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Full Length Article

# Effect of pre-homogenizing treatment on microstructure and mechanical properties of hot-rolled AZ91 magnesium alloys

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## Abstract

To improve the homogeneity and rolling formability of as-cast AZ91 magnesium, the effects of pre-homogenizing treatment on microstructure evolution, deformation mechanism, mechanical properties and tensile fracture morphology of hot-rolled AZ91 magnesium alloy were studied. The results showed that the amount of coarse β-$Mg_{17}Al_{12}$ phase decreases dramatically, being distributed along the grain boundaries as small strips after homogenizing. Twining plays a dominant role in the deformation mechanism of AZ91 alloys in the experimental condition, while dynamic recrystallization (DRX) considerably occurred in homogenized-rolled alloys, contributed to microstructure uniformity and β-$Mg_{17}Al_{12}$ phase precipitated refinement. The tensile strength of homogenized-rolled AZ91 alloys increases dramatically with elongation declining slightly in contrast to homogenized alloys. The fracture surface of homogenized-rolled specimen exhibits more ductile fracture with the manifestation of a large amount of dimples distributing higher density in matrix, while the micro cracks are prone to initiate around the Mg/$Mg_{17}Al_{12}$ phase interface and grain boundaries owing to the fragile interface bonding of two phases.

*Keywords:* Homogenization; AZ91 magnesium alloys; Twining; Hot rolling; β-$Mg_{17}Al_{12}$ phase

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## 1. Introduction

As the lightest metal structural materials in practical engineering application, magnesium alloys have the advantages of low density, high specific strength, good thermal conductivity and electromagnetic shielding, and recyclability, which has been hailed as "green structural materials in the 21st century" [1,2]. However, since its limits of low formability at room temperature, the application of magnesium alloy is mainly in casting products, which have poor mechanical properties [3]. The wide application of magnesium alloys in automotive area, electronic communications and other fields is seriously restricted. Compared with casting magnesium alloy, wrought magnesium alloy, with finer grains, more various structure and mechanical properties, has great developing potential and application prospect [4,5]. But due to its hexagonal-close-packed (hcp) crystal structure, magnesium alloys have a limited number of independent slip systems, which leads to poor plastic forming ability and low finished product rate [6,7]. The application of magnesium alloy sheets is greatly limited.

As one of the most widely used magnesium alloys, the products of AZ91 magnesium alloy are still mainly used in casting [8]. To improve formability and increase the strength of AZ91 magnesium alloys, many plastic deformation methods have been attempted through grain refinement and precipitated evolution, such as hot extrusion [9,10], twin roll casting [11], hot rolling [12] and severe plastic deformation (SPD), including equal channel angular pressing [13] (ECAP), multi-directional forging [14] (MDF) and differential speed rolling [15] (DSR) and so on. Compared with other plastic deformation methods that could obtain more grain refinement by dynamic recrystallization (DRX) relatively more easily, the rolling process of the AZ series of magnesium alloys is mostly focused on AZ31 and had achieved comparatively matured rolling technology [16], but research on rolling process parameters about AZ91 was rarely reported. The rolling forming of as-cast AZ91

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magnesium alloy is still difficult, and its plastic deformation mechanisms are not yet clarified [17].

AZ91 magnesium alloy, which has higher aluminum content than AZ31, shows the better corrosion resistance ability and higher strength performances; however, worse forming ability due to intermetallic compound with a stoichiometric composition of $Mg_{17}Al_{12}$, with a coarse net-like distribution along the interphase boundaries [18]. The discordance between $Mg_{17}Al_{12}$ phases, with its body centered cubic (bcc) structure, and the hexagonal close packed (hcp) structure of magnesium matrix, cause the $Mg/Mg_{17}Al_{12}$ phase interface fragility [19]. Then, micro cracks are inclined to initiate along the $Mg/Mg_{17}Al_{12}$ phase interface, and could also be formed in $Mg_{17}Al_{12}$ phases during rolling deformation [18]. So the amount, description and distribution of $Mg_{17}Al_{12}$ phases play a very important role in formability and mechanical properties of AZ91 magnesium alloy. Studies showed that refining distribution of $Mg_{17}Al_{12}$ phase was of great importance to the microstructure uniformity and mechanical properties improvement of AZ91 magnesium alloy. J.-Y. Li [20], S.W. Xu [21] and F. Pilehva [22] studied the effect on microstructural evolution, dynamic recrystallization (DRX) and mechanical properties of AZ91 magnesium alloy during homogenizing treatment and hot extrusion. They all found that homogenizing treatment can effectively improve microstructure uniformity and distribution of the $Mg_{17}Al_{12}$ phase, and also increase the mechanical properties of the AZ91 magnesium alloys.

Nowadays, as we know, rolling has become the most economic and effective plastic processing method in large-scale and commercial production of magnesium alloys as plates and sheets, and has also become one of the hottest research topics in the application of magnesium alloys [7]. But little research has been reported about the effect of homogenizing annealing on the microstructures and properties of as-cast AZ91 magnesium alloy during general hot rolling deformation yet. Due to the reticular distribution of course $Mg_{17}Al_{12}$ phase, AZ91 magnesium alloy shows poor plastic deformation capacity generally, so it is very essential that research on pre-homogenizing treatment of AZ91 magnesium during hot rolling. In this article, the effects of homogenizing treatment on microstructure evolution, mechanical properties and tensile fracture morphology of AZ91 magnesium alloy before and after rolling deformation were studied, so as to lay a foundation for further study on the rolling forming of AZ91 magnesium alloy with different technological parameters.

