Determining Casting Defects in Thixomolding Mg Casting Part by Computed Tomography

Jiehua Li, Bernd Oberdorfer and Peter Schumacher

Abstract A quantitative analysis on the casting defects is of great necessity to further improve the mechanical properties of high-performance alloys, in particular dynamic fatigue properties. Computed tomography (CT) is frequently utilized to determine the casting defects of casting parts and thereby evaluate their casting qualities. In this contribution, one Mg casting part (AZ91D, Mg–9Al–1Zn) produced by thixomolding was investigated by computed tomography. No significant casting defect was observed, strongly indicating that thixomolding could produce high-quality Mg casting parts. Furthermore, newly developed reconstruction software developed in Austria (VrVia GmbH) was used to obtain more details from the same casting part. This investigation demonstrates that computed tomography is an efficient method to determine casting defects in near-net-shape casting parts.

Keywords Mg alloy · Thixomolding · Computed tomography · Casting defects

Introduction

High-performance Mg alloys (i.e. AZ91) have been widely used in automotive industry due to their lightweight. To date, high-pressure die casting is one of the most important casting technologies to produce high-quality near-net-shape Mg casting parts. However, various casting defects (i.e. porosity and inclusion) very often occur during high-pressure die casting due to its higher filling process and thereby gas entrapment. Although necessary vacuum system together with conventional high-pressure die casting can be used to reduce the formation of casting defects and improve the mechanical properties, the application of vacuum system also increases the costs in terms of facility itself and necessary maintenance.

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Compared with high-pressure die casting, thixomolding is another very promising to produce high-quality near-net-shape Mg casting parts due to its lower process temperature and smooth filling process. Furthermore, during thixomolding, α-Mg dendrites can be broken and distributed evenly within the α-Mg matrix, which is favourable for improving the performance of castings. The formation of casting defects (i.e. pore and/or shrinkage cavities) can be significantly decreased. However, appropriate technology parameters have to be provided; otherwise, the inherent merits of thixomolding could not be utilized perfectly. In order to optimize the technology parameters, it is of great necessity to determine casting defects of thixomolding Mg casting part as a feedback. In order to determine casting defects of thixomolding Mg casting part, computed tomography (CT) has very often been used [1–8]. The main aim of the present investigation is to determine casting defects and thereby evaluate the quality of one near-net-shape thixomolding Mg casting parts using CT.

Experimental

One near-net-shape thixomolding Mg casting part (AZ91D) was investigated by CT, with the aim to determine casting defects and thereby evaluate the quality. The sample was scanned on a Phoenix X-ray v|tome|x c equipped with a 240 kV cone-beam X-ray tube operated at 70 kV. For the volume reconstruction, a modified Feldkamp algorithm for the filtered back projection as implemented by the system supplier was used [1]. Porosities were thus determined.

Results

Figure 1a shows 3D image of porosities in the near-net-shape thixomolding Mg casting part (AZ91D). Clearly, no significant casting defect was observed, strongly indicating that thixomolding could produce high-quality Mg casting parts. Figure 1b and c shows some small porosities but with a low number density.

Figure 2 shows the optical microscopy image (Fig. 2a) and SEM image (Fig. 2b) of the near-net-shape thixomolding Mg casting part (AZ91D), respectively. Clearly, after thixomolding, α-Mg dendrites were broken and distributed evenly within the α-Mg matrix, which is different from the presence of α-Mg dendrites in the samples produced by high-pressure die casting.

Figure 3 shows the hardness of the near-net-shape thixomolding Mg casting part (AZ91D). For comparison, the hardness values of the samples produced by high-pressure die casting and alloying with RE are also shown. Clearly, thixomolding AZ91D shows a much higher hardness (86 compared with 57.6 and 58.3), which can be due to the microstructure change (Fig. 2) and less porosities (Fig. 1). Again, it further confirms the advantage of thixomolding.

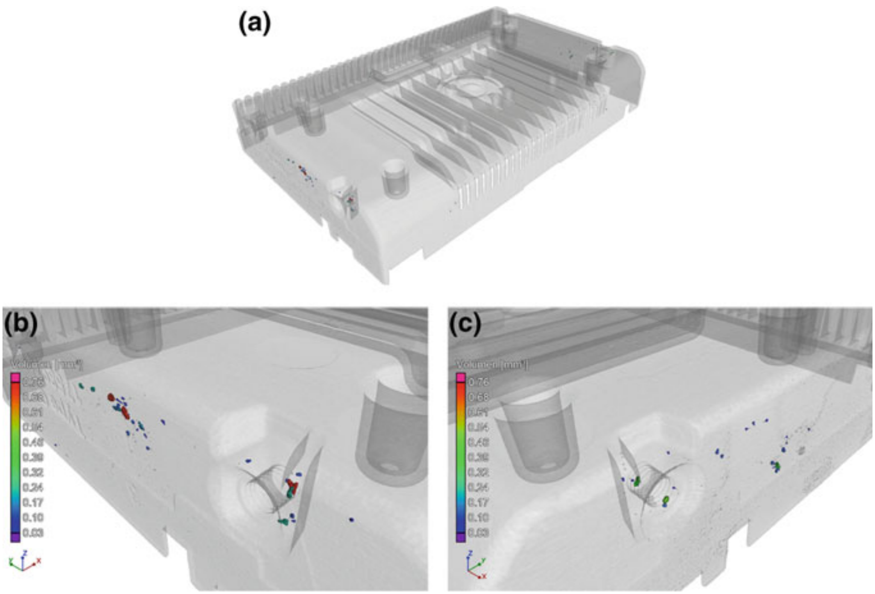

Fig. 1 **a** Three-dimensional image of porosities in the near-net-shape thixomolding Mg casting part (AZ91D), and **b**, **c** show some small porosities

