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COMPRESSION CREEP OF SHORT FIBRE REINFORCED MAGNESIUM ALLOY AE42

Magnesium alloys are gaining increasing interest for automotive applications. Due to their low density and good specific strength cast parts are already in use, such as steering columns, steering wheels or fuel tank covers. Low creep properties at elevated temperatures are limiting applications at temperatures higher than 130°C. Magnesium based mmc's show clearly decreasing creep rates compared to its matrix alloys. In the present paper a 20 vol.-% Saffil® short fibre reinforced AE42 magnesium alloy is investigated. Compression creep tests at 200°C with a load of 100 MPa were performed. Creep curves and microstructural changes in the matrix alloy as well as in the mmc are discussed.

Key words: **metal matrix composite, compression creep, Saffil® fibre, AE42, magnesium alloy**

PEŁZANIE W WARUNKACH ŚCISKANIA STOPU MAGNEZU AE42 ZBROJONEGO KRÓTKIMI WŁÓKNAMI

Stopy magnezu cieszą się rosnącym zainteresowaniem w motoryzacji. Ze względu na mały ciężar właściwy i dobrą wytrzymałość części odlewane są już stosowane jako kolumny kierownic, koła kierownic czy pokrywy do zbiorników paliwa. Niska odporność na pełzanie w podwyższonych temperaturach ogranicza ich zastosowania w temperaturach wyższych niż 130°C. Tymczasem kompozyty o osnowie metalowej na bazie magnezu wykazują wyraźnie zmniejszone prędkości pełzania w porównaniu ze stopem osnowy. Niniejszy artykuł omawia badania stopu magnezu AE42 zbrojonego krótkimi włóknami Saffil® w ilości 20% obj. Przeprowadzono badania pełzania przy ściskaniu w temperaturze 200°C pod obciążeniem 100 MPa. Omówiono krzywe pełzania i zmiany mikrostrukturalne w osnowie oraz w kompozycie.

Słowa kluczowe: **kompozyty o osnowie metalowej, pełzanie przy ściskaniu, włókna Saffil®, stop magnezu AE42**

INTRODUCTION

When application of extreme light magnesium materials shall be pushed, high temperature strength and creep resistance has to be improved. Besides alloy development a second way to get high temperature magnesium materials is reinforcing magnesium alloys with short ceramic fibres. It is conceivable that for example only highly compressed parts of a gear box housing or an engine block need to be reinforced locally with fibres. That are areas where parts are bolted or where gaskets are positioned. In this paper AE42 magnesium alloy reinforced with 20 vol.-% Saffil® (Al_2O_3)-fibres is investigated. Alloys like AE42 have been developed to improve creep properties and strength at elevated temperatures compared with standard magnesium cast alloy AZ91. It can be used in HPDC as well as in other casting techniques. Therefore it is suitable in engine applications either monolithic or as matrix alloy for mmc's.

MANUFACTURE OF COMPOSITE MATERIAL

Saffil® fibre reinforced AE42 mmc's are produced by squeeze casting [1-5]. Figure 1 shows a scheme of this process. A preheated preform containing 20 vol.-% Al_2O_3 fibres is preheated and put in the casting mould and melt is poured over it. A vertical hydraulic press infiltrates the preform with melt. Table 1 shows parameters for casting process. The part solidifies under pressure. That leads to a microstructure which is dense and free of pores and makes squeeze castings heat treatable. The fibre preform was made from Saffil® fibres with a length of about 200 μm and a diameter of 8 μm at company „Thermal Ceramics". Due to the manufacturing process of the preform the fibres show a planar isotropic distribution perpendicular to press direction. That leads to anisotropic mechanical properties of the mmc. Properties and composition of alloy and fibres are shown in Table 2.

