IDENTIFICATION OF DECREASE OF CORROSION PROTECTION OF SILUMIN CASTINGS

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Abstract
Identification of decreased corrosion resistance of metal components working in real conditions is often very difficult. The reason is hidden in the large number of factors that can cause corrosion. The most important factors are: type of material, its processing technology, the resulting structure as well as the environment where the given part is used. The content of this paper is closely connected with the identification and description relating to corrosion of the part which operated without any problems under the real conditions in the past. The given investigated part was silumin castings. The designations as well as operating environment were not changed from the aspect of the used material.

Keywords: silumin casting, microstructure, EDX-analyse, corrosion, copper, porosity

1 Introduction

Analyzed component is part of the compressor unit and is documented in Fig. 1. Figure 2 shows its inner surface and there is the presence of corrosion products in the form of white powder. The presence of corrosion products influenced the given part negatively because there was the occurrence of untightness after about half a year of device operation. In the past, the similar or even the same defect was not observed. The designations as well as operating environment were not changed from the aspect of the used material. According to the mentioned fact, the impact of the working environment was excluded and the attention was paid to the evaluation of the structure of castings and the differences in their chemical composition. The old parts without any defects were observed and they were designated AR 20 and AF 20 was the designation for the parts where the corrosion effect was recognized.

Fig. 1 *Casting AF 20*

Fig. 2 *Corrosion attack of casting AF 20*

2 Microstructure

Microstructure was evaluated using metallographic sections representing the entire thickness of the part wall. The castings, which were not etched, exhibited the presence of a relatively high number of shrinkage porosity in the central area and it is closely connected with the increased porosity - Fig. 1, 2. The presence of shrinkage porosity was not observed in the areas of the external and internal surfaces and it can be confirmed by help of etched samples. On the basis of microstructure, it can be concluded that both two parts are made of aluminum based alloys. And more precisely, it could be said that the given parts are aluminum-based alloys with silicon – i. e. silumin.

The subsurface areas of both samples have dendritic microstructure, Fig. 3 and Fig. 4. Silicon phase is excluded in the eutectic form without the presence of silicon of acicular shape. In the central areas, the silicon of acicular shape can be observed for both castings while in the case of AR 20 samples, Si of acicular shape has more distinctive character, Fig. 9 – 12 and the mentioned facts can be used as evidence of the lower degree of modification for the sample AR 20. On the other side, in relation to the degree of modification, the subsurface areas of both sample types can be characterized that they are almost the same, see Fig. 5 – 8.

