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# A STUDY ON THE PREVENTION OF SURFACE DEFECTS CAUSED BY LUBRICATION IN PRODUCT PRODUCTION FROM ZAMAK 3 BY INJECTION METHOD

**Cenk Misirli[1], Mehmet Ceviz[2]*, Işık Çetintav[1], Benhur Ersoy[1]**
[1] *Trakya University, Mechanical Engineering Department, Edirne, Turkey*
[2] *Trakya University, Vocational School of Keşan, Edirne, Turkey*

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ABSTRACT

*Due to its economic, easy formability, high corrosion resistance, excellent electrical conductivity and low cost, Zamak-3 has a wide usage area in many sectors, especially accessories and fasteners in the window and furniture sector, and spare parts in the automobile sector. For this reason, it is important to prevent visual and functional defects caused by production. In this study, the determination of the errors caused by lubrication in the production of zamak products by injection method, the effect of the amount of lubrication on the surface defects, the relationship between lubrication and mold design and the effects of all these problems on the quality of the products were investigated. In this study, 1.2344 hot work tool steel was used as mold material and Zamak-3 as product raw material. Different products were produced by changing the lubrication parameters in the injection machine and application examples were examined. In line with this investigation, it is planned to optimize the lubrication parameters.*



## INTRODUCTION

Zamak alloys are the products with the highest commercial importance due to their superior physical and mechanical properties among zinc alloys. This material is used because of its suitability for mass production, low dimensional tolerance, high corrosion resistance, high viscosity at low casting temperatures, long mold life and superior shapeability in the final product. They are used as raw materials in the production of products and semi-products in many fields such as intermediate fasteners, window middle records, hinges, sports equipment, toys, hardware, decorative parts, white goods parts, especially in the automotive and building sectors. It also offers perfect surface quality for zamak coating, dyeing and chromate processes.

The component amounts of the elements in the zamak alloys vary and are classified according to their percentage components. Al, Mg, Cu, Fe, Pb, Cd, Sn, Ni and Zn elements are used in the zamak alloy. Zamak 2, zamak 3 and zamak 5 and zamak 7 are commonly used. There are also different zamak alloys such as zamak 8, zamak 12, zamak 27. Chemical percentage components of commonly used zamak alloys are as in the table1 and table 2.

Zamak 3 is the most commonly used zamak alloy in the die casting method. The reason for this is its optimum physical and mechanical properties, dimensional stability, and its use by the casting industry more than other zamak alloys. Zamak 3 is especially preferred in the production of materials where high dimensional stability and high strength are expected.

***Table 1*** *Chemical Specification (per ASTM) (% by Weight) for ZAMAK Alloys*

| | **Zamak 3** | | **Zamak 5** | |
|---|---|---|---|---|
| | Ingot | Casting | Ingot | Casting |
| **Al** | 3,9-4,3 | 3,7-4,3 | 3,9-4,3 | 3,7-4,3 |
| **Mg** | 0,03-0,06 | 0,02-0,06 | 0,03-0,06 | 0,02-0,06 |
| **Cu** | 0,10 max | 0,1 max | 0,7-1,1 | 0,7-1,2 |
| **Fe (max)** | 0,035 | 0,05 | 0,035 | 0,05 |
| **Pb (max)** | 0,004 | 0,005 | 0,004 | 0,005 |
| **Cd (max)** | 0,003 | 0,004 | 0,003 | 0,004 |
| **Sn (max)** | 0,0015 | 0,002 | 0,0015 | 0,002 |
| **Ni (other)x10** | - | - | - | - |
| **Zn** | Bal. | Bal. | Bal. | Bal. |

Pressure injection is widely used in the production of Zamak products. The reason for this is that the cycle time is short, the surface defects are less in the production of products with difficult geometry compared to other production methods, the production of high-strength products is appropriate, and the automation system is appropriate.

* Corresponding author. E-mail: mehmetceviz@trakya.edu.tr

***Table 2** Chemical Specification (per ASTM) (% by Weight) for ZAMAK Alloys*

| | **Zamak 7** | | **Zamak 2** | |
|---|---|---|---|---|
| | **Ingot** | **Casting** | **Ingot** | **Casting** |
| **Al** | 3,9-4,3 | 3,7-4,3 | 3,9-4,3 | 3,7-4,3 |
| **Mg** | 0,01-0,02 | 0,005-0,02 | 0,025-0,05 | 0,02-0,06 |
| **Cu** | 0,10 max | 0,10 max | 2,7-3,3 | 2,6-3,3 |
| **Fe (max)** | 0,035 | 0,05 | 0,035 | 0,05 |
| **Pb (max)** | 0,003 | 0,003 | 0,004 | 0,005 |
| **Cd (max)** | 0,002 | 0,002 | 0,003 | 0,004 |
| **Sn (max)** | 0,0010 | 0,001 | 0,0015 | 0,002 |
| **Ni (other)x10** | 0,005-0,02 | 0,005-0,02 | - | - |
| **Zn** | Bal. | Bal. | Bal. | Bal. |