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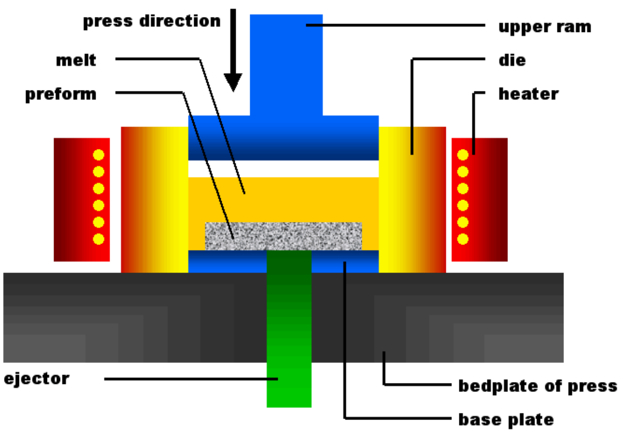


Fig. 1. Schematic sketch of a squeeze cast tool

TABLE 1. **Parameters of squeeze casting process**

Preformtemperature °C	Melttemperature °C	Upper ram speed m/s	Time of cooling min
750	770	10	2.5

TABLE 2. **Composition and properties of used material**

Material	Composition	Young's modulus GPa	Density g/cm^3	Tensile strength MPa
Saffil® fibres [6]	>95% δ-Al_2O_3, <5% SiO_2	270÷330	3.3	2000
AE42 [7]	4.0% Al, 2.5% RE, 0.2% Mn	45	1.86	230

COMPRESSION CREEP TESTS

For compression creep tests a „Lever Arm Creep Testing System" from company ATS was used. Tests were performed with a constant load of 100 MPa at 200°C because this is a temperature range in which automotive application must show its creep resistance. Specimens were manufactured out of the monolithic material and out of the reinforced area in both, longitudinal and perpendicular direction to fibre orientation. Cylinders with a diameter of 6 mm and a length of 15 mm were prepared and crept for 100 hours. Figure 2 shows creep curves for three samples.

After 100 hours AE42 shows a creep compression of 21.84% and a minimum creep rate of 2.65E-7 s^{-1}. The mmc in perpendicular direction to fibre direction shows a creep compression of 2.07% and a minimum creep rate of 8.49E-9 s^{-1} and in longitudinal direction a creep compression of only 1.09% and a minimum creep rate of 3.16E-9 s^{-1}. The difference in minimum creep rate and creep compression of mmc specimens in both direction is supposed to different mean fibre orientation referred to compression direction. Table 3 summarizes the creep data.