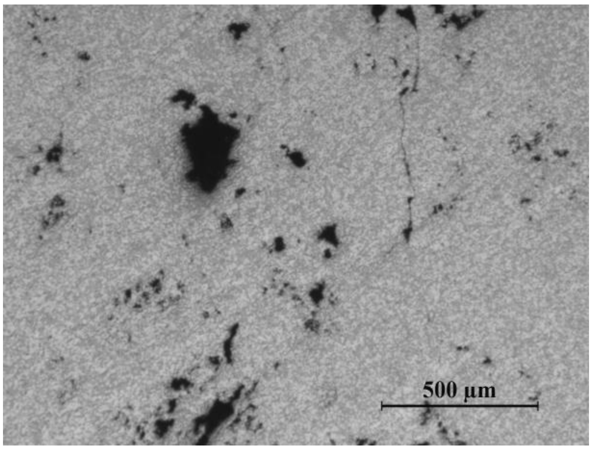


Fig. 3 *Sample AF 20 – Central area*

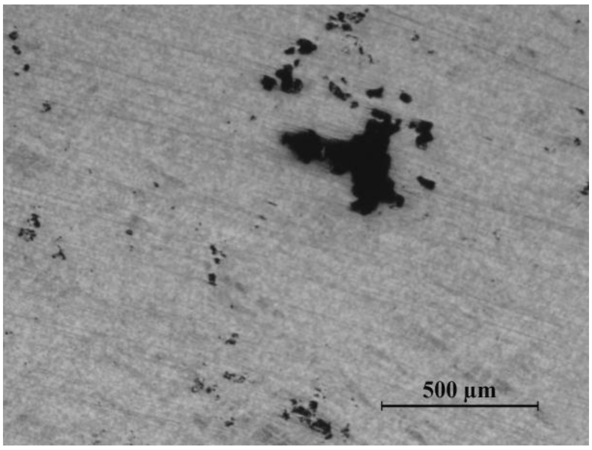


Fig. 4 *Sample AR 20 - Central area*

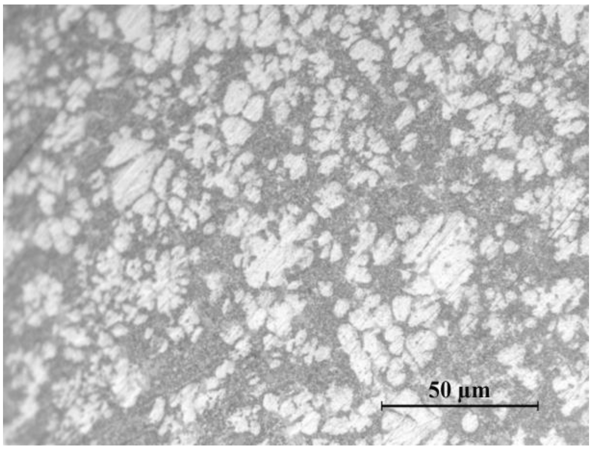


Fig. 5 *Sample AF 20 – Subsurface area*

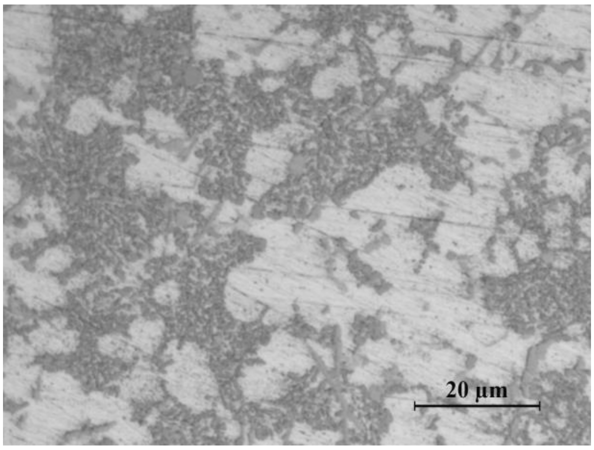


Fig. 6 *Sample AF 20 - Subsurface area*

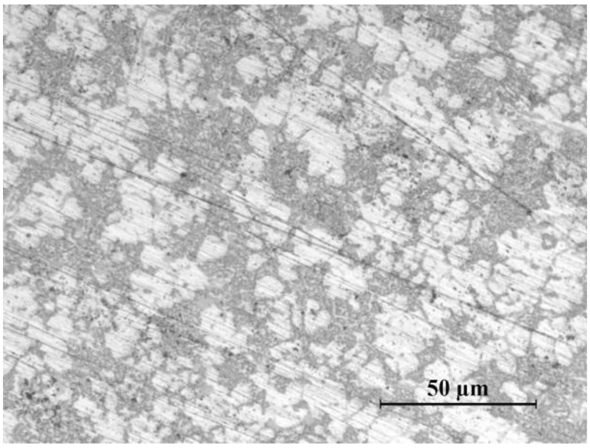


Fig. 7 *Sample AR 20 – Subsurface area*

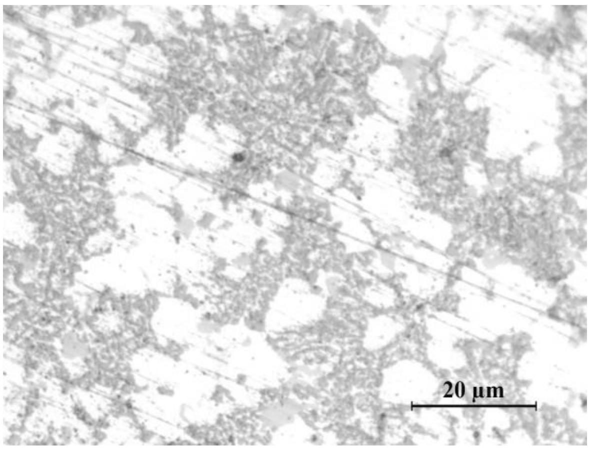


Fig. 8 *Sample AR 20 – Subsurface area*

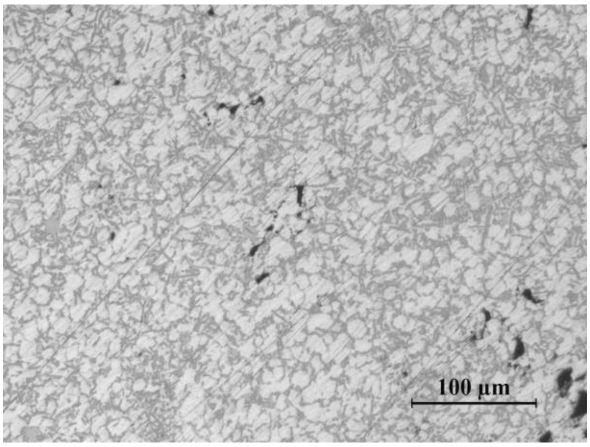


Fig. 9 *Sample AF 20 - Central area*

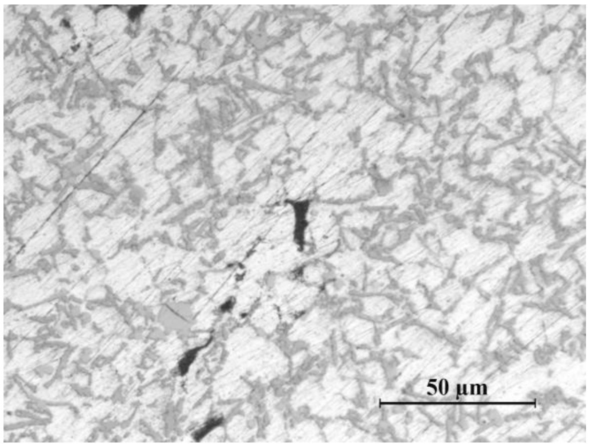


Fig. 10 *Sample AF 20 - Central area*