## 2. Experimental materials and methods

The starting experimental AZ91 magnesium alloy in this study was employed in as-cast ingot with the chemical composition shown in Table 1. The plate specimens, which denoted by "as-cast", were machined into 55 mm in length, 30 mm in width and 4 mm in height from the central part of ingot casting through wire cut electrical discharge machining (WEDM). In order to improve the uniformity of microstructure, the as-cast specimens were homogenized at 415 °C for 24 h followed by water quench at 25 °C [14], then denoted it by "homogenized". With the aim of investigating the effect of homogenizing treatment on microstructure and mechanical properties of hot-rolled AZ91 magnesium alloy, the rolling process was carried out on "as-cast" and "homogenized" specimens, and also denoted them by "as-rolled" and "homogenized-rolled" separately. The specimens before the rolling process were reheated to 400 °C and held for 60 min in the resistant furnace. The rolling process was performed at 400 °C, which is initial rolling temperature, with the rolling speed of 5 m/min. Owing to relativity poor formability of specimens, the lower rolling reduction of 10%–15% was provided for each pass of hot rolling. After six passes rolling, the accumulated rolling reduction in thickness was about 60% with the inter-passes reheating at 400 °C for 10 min.

Table 1
Chemical composition of as-cast AZ91 magnesium alloy (mass fraction, %).

| Element | Al | Zn | Mn | Si | Mg |
|---|---|---|---|---|---|
| Content | 8.98 | 0.64 | 0.26 | 0.02 | Bal. |

Optical microscopy (OM), scanning electron microscopy (SEM), energy dispersive system (EDS) and X-ray diffraction (XRD) were employed to study the microstructure evolution of AZ91 magnesium alloy during the hot rolling process. The samples for microstructure analysis were sectioned from the center area of the specimens parallel to the rolling direction and transverse direction, called as TD×RD plate plane, and also parallel to the rolling direction and normal direction, called as ND×RD plate plane. The metallographic samples were prepared by the standard mechanical ground and polishing, then etched using the acetic picric solution, with the composition of 4.6 g picric acid, 10 ml acetic acid, 10 ml distilled water and 70 ml ethanol. The analysis of metallographic microstructure and grain size distribution was carried out by optical microscope with the model DM4500M. The phase composition was analyzed by X-ray diffraction (XRD) using a Siemens X-ray diffractometer D5000 operating at 40 kV and 20 mA (Cu-Kα radiation). The tensile samples were cut from above denoted specimens parallel to the rolled direction with the gauge length of 25 mm, and then the tensile mechanical properties were tested by electronic universal testing machine (model CMT5205) at room temperature with the tensile rate 0.5 mm/min. The second phase evolution and the tensile fracture morphology were carried out by Tescan-Vaga-Mira-3 scanning electron microscope equipped with EDS.

## 3. Results and discussion

### 3.1. *Microstructure of as-cast and homogenized AZ91 magnesium alloy*

The solid solubility of aluminum in magnesium matrix varies with the different temperature according to Mg-Al binary equilibrium phase diagram, which indicates that the higher solid solubility of aluminum reaches 12.7% at about the eutectic temperature of 437 °C and about 2% at room temperature [23]. Fig. 1 shows the microstructures of as-cast and homogenized AZ91 magnesium alloy. It can be seen that the original