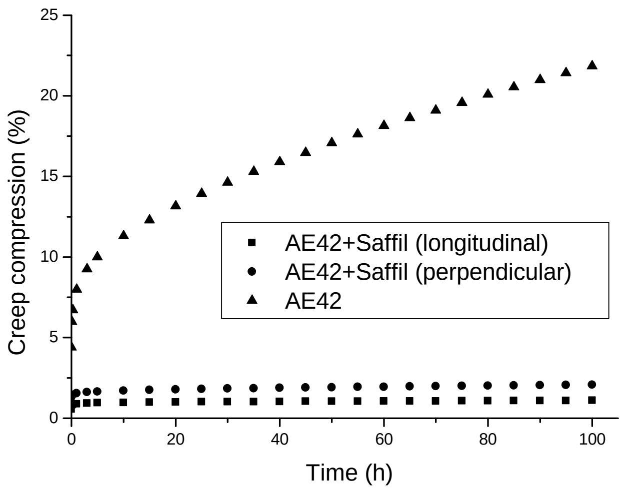


Fig. 2. Creep curves of squeeze cast specimens at 200°C and 100 MPa load

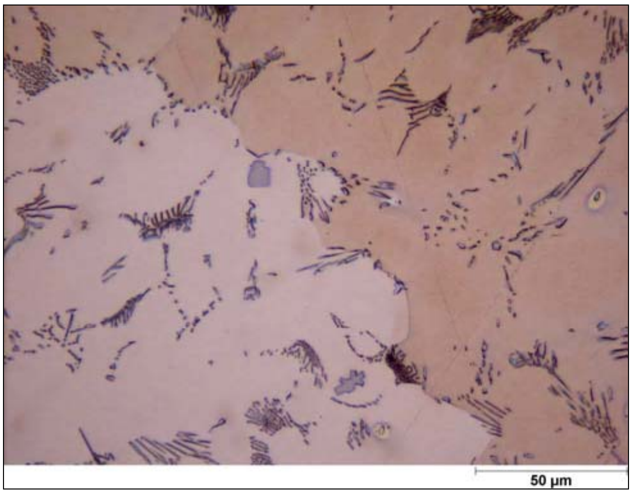
TABLE 3. **Creep data**

Material	Minimum creep rate, s^{-1}	Creep compression, %
AE42	2.65E-7	21.84
AE42+20%Saffil (perpend.)	8.49E-9	2.07
AE42+20%Saffil (longit.)	3.16E-9	1.09

MICROSTRUCTURE INVESTIGATION

The microstructure of monolithic AE42 as squeeze cast and after creep is shown in Figures 3a and 3b. Eutectic phases are visible in both states. During creep twinning occurs as a very important form of deformation. Figures 4a and 4b are showing microstructure of mmc perpendicular to fibre plane. All fibres are lying in horizontal direction, some are cut in lengths most are cut cross. Figure 5a and 5b show microstructure of mmc in fibre plane. Fibres are distributed in all directions. Most of them are cut in length. There are no microstructural changes visible that may lead conclusions of which mechanism of deformation took place. Twinning as it is seen in unreinforced material is not visible. Specimens are not etched because several results of etching this mmc were very poor. Further investigation using SEM studies and EDX shall clear up those deformation mechanisms.

a)



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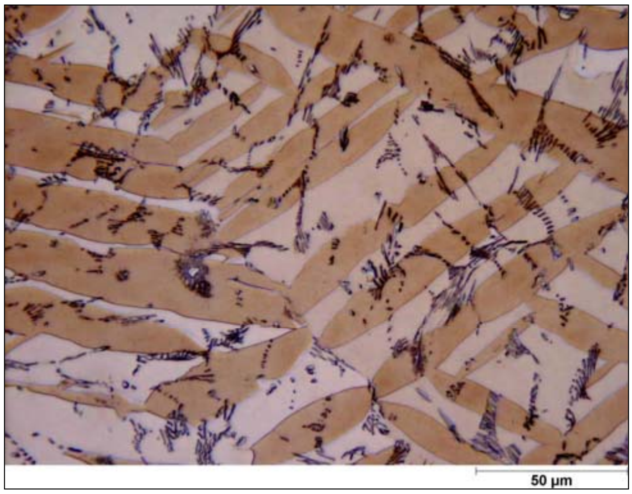
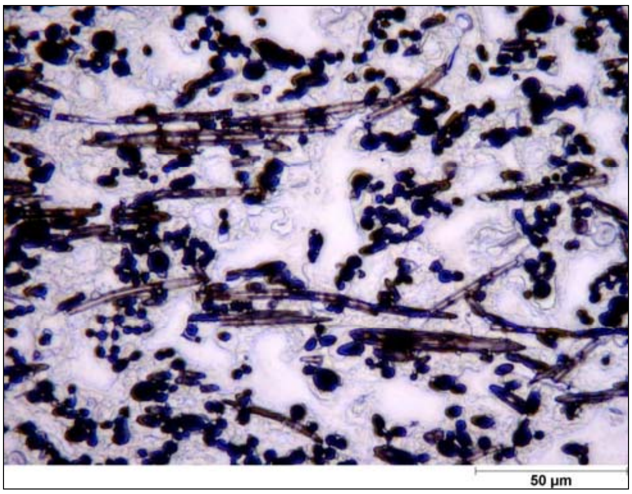


Fig. 3. Microstructure of AE42: a) as squeeze cast, b) after creep

a)