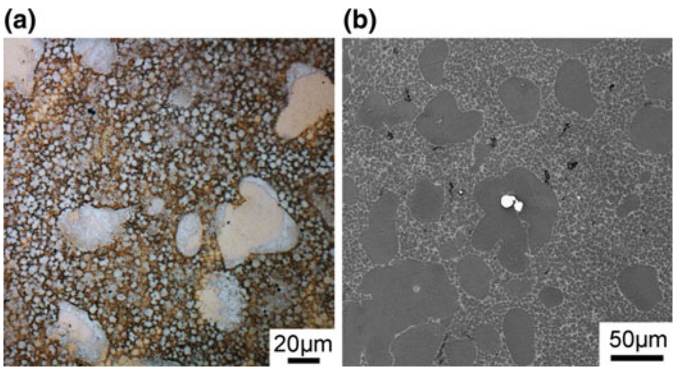

Fig. 2 Optical microscopy image (**a**) and SEM image (**b**) of the near-net-shape thixomolding Mg casting part (AZ91D)

Finally, it should also be noted that some possible artefacts may be present during reconstruction using commercial reconstruction software. For example, for the casting parts with different thicknesses, a misleading about the determination of porosities has been found [2, 3]. In order to solve this problem and other possible reconstruction problems, new reconstructed software has been developed in Austria (VrVia GmbH) under the support of FFG funding. Figure 4a shows 3D image of

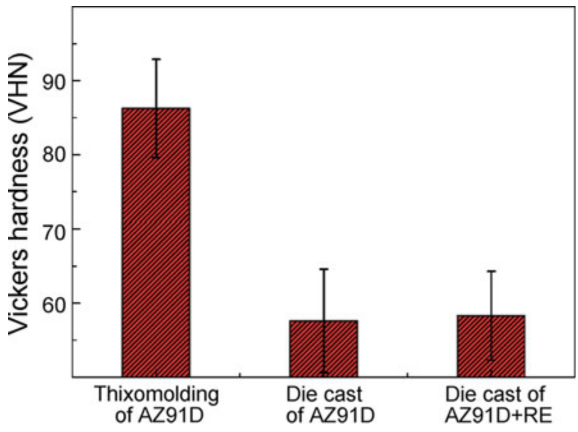

Fig. 3 Hardness of the near-net-shape thixomolding Mg casting part (AZ91D). For comparison, the hardness values of the samples produced by high-pressure die casting and alloying with RE are also shown. Clearly, thixomolding AZ91D shows a much higher hardness (86 compared with 57.6 and 58.3), which can be due to the microstructure change (Fig. 2) and less porosities (Fig. 1)

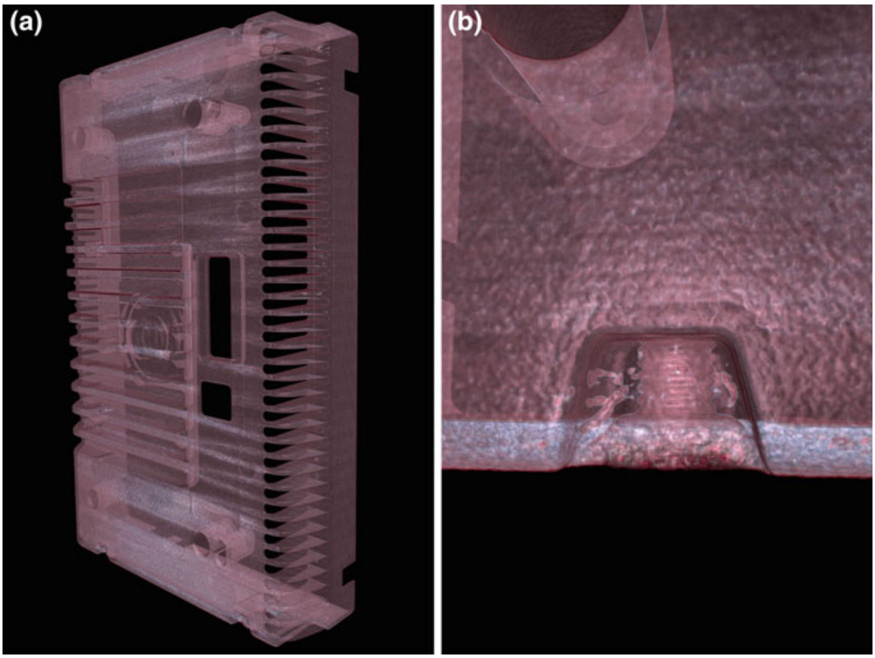

Fig. 4 **a** Three-dimensional image of porosities in the near-net-shape thixomolding Mg casting part (AZ91D) and **b** shows some small porosities reconstructed using newly developed software. A transparent mode was used to show the whole casting part (**a**) and a local region with the presence of porosities (**b**)

porosities in the near-net-shape thixomolding Mg casting part (AZ91D) reconstructed using newly developed software. Figure 4b shows the porosity in one local region. A transparent mode was used to show the whole casting part (Fig. 4a) and a local region with the presence of porosities (Fig. 4b). Clearly, newly developed software shows a great advantage compared with the commercial software.

Conclusion

One Mg casting part (AZ91D, Mg–9Al–1Zn) produced by thixomolding was investigated by CT. No significant casting defect was observed, strongly indicating that thixomolding could produce high-quality Mg casting parts. Furthermore, newly developed reconstruction software was used to obtain more details from the same casting part. This investigation demonstrates that computed tomography is an efficient method to determine casting defects in near-net-shape casting parts.

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