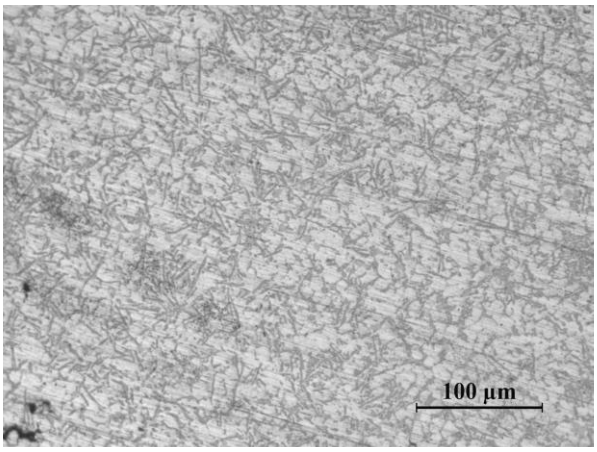


Fig. 11 *Sample AR 20 - center area*

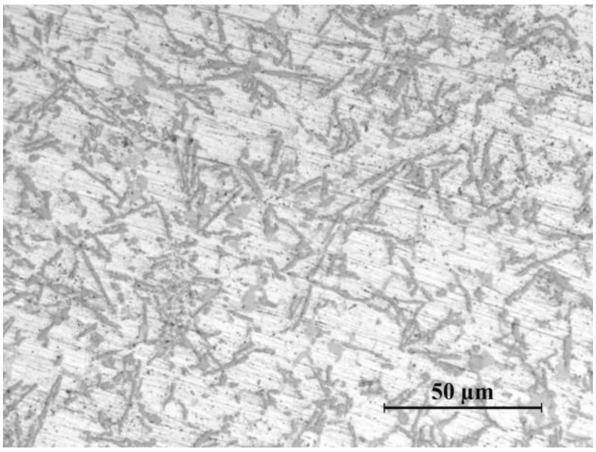


Fig. 12 *Sample AR 20 - center area*

3 EDX analysis

Qualitative chemical analysis was performed by help of a scanning electron microscope (SEM) JEOL JSM 7600 F with using planar x-ray energy-dispersive analysis. This analysis was performed for the surface of metallographic section castings. EDX spectra of individual samples are documented in Fig. 13 to 14 and measured concentrations of the analyzed elements are listed in Tables 1 – 2. The measured results show that both parts are made of aluminum-based alloys which are called silumin.

