Research on Die Casting Process of Magnesium Alloy Motorcycle Wheel Based on New Engineering Construction

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Abstract. Magnesium alloy forming technology is a hot spot in the world. This paper introduces the application of AM60B magnesium alloy and die casting technology in the forming of motorcycle wheel casting, and the test and analysis of die casting process. Finally, qualified magnesium alloy wheel castings are produced. The selection of die casting process parameters was 680 ~ 700 ℃, the casting temperature of 240 ~ 280 ℃, and the pressure ratio between 180 ~ 200MPa and the holding time was 20 ~ 25s. Under the condition of optimum technological parameters, obtained by casting the mechanical properties testing results: σb=218 ~ 227MPa, HBS=66 ~ 71, δ5=9.8 ~10.7% and ak= 17.5 * 10^3 ~ 18.7 * 10^4 J / m². The practice has proved that the die casting technology is a suitable process for magnesium alloy wheels, and it has reference value for the mass production of large area magnesium alloy casting.

1. Introduction
At present, most of the domestic and international motorcycle wheel materials are aluminum alloy, the casting method is mainly used by gravity casting. Magnesium and magnesium alloys are the lightest of all metal structures. Compared with other metal materials and engineering plastics, magnesium alloy has high specific strength. Magnesium alloy has been hailed as the metal in the 21st century. In recent years, it has gained rapid development in automotive, aerospace, electronic industry, and the development prospect is better. In order to expand the application range of magnesium alloy in automobile and motorcycle industry, the forming process of magnesium alloy was studied. Basic material for AM60B commercial magnesium alloy, the material is good, the Impact toughness, mechanical strength is higher, the size is stable, easy forming and machining, suitable for motorcycle wheel and other moving parts, AM60B magnesium alloy density is 1.8g/cm³, the shrinkage rate is 0.8%. After the design of the weight of 1.49 kg, after processing the parts weight of 1.21 kg, 2.24 kg of raw aluminum alloy, the actual weight loss of 0.75 kg, weight loss of about 1/3

2. Test Conditions and Methods
Test using commercial magnesium alloy AM60B alloy, melting in crucible furnace gas, using SF6 gas mixture of smelting protection, and modified and refined processing, in YJ32-2000 four column hydraulic press liquid pressure casting, from the forming of magnesium alloy wheel casting interception of tensile specimen and specimen size as shown in Figure 1. In automatic control universal mechanical testing machine (Shimadzu, Japan) AG-10TA type of tensile test, and in HBRVU-185.5 type Burawoy optical hardness tester hardness test.
3. Test and Result Analysis

3.1. Test and Result Analysis
In order to study the effect of die casting process on mechanical properties, Pouring Temperature $T_p$: 650-710°C; ressure Injection Pressure $P_b$: 70-110MPa; Mold Temperature $T_o$: 200-300°C; and Holding Time $T_h$: 15-30s were performed.

According to the test results, the analysis, get the injection pressure, pouring temperature, mould temperature, Paul pressure time etc. four parameters in die casting process of AM60B alloy tensile strength and elongation, hardness and Impact toughness of the analysis results.

3.2. Effect of Process Parameters on Mechanical Properties of AM60B Alloy Wheel Castings

3.2.1. Pouring Temperature $T_p$: Pouring temperature is the most active factor in die casting parameters, which not only affects the process of the die casting process, but also affects the rate of collection, product quality and mechanical properties. In the other process parameters, the influence of pouring temperature on mechanical properties is shown in Figure 2. It can be seen from Figure 2 that the tensile strength and hardness of AM60B alloy increases with the increase of pouring temperature, and decreases with the increase of pouring temperature. When the maximum value is reached, the corresponding pouring temperature is 690°C and 675°C respectively. In Figure 2, the tensile strength

![Figure 1. The cutting parts and dimensions of the specimen](image1)