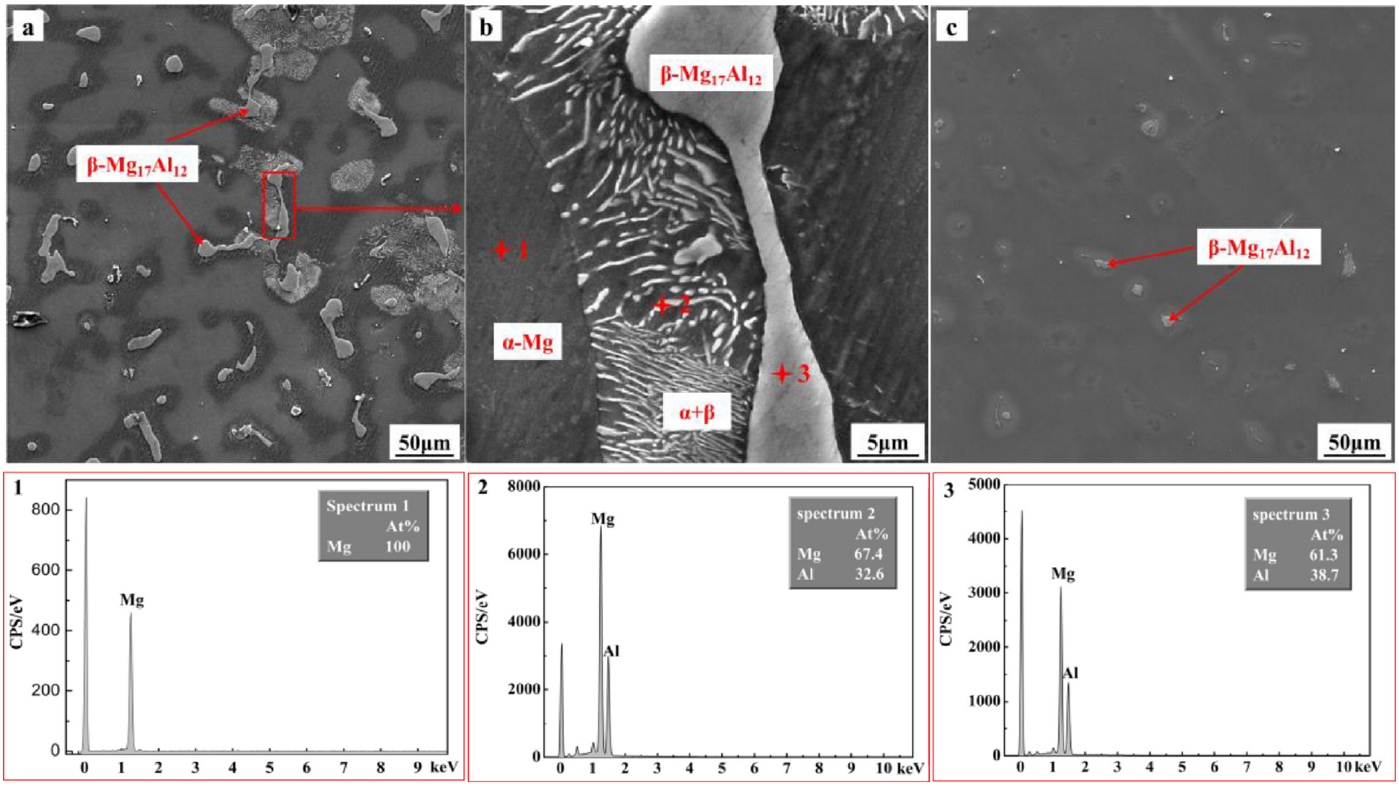

Fig. 1. Microstructure of as-cast and homogenized AZ91 magnesium alloy. (a, b) as-cast; (c) homogenized; (1), (2), and (3) EDS of area in (b).

microstructure of as-cast AZ91 exhibits typical dendritic segregation from the Fig. 1(a), which contains a large amount of course and reticular β-$Mg_{17}Al_{12}$ phase distributing along the original grain boundaries besides α-Mg matrix.

In detail, since the actual cooling rate is too high to keep the aluminum equably distributed during the solidification, the non-equilibrium solidification microstructures could be developed [20]. Partially enlarged version of Fig. 1(a) is shown in Fig. 1(b). As shown in Fig. 1(b), the white β-$Mg_{17}Al_{12}$ phase is surrounded by dark gray materials, which have been considered to be the divorced eutectic of β-$Mg_{17}Al_{12}$ phase after the cooling process of non-equilibrium solidification, and the main phases of microstructure can be described as the constitution of primary α-Mg, precipitate β-$Mg_{17}Al_{12}$ and divorced eutectic of α + β. The energy spectrum analyses of three points in Fig. 1(b) are shown in Fig. 1 (1), (2) and (3), in which the concentration of solid solution aluminum is higher could be seen, proving the above analysis.

Fig. 1(c) shows the microstructure after homogenization treatment at 415 °C for 24 h. Compared with the original as-cast microstructure, the amount and form of the second phase vary dramatically after homogenizing. The amount of the coarse β-$Mg_{17}Al_{12}$ phase decreases greatly being distributed along the grain boundaries and inside α-Mg matrix as small particles or strips. It is generally believed that homogenization treatment of AZ91 magnesium alloy includes solid solution and precipitation of second phase [24]. In the process of heating and heat holding of homogenization, the solid solubility of Al in the Mg matrix increases due to the rise of temperature, which occurs as β-$Mg_{17}Al_{12}$ phase along the grain boundary dissolves in α-Mg matrix gradually. In the following cooling process, β-$Mg_{17}Al_{12}$ phase precipitates from α-Mg supersaturated solid solution due to the higher temperature, and disperses in α-Mg matrix as small particles. As XRD diffraction pattern showed in Fig. 2, β-$Mg_{17}Al_{12}$ phase diffraction peak is nearly invisible in the specimen after homogenization. It also suggests that almost single-phase supersaturated solid solution could be obtained through homogenization processing.

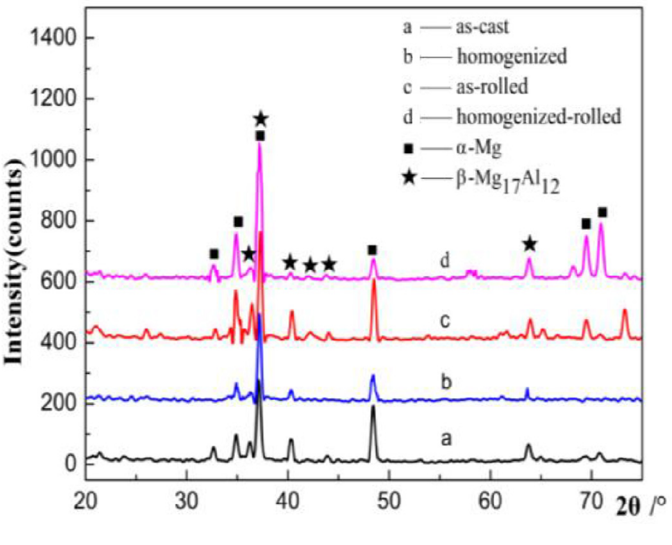

Fig. 2. XRD of different status of AZ91 magnesium alloy.