We cannot confirm clearly that it is the same type of silumin in all cases because only qualitative analysis was performed.

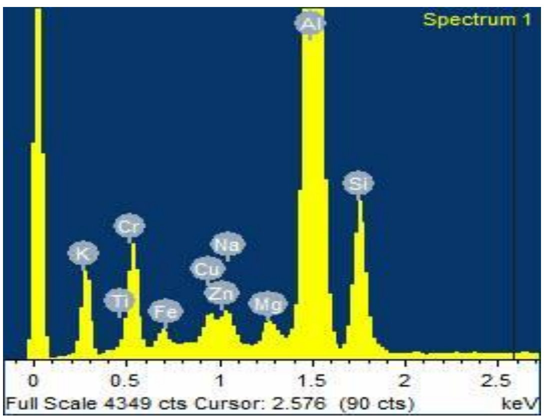


Fig. 13 *EDX – spectrum of sample AF 20*

***Table 1** Qualitative EDX chemical analysis of sample AF 20*

Element	**Al**	**Si**	**Mg**	**Fe**	**Cu**	**Zn**	**Cr**	**Ti**
Weight %	72,43	14,47	1,04	1,18	3,52	2,32	1,12	2,95

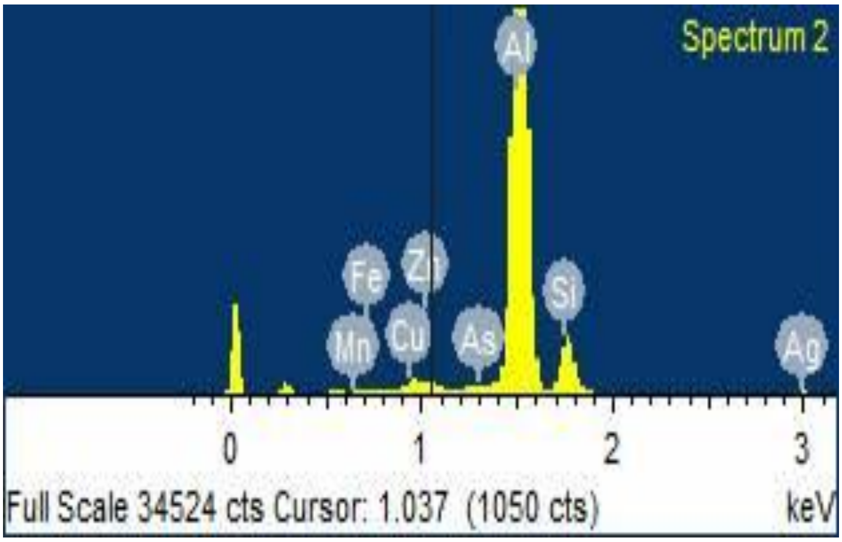
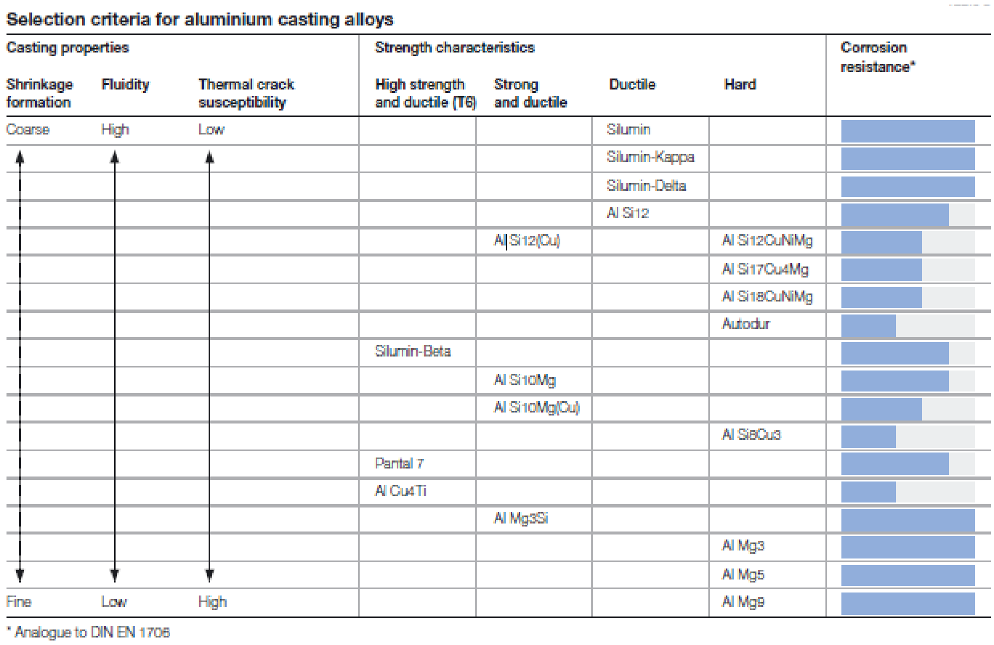