![Figure 2. Effect of $T_p$ on the mechanical properties of the AM60B alloy in the back squeeze cast magnesium alloy ($P_b=170$MPa, $T_o=280°C$, $T_h=25s$)](image2)
and Impact toughness of AM60B alloy are relatively flat, which shows that the effect of pouring temperature on elongation and Impact toughness of AM60B alloy is small. When the curve of elongation and Impact toughness reaches the maximum, the corresponding pouring temperature is 675 °C and 690 °C respectively. The suitable pouring temperature is the key to the magnesium alloy die casting. Pouring temperature has a direct Impact on at the beginning of the casting solidification layer thickness and die casting solidification process of liquid metal in the total heat loss. When pouring temperature is too low, the outer layer of the casting easy to solidify into a hard shell, in die casting pressure is mainly crust consumption, resulting in the center position of the feeding problem, easy to form shrinkage. When pouring temperature is too high, because of the difference between the solution and the mould, the heat transfer rate is high, and the melt solidification rate is slow, so the grain size of the specimen is larger, and the molten liquid is easy to splash out. In addition, the pouring temperature is too high, the energy consumption is high, the consumption of the mold, and may cause the metal to air oxidation seriously, directly affect the casting quality.

In summary, the pouring temperature Tp range needed for good comprehensive mechanical properties are obtained at 680 °C to 700 °C.

![Figure 3. Effect of Pb on mechanical properties of AM60B in the back squeeze cast magnesium alloy](image)

3.2.2. Pressure Injection Pressure $P_b$:

The key parameters of die casting process are the pressure and shoot ratio. From Figure 3 can be seen when the injection pressure is lower than 70 MPa, with the injection pressure increases, tensile strength $\sigma_b$ increased slowly. When injection pressure in 70 ~ 85MPa. With the injection pressure increases, tensile strength $\sigma_b$ increased dramatically; when injection pressure increased to85MPa, with injection increase of less than the pressure of high tensile strength increases curve is close to the level of state changes. From the point of view of practical production, injection pressure 85MPa AM60B alloy in die casting under the condition of tensile strength reaches the maximum value. At this time of AM60B alloy tensile strength $\sigma_b$ is about 212 Mpa, While the hardness value increases with the increase of the pressure and the pressure of the pressure, and when the hardness reaches the highest value 72HBS, the pressure is increased, but then decreased. When the pressure ratio is 100MPa, then the hardness curve is changed to a horizontal state.

The change of elongation and Impact toughness curve were increased first and then decreased with the increase of pressure. When the injection pressure is 85MPa, the corresponding AM60B elongation
δ5 was 10.7%. The Impact toughness of a5 is 18.4J/m² when the pressure ratio is 100MPa. There is a direct relationship between the mechanical properties of the pressure and the pressure and the casting. Only in the sufficient pressure to shoot the pressure to ensure that the final setting of the casting is fully effective. The forced flow of the alloy during the solidification of the alloy is enhanced by the increase of the pressure and the injection pressure. The reduction or elimination of the reduction conditions, and the density of the alloy are reduced.

For each kind of casting there is a critical pressure, below the critical pressure, it can not get high quality castings. The friction coefficient “μ” direct punch die casting μ=0.3 ~ 0.5. The test on the surface of the punch and the mold coated with release agent, can reduce the friction resistance, so take μ=0.3. The yield limit of magnesium alloy 73.5MPa was AM60B. Will the numerical and casting sizes are substituted in the critical pressure shot than the pressure PCRI theory formula to calculate the critical injection pressure PCRI theory obtained AM60B alloy critical injection pressure PCRI value 77.1 MPa. The results of the test show that the tensile strength curve of figure 4.3, the first inflection point on the graph is the critical pressure ratio of the test, the value is 75 MPa and the error is 2.8%.

To sum up, get shot required good comprehensive mechanical properties than the pressure range of Pb should be 85 ~ 100MPa.

3.2.3. Mold Temperature T₀: The test results are shown in Figure 4. The tensile strength and hardness of Fig. 4 are increased with the increase of the pressure and the pressure drop, but the tensile strength curve is more severe than that of the hardness curve. When the maximum value of the tensile strength curve and hardness curve is reached, the corresponding mold temperature is about 280 and 240 respectively. The change trend of elongation curve and Impact toughness curve in Figure 4 is relatively flat, and the change of Impact toughness is almost a horizontal change, which shows that

![Figure 4](image-url)