We encounter mechanical and visual errors in the injection production of Zamak products. Visual imperfections are important depending on where the piece will be used. Part surface defects are often caused by mold design or lubrication. Mechanical defects are caused by the mold design, the machine settings of the injection machine, the zamak raw material used, the cleaning of the melting pot, the lubrication method, the lubrication mechanism and the quality of the oil used. If mechanical failures are not prevented, the desired mechanical properties cannot be achieved, brittle breaks in the product, shortened product life and low corrosion resistance are encountered.

In the literature, many studies have been carried out on the pressure injection method and zamak products. The studies focused on the improvement of the mold designs, the zamak raw material used and the errors encountered. In this study, visual and mechanical defects were investigated by changing the lubrication amounts and lubrication angle. This experimental study allows to examine the effect of increases in the amount of lubrication on the mechanical and surface defects of the part.

## MATERIALS AND METHOD

Zamak 3 alloy was used in my work. Shown in Table 3 is the percent chemical composition of Zamak 3. The zamak 3 used was supplied from Belgium.

***Table 3** Chemical composition of alloy ZAMAK 3 in wt%.*

| Zn | Mg | Cu | Fe | Pb | Cd | Sn | Al |
|---|---|---|---|---|---|---|---|
| 4.17 | 0.02 | 0.018 | 0.01 | 0.001 | 0.0009 | 0.0009 | Bal. |

Supplied zamak 3 strength, hardness, conductivity etc. subjected to mechanical and chemical tests. The results obtained from the tests are given in table 4.

The experiment was carried out using the pressure injection method. A 50-ton pressure injection machine produced by Özmak Makina was used for the injection process. In the experiment, a 2-cavity mold with dimensions of 480x340x320 made of 1.2344 hot work tool steel was used.

In this study, the causes and prevention of surface defects caused by lubrication in the production of products made of zamak 3 by pressure injection method were investigated. So lubricant selection is very important. Lubricant must be hydraulic and shouldn’t be synthetic and evaporating easily.

For this reason, “SuperMax Oil Germany HD Series Sae 40”, which can also be used for industrial purposes, was used to observe the defects in the samples. Technical specifications for SuperMax Oil Germany HD Series Sae 40 are in table 5.

***Table 4** Zamak 3 chemical and mechanical analysis results*

| | |
|---|---|
| **Ultimate Tensile Strength (MPa)** | 283 |
| **Yield Strength - 0.2% Offset (MPa)** | 221 |
| **Elongation: % in 2"** | 10 |
| **Shear Strength (MPa)** | 214 |
| **Hardness (Brinell)** | 82 |
| **Poisson's Ratio** | 0,27 |
| **Density (g/cm3)** | 6,6 |
| **Melting Range (°C)** | 381-387 |
| **Electrical Conductivity: %IACS** | 27 |
| **Thermal Conductivity (W/m/hr/°C)** | 113 |
| **Coefficient of Thermal Expansion (100-200°C µm/mm/°C)** | 27,4 |
| **Specific Heat (J/kg/°C)** | 419 |

***Table 5** SuperMax Oil Germany HD Series Sae 40 technical specifications*

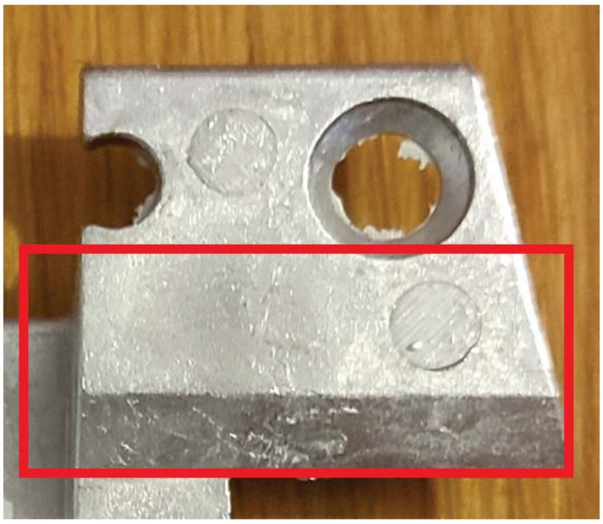
| **Analysis** | **Unit** | **Analysis Method** | **Ideal Values for HD 40** |
|---|---|---|---|
| **Density, 15°C** | g/cm3 | ASTM D 4052 | 0,8882 |
| **Viscosity, 40°C** | cSt | ASTM D 445 | 132,2 |
| **Viscosity, 100°C** | cSt | ASTM D 445 | 14,71 |
| **Viscosity Index** | - | ASTM D 2270 | 5 110 |
| **Pour Point** | °C | ATM D 92 | -21 |
| **Flash Point** | °C | ASTM D 93 | 238 |