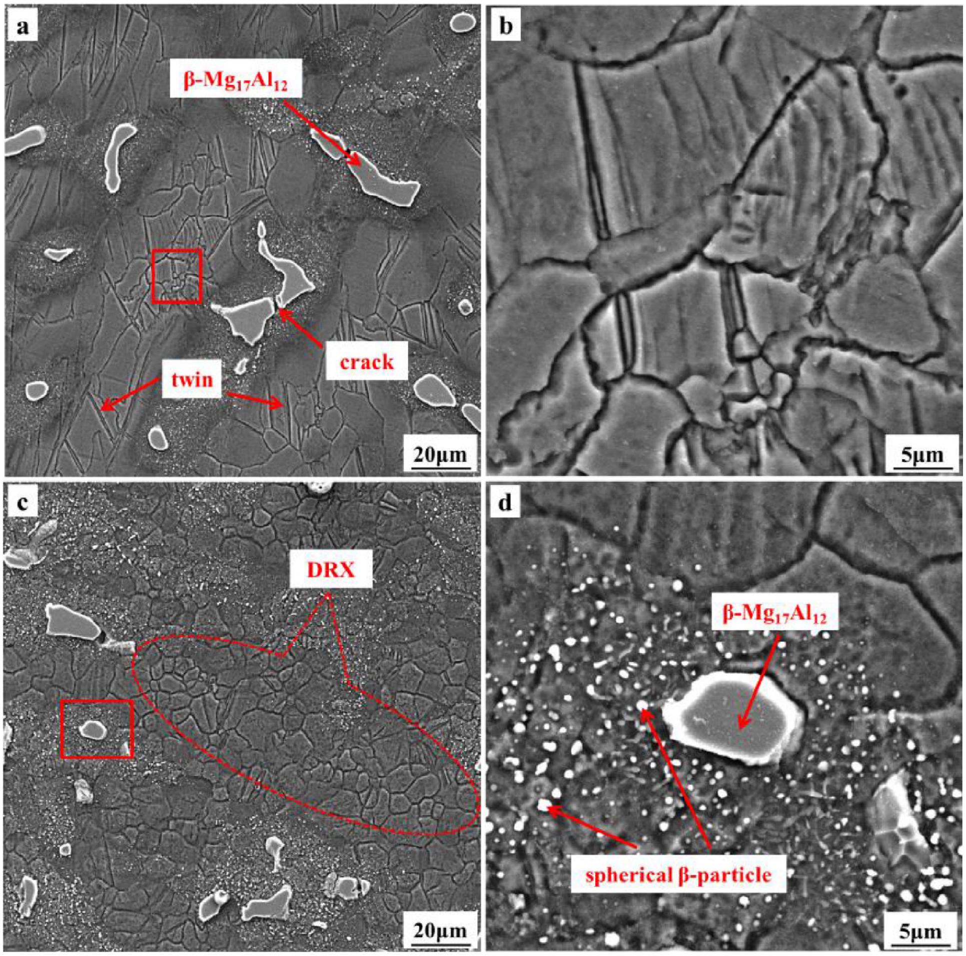

Fig. 3. Microstructure of as-rolled and homogenized-rolled AZ91 magnesium alloy. (a, b) as-rolled; (c, d) homogenized-rolled.

### 3.2. *Microstructure of as-rolled and homogenized-rolled AZ91 magnesium alloy*

The microstructures of as-rolled and homogenized-rolled AZ91 magnesium alloy with about 10%–15% per pass reduction in thickness at 400 °C taking the rolling speed of 5m/min by hot rolling are shown in Fig. 3. The grain size distribution for as-rolled and homogenized-rolled AZ91 magnesium alloy is shown in Fig. 4. It can be clearly observed that part of the brittle second phases fracture to crack during the hot rolling process, and the grains of the alloy are dramatically refined as shown in Fig. 3. The average grain size of homogenized-rolled AZ91 magnesium alloy is reduced to a final value of about 10 μm compared with about 25 μm of as-rolled AZ91 due to the total rolling reduction in thickness is close to 60% as shown in Fig. 4. This significant effect of grain refinement can be also observed in other related literature [10,21].

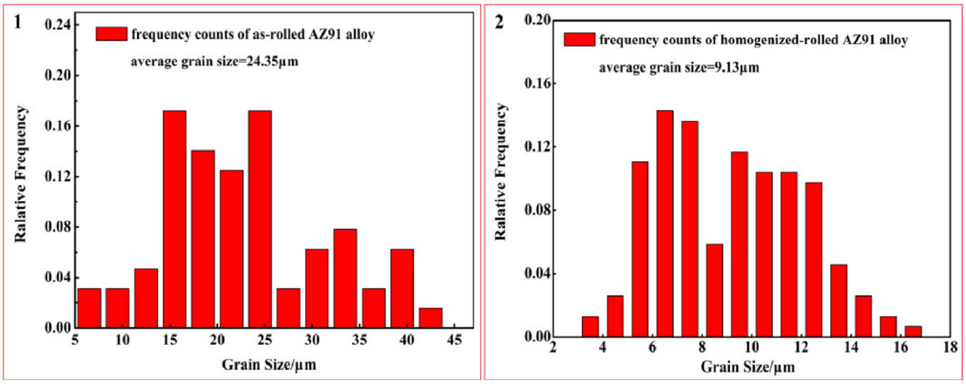

Fig. 4. Grain size distribution of AZ91 magnesium alloy. (a, b) as-rolled; (c, d) homogenized-rolled.