***Fig. 14** EDX – spectrum of sample AR 20*

***Table 2** Qualitative EDX chemical analysis of sample AR 20*

Element	**Al**	**Si**	**Mn**	**Fe**	**Cu**	**Zn**	**Ag**	**As**
Weight %	89,34	6,68	0,20	0,37	1,68	0,81	0,54	0,67

Results of EDX analysis confirmed the presence of copper in the material in relation to both castings. Copper generally reduces the corrosion resistance of silumin but the content of copper is more than double for the sample AF 20 sample and it rises up to 3.5%.



Selection criteria for aluminium casting alloys

Casting properties			Strength characteristics				Corrosion resistance*
Shrinkage formation	Fluidity	Thermal crack susceptibility	High strength and ductile (T6)	Strong and ductile	Ductile	Hard	
Coarse	High	Low			Silumin		
					Silumin-Kappa		
					Silumin-Delta		
					Al Si12		
				Al Si12(Cu)		Al Si12CuNiMg	
						Al Si17Cu4Mg	
						Al Si18CuNiMg	
						Autodur	
			Silumin-Beta				
				Al Si10Mg			
				Al Si10Mg(Cu)			
						Al Si8Cu3	
			Pantal 7				
			Al Cu4Ti				
				Al Mg3Si			
						Al Mg3	
						Al Mg5	
Fine	Low	High				Al Mg9	

* Analogue to DIN EN 1706

***Fig. 15** Selection criteria for Al castings*

4 Conclusion

The solution relating to the whole complex of corrosion problem for analyzed silumin castings was complicated because of unknown designation of material which was used for production of castings. Corrosion resistance of silumin without Cu is generally evaluated as high, Fig 15. Copper is an alloy element deteriorating corrosion properties and its increasing content causes a significant decrease of corrosion resistance of silumin. Negative effects of copper may be seen for content exceeding 0.4% while iron increases its negative effect [1, 2]. The impact of analyzed microstructural characteristics, namely porosity and degree of modification of subsurface areas, on the corrosion resistance of castings is low in our case. On the basis of the above mentioned fact, higher copper content in the casting can be the primary reason of the corrosion. In mutual cooperation with supplier, the supplemental analysis showed that the problem of corrosion was closely connected with the change of supplier. The castings were supplied by Japanese manufacturer for long time in the past. The economical aspect including costs of the given part led to the change from Japanese supplier to Chinese supplier. Therefore, as the prediction to the future, is concerned with the recommendations to return to former certified supplier of castings or the problem can be also solved by the order of material with low Cu content. The attention has to be also paid to the porosity because it can have negative influence from the aspect of the corrosion resistance.

Acknowledgements

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