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Application of an integrated RE/RP/CAD/CAE/CAM system for magnesium alloy shell of mobile phone

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ABSTRACT

Magnesium alloys are becoming more and more popular because of their high specific strength, light specific weight, recyclability, and ability to shield electromagnetic shocks. This paper introduces an integrated RE/RP/CAD/CAE/CAM system for constructing a magnesium-alloy AZ31 shell for the mobile phone and developing related progressive dies using concurrent engineering (CE). This integrated system uses an optical scanning system (ATOS), a rapid prototyping machine (SOUP600), a CAD/CAE/CAM software (CATIA), a sheet metal forming simulation software (DYNAFORM), a CAM software (POWERMILL), and a die design knowledge-based system as the operating platform. The die design knowledge-based system includes die design procedures, die design standards, design criteria, and empirical formulae. Our system has been used successfully in constructing a magnesium-alloy AZ31 shell for the mobile phone and developing related progressive die. Since the entire development process shares the same 3D geometric model, the various process of developing dies can be performed in parallel. Our system can greatly reduce the development time and cost, improve the product quality, and push products into the market in a relatively short time.

1. Introduction

Lately, great attention has been paid worldwide to preserving the environment and to reducing the volume and weight of products. Therefore, magnesium alloys are becoming more and more popular, because of their high specific strength, light specific weight, recyclability, and ability to shield electromagnetic shocks. Doege and Kurz (2001) conducted a series of experiments on magnesium alloy AZ31 sheets to identify different deep drawing parameters in different strain rates. They found that magnesium alloy could be adaptively softened in different working temperatures, and concluded that magnesium alloy sheets can be pressed into desired shapes.

Since stamping products have considerable potential because of its competitive productivity and performance, they have been widely used in the automotive, space, computer, communication and consume product industries. Therefore, the stamping process has become one of the most important processes in shaping products. Nobuhiro and Ratchanee (2001) attempted to identify the influences of friction on the stamping of AZ31 magnesium alloy sheets. The results indicate the better limiting drawing ratio when tools coated with carbon films. Ohwue et al. (2001) discussed the formability of AZ31 magnesium alloy sheets under warm working. They conducted a square shell deep drawing test at elevated temperature. Chen and Huang (2003) used conical cup value and V shape bending tests to investigate the formability of stamping magnesium alloy AZ31 sheets at elevated temperatures. Wahab et al. (2006) investigated heat transfer effect in the warm deep-drawing process of magnesium AZ31 alloy sheet.

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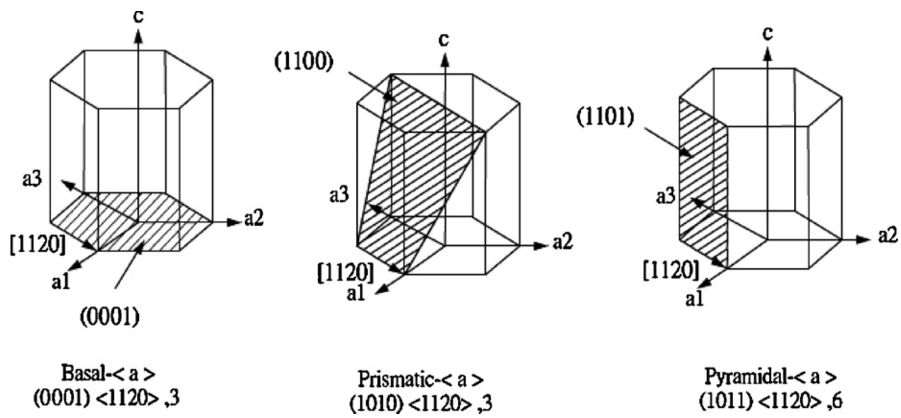

Fig. 1 – Basal-⟨a⟩, prismatic-⟨a⟩, and pyramidal-⟨a⟩ slip system in HCP materials (Yang et al., 2002).

As a result of the highly competitive market, a way to design and develop high quality dies in a relatively short time and with a relatively lower cost has been one of the most important topics for the die industry. An integrated system consists of advanced manufacturing techniques. Accordingly, die manufacturers are spending more and more time in developing integrated systems. Recently, the ideas of reverse engineering and concurrent engineering have been incorporated into the die design and development process. Sokovic and Kopac (2006) identified a rapid product development method using reverse engineering. Yue et al. (2003) developed an integrated CAD/CAE/CAM system for developing die casting dies of water pump using a concurrent engineering approach. Yang et al. (2002) developed the technology integration of CAD/CAM/CAE and RP&M (rapid prototyping and manufacturing) for the development of trial product and dies for metal forming processing. Park et al. (2007) developed an integrated application of CAD/CAM/CAE and rapid prototyping (RP) for the humanoid biped robot's outer shells on the vacuum casting process.

This paper introduces an integrated RE/RP/CAD/CAE/CAM system for constructing a magnesium-alloy AZ31 shell for the mobile phone and developing related progressive dies using concurrent engineering (CE).

2. A magnesium alloy shell for a mobile phone and related progressive dies

2.1. *Properties of magnesium alloy materials*

The atomic structure of magnesium alloys is a stable structure called hexagonal close-packed (HCP), as shown in Fig. 1. When performing plasticity work on magnesium alloys, the minimum shear force required to shear the non-downside part is at least one hundred times stronger than that required to shear the downside part at room temperature (Staroselsky and Anand, 2003). In other words, it is very difficult to perform stamping work at room temperature. However, the shear force required to shear the non-downside part decreases drastically with an increase in temperature. At approximately 300 °C, it is almost the same as that required to shear the downside part, which makes plasticity work easy to perform (Chen and Huang, 2003), as shown in Fig. 2. Therefore, warm working is required on stamping process of magnesium-alloy AZ31 sheets.

2.2. *Progressive dies for magnesium-alloy parts*

Since performing plasticity working on magnesium-alloy AZ31 sheets should be done in warm working, the working temperature of dies usually ranges from 150 to 200 °C. For the purposes of safety and productivity, progressive stamping is used to automate the manufacturing process. The development of progressive stamping consists of two parts: layout of sheet metal strip and design of progressive die.

2.2.1. *Sheet metal strip*

The stamping process of shells for mobile phones consists of the following sub-tasks: blanking of raw material outline, drawing of shell shape, piercing of keyboard and screen holes, side-piercing of earphone and charger holes, and cutting of shell outline. The progressive process includes all sub-tasks in a single die. This die is called a progressive die. Each of the processes performed within progressive dies is called a process station.

Since sheet metal strips should be feed into the progressive system continuously, the magnesium-alloy coils will go though the decoiler, the straightener, and the feeder before

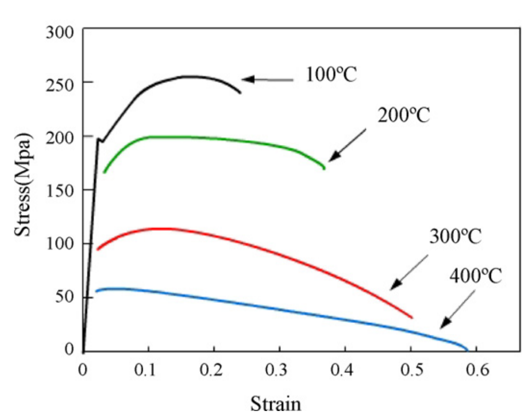

Fig. 2 – Stress–stain relations at elevated temperatures (Chen and Huang, 2003).