Partially enlarged version of Fig. 3(a) is shown in Fig. 3(b). The microstructures of as-rolled specimens reveal significant deformation twinning as shown in Fig. 3(b). It can be clearly observed that numerous needle-like deformation twins appeared around β-$Mg_{17}Al_{12}$ phase precipitates and α-Mg matrix; however, dynamic recrystallization (DRX) can be hardly found. This may indicate that deformation twins are prone to occur even at relatively higher strain in the microstructure with the condition of hot rolling without pre-homogenization due to limited slip system and coarse microstructure of the as-cast specimen [22] and the twining has become the dominant deformation mechanism in this condition. Some micro cracks initiate with the β-$Mg_{17}Al_{12}$ phase breaking out under the action of rolling owing to its frangibility. Previous researches [25] had suggested that there are close relationships between the deformation twins and micro crack initiation in AZ series alloys, and stress concentrations caused by deformation twins have been perceived as the potential source for crack initiation. With the intensification of deformation, the number of shear deformation bands could be increased, which results in the twins intersection and cutting mutually and also refined in more area of microstructure as can be observed in Fig. 3(b).

Fig. 3(c) shows the microstructures of homogenized-rolled AZ91 specimens. Compared to the as-rolled specimens, the proportion of deformation twins emerged around β-$Mg_{17}Al_{12}$ phase precipitates decreases notably; however, more dynamic recrystallization grains generate in the α-Mg matrix of homogenized-rolled AZ91 specimens. This can be considered to refer to the microstructure homogenization and β-$Mg_{17}Al_{12}$ phase precipitating refinement. The previous study [26] showed nearly few deformation twins in the specimens with finer grains, while a mass of twins were found in the microstructures of coarse-grain specimens. This could be related to the activation of non-basal slip systems for the reason of the reduction of its critical resolved shear stress (CRSS) with microstructure refinement and appropriate temperature [27]. It can also be noticed that dynamic recrystallization (DRX), with the average size of approximately 5–10 μm, has occurred at homogenized-rolled specimens, which nucleated within the deformation twins. Yan Xu et al. [3] have achieved similar results during studying deformation behavior and dynamic recrystallization of AZ61 magnesium alloy.

A higher volume fraction of dynamically recrystallized grains could be attributed more to the probability of the non-basal slip systems activated at these deformation conditions. Twinning is still one of the primary plastic deformation mechanisms of AZ series alloys in spite of the higher deformation temperature (400 °C) and relatively lower strain, while the dynamic recrystallization (DRX) plays a more considerable role in homogenized-rolled AZ91 alloys. Comparing the XRD spectrums of as-rolled with the one of homogenized-rolled in Fig. 2, it can be clearly observed that β-$Mg_{17}Al_{12}$ diffraction peak is still evident in as-rolled specimen while it decreased significantly in homogenized-rolled. This is consistent with the aforementioned microstructure analysis.

Partially enlarged version of Fig. 3(c) is shown in Fig. 3(d). Fig. 3(c) shows $Mg_{17}Al_{12}$ precipitated phase morphology and distribution of homogenized-rolled AZ91 alloy subjected to hot rolling process. It can be clearly observed that more refiner precipitates emerge around the undissolved β-$Mg_{17}Al_{12}$ phase, and also especially inside the grains. As the previous analysis in section of 3.1, to improve the hot work ability, the as-cast AZ91 alloy was homogenized prior to hot rolling process to dissolve the $Mg_{17}Al_{12}$ phase. The areas around the undissolved β-$Mg_{17}Al_{12}$ phase have been proven to the Al-rich area with higher Al concentration after hot rolling [14], and then the dynamic precipitation of $Mg_{17}Al_{12}$ phase occurs just in the areas of high Al content under cooling after hot rolling process. In the present homogenized-rolled AZ91 samples, some spherical and lamellar precipitates are observed in Fig. 3(d). This could be attributed to high dislocation density introduced by hot rolling process, which could lead to the faster diffusion of solute Al atoms and reduction in the growth of precipitates. At the same time, the high density of crystal defects caused by hot rolling has been regarded as priority area for the heterogeneous nucleation of precipitates, and spherical and lamellar precipitates emerged around the undissolved β-$Mg_{17}Al_{12}$ phase can be noticed obviously.

### 3.3. Mechanical properties of AZ91 magnesium alloy

Reference [28] shows that the amount, size, distribution and morphology of β-$Mg_{17}Al_{12}$ phase play a critical part of the strength and plasticity of Mg-Al alloys. As shown in Fig. 5, the strength and elongation of AZ91 alloy are enhanced simultaneously after homogenization treatment in this test. The ultimate tensile strength increases from 160 MPa to 210 MPa, about 30%, and elongation increases from 4% of the original as-cast to more than 10% after homogenization. This is mainly due to microstructure uniformity and the β-$Mg_{17}Al_{12}$ phase refinement. Micro cracks are more inclined to initiate from Mg/$Mg_{17}Al_{12}$ phase interface and even in $Mg_{17}Al_{12}$ phase in the process of tensile deformation due to the weakness of interface bonding between α-Mg matrix and coarse reticulate β-$Mg_{17}Al_{12}$ phase in as-cast AZ91 alloys. After homogenizing treatment, dendritic segregation is weakened and the second phase