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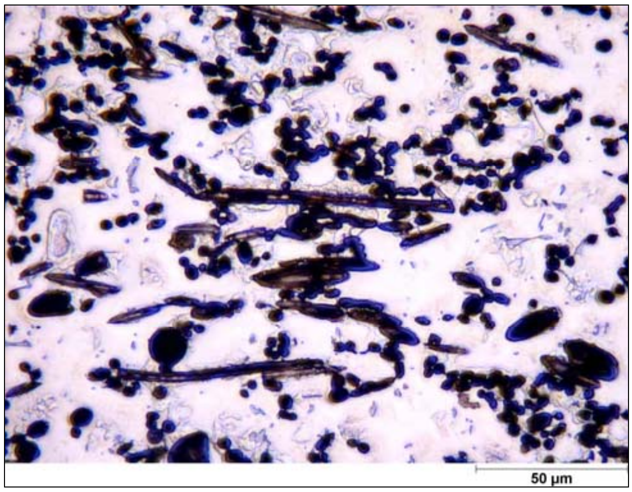
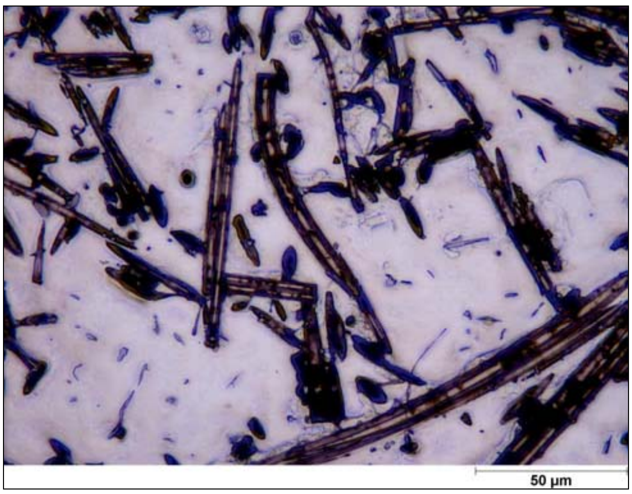


Fig. 4. Microstructure of AE42+Saffil perpendicular to fibre plane: a) as squeeze cast, b) after creep

a)



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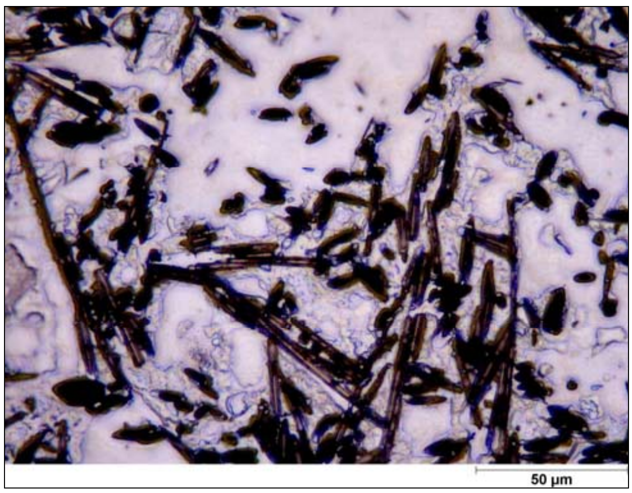

Fig. 5. Microstructure of AE42+Saffil in fibre plane: a) as squeeze cast, b) after creep

CONCLUSIONS

Magnesium alloy AE42 reinforced with 20 vol.-% Saffil® fibres shows significantly increased creep resistance in compression creep compared to matrix alloy. Creep rate as well as creep compression after 100 hours creep at 200°C and 100 MPa load is reduced in more than one order of magnitude. Creep properties of specimen manufactured in fibre plane direction are better than properties of specimens perpendicular to that direction. This difference is caused by the fact that fibres are only compressed in their length when specimens are prepared in fibre plane direction. It is visible that mean creep deformation mechanism of magnesium alloy AE42 is twinning. Mechanism of creep deformation in compression test have to be cleared in further investigation.

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Recenzent
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