rate (**v_c**); gradient increase rate (**v_G**) and **v_c / v_G** ratio

Number of casting	DAS [µm]	v_c [K/s]	v_G [K/cm·s]	p_T [cm]
7	117-164	0. 5- 0.8	0.2 0.4	2.88- 3.38
8	52.2-52.6	3.3	3.1	2.2 - 2.204
9	49-53.3	3.2- 3.7	2.9- 3.7	2.165 - 2.211
10	39 - 49	3.6- 5.5	3.6- 6.7	2.060 -2.170
11	48-51.3	3.4- 3.8	3.2- 3.8	2.156-2.191

On basis of this research with ATDG method autors observed fundmental influence pouring temperature on parameters of crystallization. Therefore ATDG method is effective shaping implement of structure and mechanical properties of skeleton under condition precise selection of moulding materials.

4.1. Summary of structural analysis

On basis of results of microstructural analysis autors compares research of samples (Table 7). The aim of analysis was selected samples on least diversification of refinement degree of structure and least silicon crystals.

The least average overall surface of silicon crystals is for sample 5 ($A_{śr}$ = 27.27 [$µm^2$]). B/L factor highest values is for sample 5, factor value is from 0.45 to 0.52 for extreme regions of skeleton castings, this is connected with least elongated silicon crystals in this sample.

Values of P/A fator for sample 5 are variables in range least in extreme regions. Values of factor are from 0.47 to 0.54. The least values of dendrite arm spacing are for samples 1, 5, 6, 9, 10. Autors selected samples 5 for which DAS are variables in range limit and DAS values are the least for extreme regions of casting. On basis research autors state that the best structural properties for samples 5 (AlSi11, T_{zal} 1013K, T_{formy} 333K, h – 265 mm).

Table 7.
Statement results of microstructural analysis

Number of casting	$\frac{B}{L}\left[\frac{1}{1}\right]$	$\frac{P}{A}\left[\frac{1}{\mu m}\right]$	DAS [µm]
1	0.42 – 0.51	0.47 – 0.60	47.6 – 51.6
2	0.44 – 0.48	0.44 – 0.54	54.1 – 69.7
3	0.41 – 0.46	0.81 – 9.33	116.2 - 188
4	0.31 – 0.45	0.83 – 0.99	96.6 - 120
5	0.45 – 0.52	0.47 – 0.54	49.1 – 50.2
6	0.39 – 0.44	0.48 – 0.56	44.1 – 59.7
7	0.40 – 0.52	1.07 – 12.27	117 - 164
8	0.45 – 0.51	0.48 – 0.56	52.2 – 52.6
9	0.39 – 0.43	0.47 – 0.56	49 – 53.3
10	0.44 – 0.46	0.47 – 0.55	39 - 49
11	0.40 – 0.48	0.50 – 0.55	48 – 51.3

5. Conclusions

1. Authors confirmed possibility of obtain of profitable structures of AlSi11 alloy in applied solidification conditions of skeleton.
2. Executed research enables elaborating technological guidelines process of manufacture of skeleton castings and determination of relation technological factors of manufacturing with structure.
3. On basis microstructural analysis authors state that samples 5 (AlSi11, T_{zal} 1013K, T_{formy} 333K, h – 265 mm) has the best structural properties (least diversification of refinement degree of structure and the least refinement of silicon crystals).

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