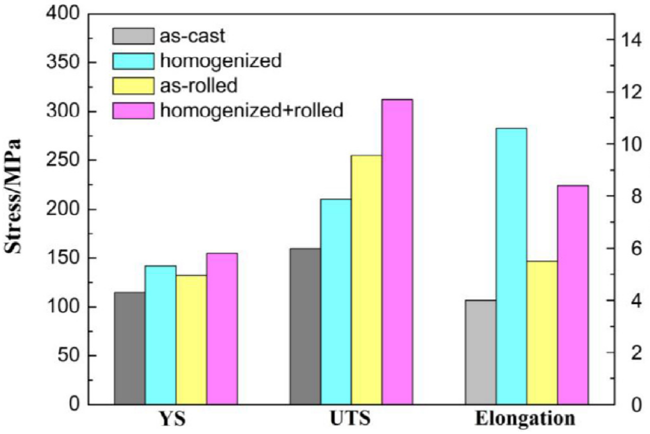

Fig. 5. Tensile properties of AZ91 magnesium alloy.

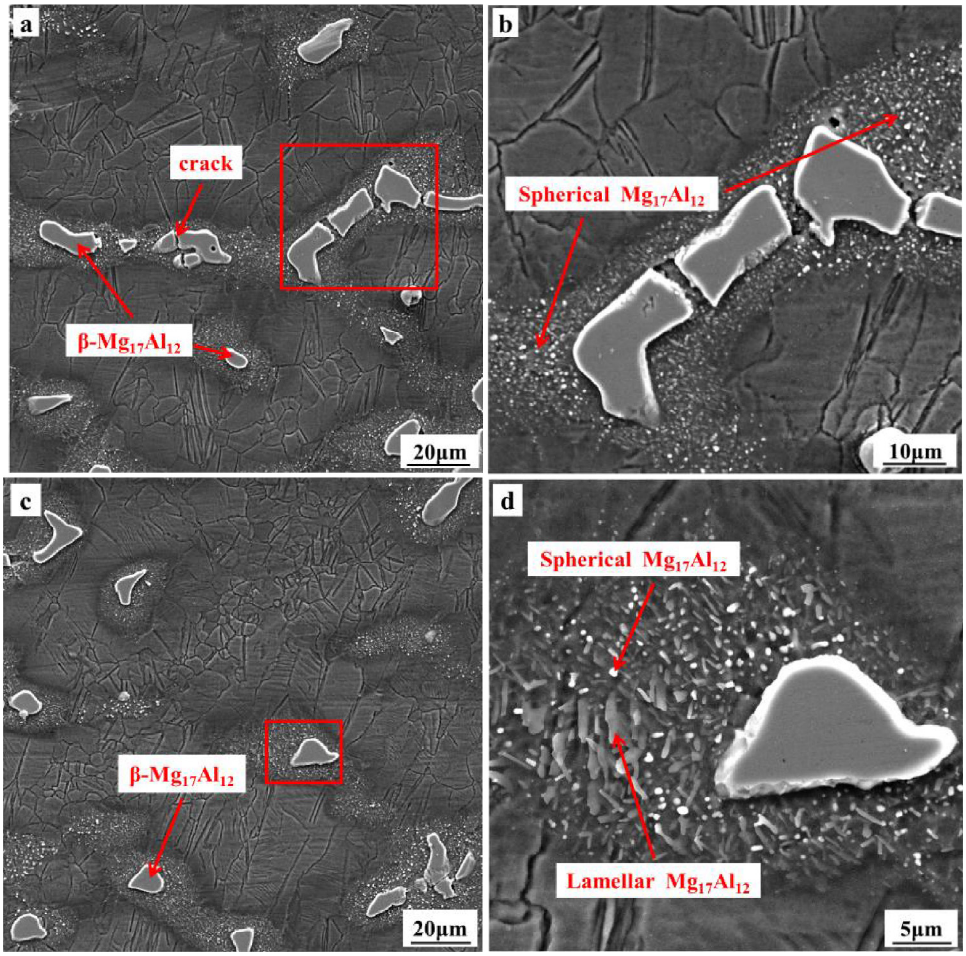

Fig. 6. Second phase morphology of AZ91 magnesium alloy. (a, b) as-rolled; (c, d) homogenized-rolled.

distribution is scattered, which also contributes to the increase of its strength and plasticity.

The tensile strength of as-cast alloy after rolling increases from 160 MPa to 255 MPa, about 60%, and yet the elongation varies very little. Compared with the as-rolled specimen, the ultimate tensile strength of homogenized-rolled AZ91 alloys increases slightly, while the elongation increases dramatically from 5.5% to 8.4%, about 50%, in this hot rolled condition. After hot rolling, the tensile strength of homogenized-rolled increases about 35%, from 210 MPa to 312 MPa, with the elongation declining slightly. The enhancement of mechanical properties during hot rolling can also be found in recent related literature [12,15]. Combining Figs. 3 and 4, the improvement of tensile strength could be attributed to the following aspects: on one hand, according to the classical Hall–Petch equation $\sigma_y = \sigma_0 + Kd^{-1/2}$ [29], with $\sigma_y$ and $d$ indicating yield strength and grain size separately, while $\sigma_0$ and $K$ are material parameters, it is generally believed that grain boundaries possess significant obstacles to the dislocation motion, and smaller grains of structures have higher density of grain boundaries, which could result in the increase of tensile strength [14]. The average grain size of the as-rolled and homogenized-rolled AZ91 alloys is decreased with the hot rolling process as the deformation twin refinement and dynamic recrystallization (DRX). On the other hand, the refined second phases distributing along the grain boundary as spherical and lamellar particles or strips play a dominant role in promoting the tensile strength and ductility. S.W. Xu et al. [7] and J.D. Robson et al. [24] have also reported that refined twins and DRX grains play a critical role in strengthening the mechanical properties of AZ91 magnesium alloys.