In this study, zamak 3 that melted at 430-440°C is injected into the mold consisting of 2 chambers in closed position with the help of a pressure injection machine. After the injection process is finished, the products are pushed out of the mold with the help of pushers and then the mold is brought back to the closed position. This process creates our cycle. It is lubricated every 4 cycles to ensure efficient operation of the mold and to produce quality surface products (After the products are pushed with the help of the pusher, surface lubrication is done.). The lubrication process works with an apparatus that throws spray oil into the center of the mold. This mechanism lubricates the inside of the mold with 1.2-0.2 ml (depending on the size of the product) Super Max Oil Germany HD Series Sae 40 in each operation. The position of the lubrication process is adjusted in the x and y axes according to the mold depth. The aim here is to complete the lubrication process in all parts of the mold, including the deep points. On deep surfaces that cannot be lubricated, a part of the mold may break off or a part of the part may remain in the mold as a result of the part sticking to the mold surface. If there are parts left in the mold, we cannot get the geometry parts we want from the products in the next printings (it is called incomplete printing of the part).

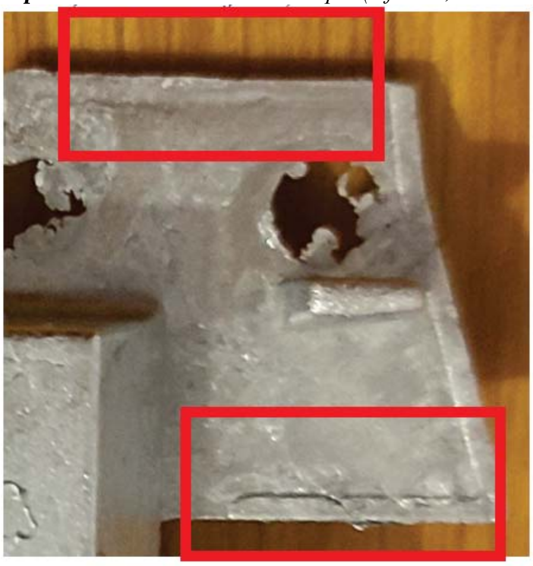
In this study, values in the range of 1.1-0.8 ml/lubrication, 0.8-0.5 ml/lubrication and 0.5-0.3 ml/lubrication were studied.

***Test sample 1*** *0.5-0.3ml/lubricated sample (left side, top surface)*

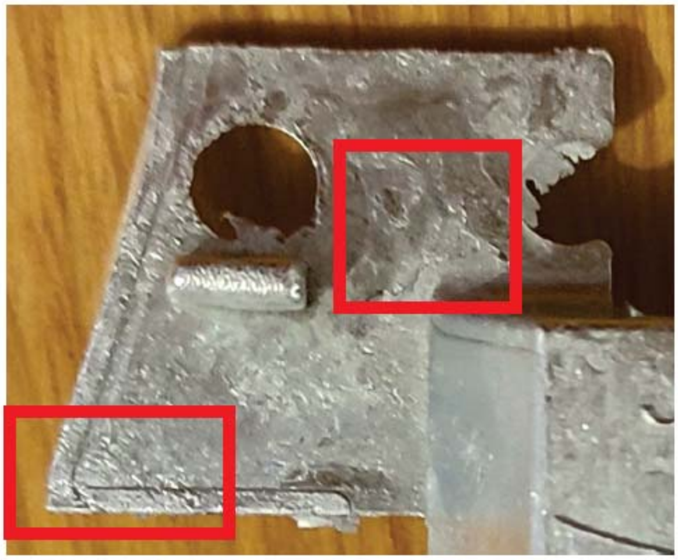
***Test sample 1*** *0.3-0.5ml/lubricated sample (right side, top surface)*