**Figure 4.** Effect of T₀ on the mechanical properties of AM60B alloy in the back squeeze cast magnesium alloy

\(P_b=170MPa, T_p=80^\circ C, t_H=25s\)

the Impact toughness has little effect on the mold temperature, and the maximum value of the mold temperature is about 240. The casting temperature is the key to the cooling rate of the alloy liquid, which can affect the casting quality. Generally speaking, the mold can remove the water and gas, and the release agent is covered on the wall, and can adjust the solidification rate of the melt. The
preheating temperature is low, solidification of melt and mold contact part of the fast and the punch on top of outer shell will bear most of the pressure, after the completion of the die casting pattern of heart still shrinkage, porosity and other defects. The mold preheating temperature is too high will make the casting solidification after the grain size, and in the die casting process of metal liquid easy to splash. In summary, the mold temperature range needed for good comprehensive mechanical properties are obtained at 240 to 280°C.

![Figure 5. Effect of $t_H$ on the mechanical properties of the AM60B alloy in the back squeeze cast magnesium alloy](image)

3.2.4. Holding Time $t_H$: When other process parameters are given, the results shown in Figure 5 are obtained. In Figure 5, the tensile strength curve and the hardness curve of AM60B alloy were changed dramatically, the tensile strength and the hardness curve reached the highest value, and the corresponding holding time was 25s and 20s respectively. The change of elongation and Impact toughness curve in Figure 5 is relatively flat, and the influence of holding time on elongation and Impact toughness is minimal. The time of holding pressure is mainly determined by the complexity of the wall thickness and the shape of the casting. The time of holding pressure is important to the solidification of the alloy liquid. When the time of holding pressure is not enough, the core of the casting is not fully realized under the pressure, the grain size is coarse, and the heart is not fully. The time of holding pressure is too long, the density of the casting can be improved, but the mechanical properties of the castings can be improved, but it can make the casting mold difficult, affect the service life of the mould, and reduce labor productivity.

In summary, required to obtain good comprehensive mechanical properties of pressure holding time $t_H$ range should be 20 ~ 25s.

3.2.5. Other Process Parameters: In addition to the above four main process parameters, die casting speed, casting alloy super heat temperature, volume of the casting of molten metal, metal cleanliness of liquid, filling pressure curve, mound coating, die casting metal liquid residence time also has more important influence on the casting of magnesium alloy wheel molding. Filling speed of 0.56m/s, casting surface prone to flow mark, resulting in pouring defects. The filling velocity of magnesium is small, the flow time of the filling type is prolonged, and the contact with the quantitative chamber
increases, the flow is filled with 2.10m/s, and the flow pattern of the magnesium liquid is filled with the flow. The super heated temperature of the alloy is 130-140℃.

In the analysis of the influence of the process parameters on the tensile strength, the influence of

![Figure 6. Physical map of the die cast magnesium alloy motorcycle wheel](image)

4. Development of the Hub of the Motorcycle in the Die Casting Magnesium Alloy
On the basis of the above experiments, the Wang Suzuki front wheel motorcycle wheel was developed, and the selection of die casting process parameters was 680~700℃, the casting temperature of 240~280℃, and the pressure ratio between 180~200MPa and the holding time was 20~25s. The test results show that the wheel blank is filled with complete (see Fig. 6a), and the hub surface is smooth (see Fig. 6B, 6c). Under the condition of optimum technological parameters, obtained by casting the mechanical properties testing results for σ_b=218-227MPa, Brinell hardness for 66-71HBS, δ_b = 9.8-10.7% and a_k = 17.5 * 10^4~18.7 * 10^4 j / m^2. The mechanical properties show that the Hub Castings meet the technical standards of the motorcycle wheel hub.

5. Conclusion
(1) the process parameters of the mechanical properties of the die casting AM60B alloy are the primary and secondary order: pouring temperature, pressure ratio pressure, casting temperature and holding time, the influence of pouring temperature is the most significant.

(2) the condition of this experiment, the mold temperature t_0 for 240 ~ 280℃, pouring temperature T_P is 680 to 700 ℃, die casting shoot ratio pressure P_b should be in 82 ~ 100MPa, pressure time t_H range should be in 20 ~ 25s, mechanical properties of die casting AM60B alloy reached σ_b=218-227MPa, Brinell hardness for 66-71HBS, δ_b=9.8~10.7% and a_k = 17.5 * 10^4~18.7 * 10^4 j / m^2., the mechanical properties reached the technical standards for motorcycle hub.

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7. References

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