The microstructure of β-$Mg_{17}Al_{12}$ phase of as-rolled specimen can be observed in Fig. 6(a), and the partially enlarged version of Fig. 6(a) is shown in Fig. 6(b). It can be clearly noticed that the rough reticulate distribution of β-$Mg_{17}Al_{12}$ phase in as-rolled specimen shows the tendency of brittle fracture, accompanied by many micro cracks, which had been initiated in the β-$Mg_{17}Al_{12}$ phase under the effect of rolling deformation. In addition, a large number of spherical precipitated second phase particles distribute around the undissolved β-$Mg_{17}Al_{12}$ phase can also be observed as can be seen in Fig. 6(b).

Fig. 6(c) shows the microstructure of β-$Mg_{17}Al_{12}$ phase of homogenized-rolled specimen, and a partially enlarged version of Fig. 6(c) is shown in Fig. 6(d). As shown by the difference between Fig. 6(a) and (b), the β-$Mg_{17}Al_{12}$ phase is remarkably refined in hot rolling alloys after homogenizing, most of them distribute around the grain boundary as the particles, some part of the undissolved β-$Mg_{17}Al_{12}$ phase appears rolling micro

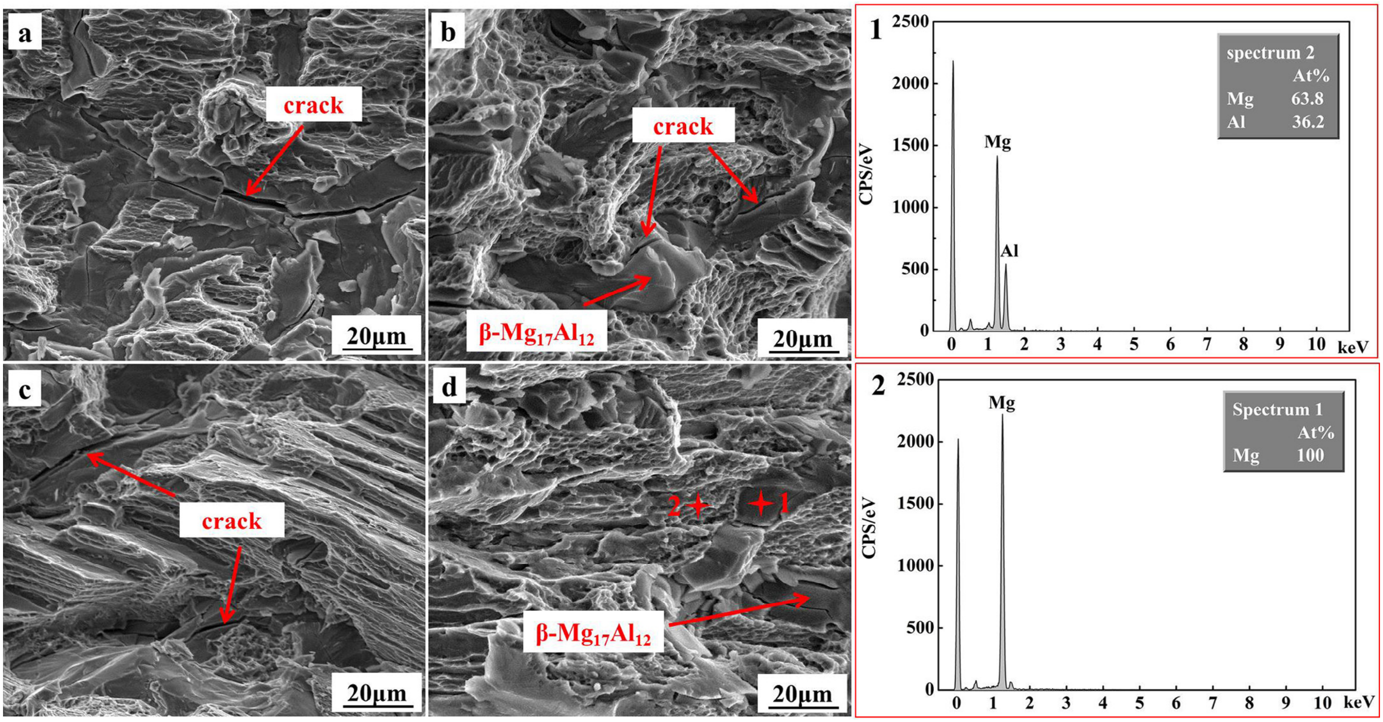

Fig. 7. Tensile fracture analysis of AZ91 magnesium alloy. (a) as-cast; (b) homogenized; (c) as-rolled; (d) homogenized-rolled; (1), (2) EDS of area (1) and (2) in (d).

cracks. It can be seen from Fig. 6(d) that plenty of spherical and lamellar particles or strips precipitate around the refined β-$Mg_{17}Al_{12}$ phase with the particle size approximately 1–3 μm. Reference 18 shows the precipitate phase of refined spherical and lamellar particles is beneficial for the improvement of plasticity.

The improvement of the forming ability of AZ91 magnesium alloys is limited by these brittle second phases seriously, which makes the subsequent plastic processing more difficult. But if one can press fit the tiny crack through the appropriate rolling technology and refine the brittle second phase through heat treatment process,then the plasticity and mechanical properties of AZ91 magnesium alloy could be improved. Therefore, research on the decomposition, precipitation, fragmentation and distribution of the β-$Mg_{17}Al_{12}$ phase in AZ91 magnesium alloy during the process of deformation and heat treatment is important for improving strength and plasticity of alloy, and will be one of the directions of further studies.

### 3.4. Tensile fracture of AZ91 magnesium alloy

Magnesium alloys are more inclined to break brittlely in the form of cleavage fracture or quasi cleavage fracture due to their limited slip systems [30]. Fig. 7 displays the room temperature tensile fracture surfaces of AZ91 magnesium alloys. After homogenization treatment, the fracture surfaces of homogenized specimens shows the tendency of a little ductile fracture, expressing much more higher volume fraction of dimples than that of as-cast specimens, which could be due to the microstructure uniformly and β-$Mg_{17}Al_{12}$ phase refinement. Some tinier micro cracks could be noticed in undecomposed β-$Mg_{17}Al_{12}$ phase from the fracture surfaces of homogenized AZ91 alloy, compared to the larger and continuous micro cracks of as-cast AZ91 alloy, shown in Fig. 7(a) and (b). In addition, much more tearing ridges and some spherical features appearing on the fracture surface of homogenized specimens also exhibit the plasticity enhanced, and elongation improved dramatically as shown in Fig. 5.

Fig. 7(c) and (d) show the tensile fracture surfaces of as-rolled and homogenized-rolled AZ91 alloys at room temperature. The tensile fracture surfaces of as-rolled specimen assume the features of cleavage fracture, in which more cleavage facets, steps and tearing ridge could be observed, as shown in Fig. 7(c). Compared with the tensile fracture surfaces of as-rolled specimen observed, the fracture features of homogenized-rolled specimen exhibit characteristics of more ductile fracture, with the manifestation of a large amount of dimples distribute higher density in α-Mg matrix, as shown in Fig. 7(d), also exhibiting enhanced plasticity and significantly improved elongation in macro. This fracture could be considered as mixed ductile-brittle fracture [31]. Some tinier micro cracks can also be observed in fracture surfaces of homogenized-rolled AZ91 alloy after hot rolling and tensile deformation, which primarily focused on the β-$Mg_{17}Al_{12}$ phase. The energy spectrum analysis of matrix and second phases was shown in Fig. 7 (1) and (2).

It should be noticed that micro cracks are prone to initiate around the Mg/$Mg_{17}Al_{12}$ phase interface and grain boundaries from Figs. 3, 6 and 7, because of the fragile interface bonding of two phases. Some cleavage facets and cleavage steps, and even cleavage "tones" [17] can be observed, which may have a connection with deformation twinning. It is generally believed that twinning plays an important role in plasticity deformation mechanism in hexagonal-close-packed (hcp) metals due to the shortage of independent slip systems, especially at lower temperature and lesser deformation rate. Due to the huge difference of deformation resistance and ductility between α-Mg and β-$Mg_{17}Al_{12}$ phase, the stress concentration easily occur in interface bonding and even twins around β-$Mg_{17}Al_{12}$ phase, resulting in the micro cracks initiated, and expanded as macroscopic cracks further more during the rolling and tensile deformation.

## 4. Conclusion

As-cast AZ91 magnesium alloy has been successfully employed to homogenizing treatment and hot rolling process. The effect of homogenizing on microstructure evolution, deformation mechanism, mechanical properties and tensile fracture morphology variation of AZ91 magnesium alloy before and after hot rolling deformation was experimentally investigated. The main conclusions are summarized as follows:

(1) Compared with as-cast AZ91 magnesium alloy, the amount of coarse β-$Mg_{17}Al_{12}$ phase in homogenized alloy decreases greatly with distributing along the grain boundaries and in α-Mg matrix as small particles or strips after homogenizing treatment at 415 °C for 24 h. The homogenized AZ91 alloy has acquired significantly higher tensile strength and elongation after homogenizing treatment.

(2) Grains distribute along the rolling direction more clearly, and part of the brittle β-$Mg_{17}Al_{12}$ phase fractures and spread along the grain boundaries during hot rolling process. Twining plays a dominant role in the deformation mechanism of AZ91 alloys in experimental condition, while dynamic recrystallization (DRX) considerably occurred in homogenized-rolled AZ91 alloys, contributed to microstructure homogenization and β-$Mg_{17}Al_{12}$ phase precipitating refinement.

(3) Compared to as-cast AZ91 alloys, the strength and elongation of homogenized AZ91 alloy are enhanced simultaneously. After hot rolling, the tensile strength of homogenized-rolled increases dramatically with elongation declining slightly in contrast to homogenized AZ91 alloy. Some brittle β-$Mg_{17}Al_{12}$ phases have been fragmented and disperse near the grain boundaries and inside matrix as small particles during hot rolling deformation.

(4) The tensile fracture surfaces of AZ91 magnesium at room temperature exhibits a strong tendency of brittle fracture. Contrast with as-rolled AZ91 alloys, the fracture features of homogenized-rolled specimen exhibit more ductile fracture with the manifestation of a large amount of dimples distribute higher density in α-Mg matrix. The micro cracks are prone to initiate around the Mg/$Mg_{17}Al_{12}$ phase interface and grain boundaries from owing to the fragile interface bonding of two phases.

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