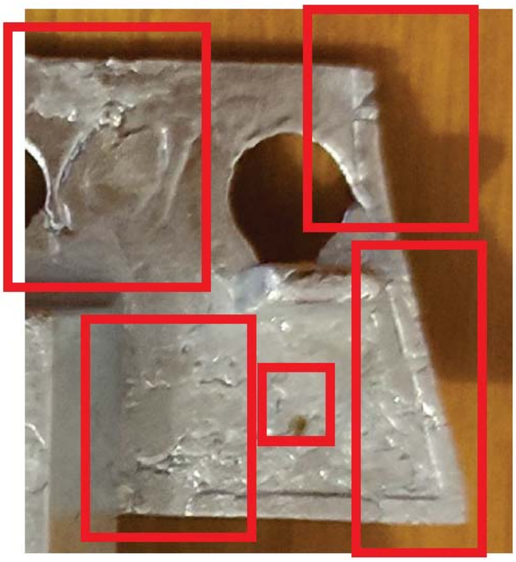
***Test sample 2*** *0.5-0.8 ml/lubricated sample (left side, under surface)*



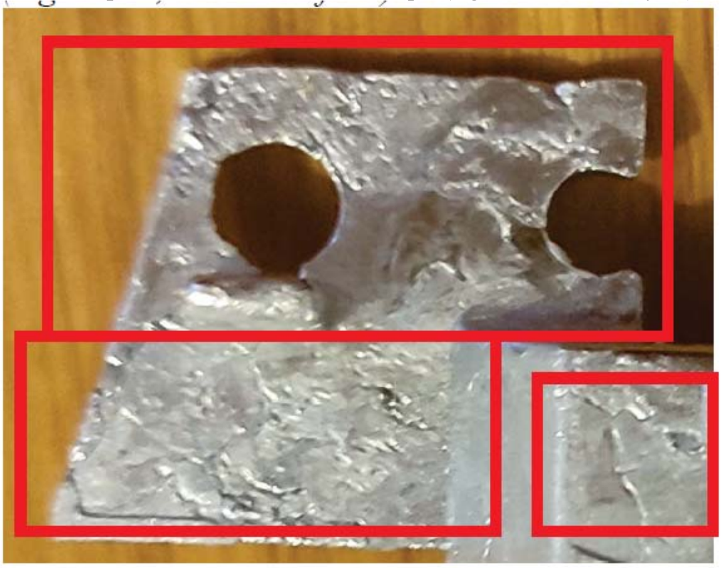
***Test sample 2*** *0.5-0.8 ml/lubricated sample (right side, under surface)*



***Test sample 3*** *0.8-1.1 ml/lubricated sample (left side, under surface)*

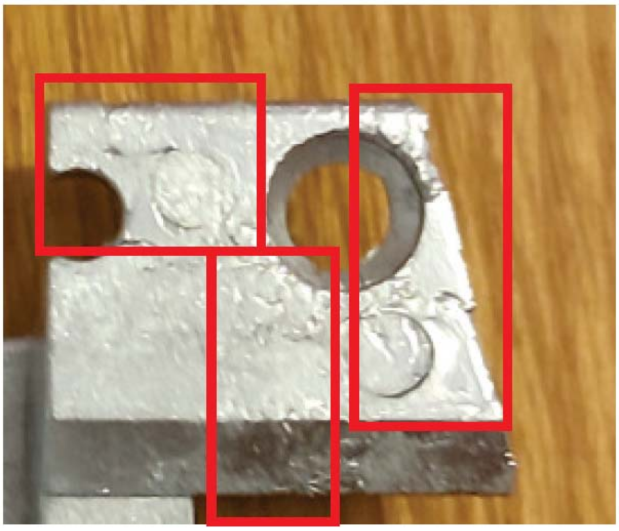


***Test sample 3*** *0.8-1.1 ml/lubricated sample (right side, under surface)*



***Test sample 3*** *0.8-1.1 ml/lubricated sample (left side, top surface)*

***Test sample 3*** *0.8-1.1 ml/lubricated sample (right side, top surface)*



The traces of lubrication on the surface of the part obtained from the 1st experiment are only a visual error and disappear after the coating process.

With the increase in the amount of lubrication in the second test piece, surface defects started and dislocations occurred.

By increasing the lubrication measure to 1.1-0.8 ml/lubrication amount, the visual defects on the surface became evident. In addition to visual defects, enlargement of hole diameters that could cause mechanical problems, thinning of part thickness in some regions, and distortions in the desired part geometry began to be observed. It is inevitable that the parts produced with these errors will get stuck during assembly or shorten their life.

## CONCLUSION

Zamak 3 is one of the best options compared to other alloys. Because it has good mechanical properties such as abrasive resistance and easy deformation.

Lubrication is essential to aid production. This help may cause some defects during production. The lubricant should offer good mechanical and thermal properties. Because the lubricant directly affects the surface and internal structure of the product.

This study proves that the oil should be chosen carefully and that the lubrication should not be too high or low. As can be seen from the examples, while the amount of lubrication is around 0.3 ml, some surface defects (dislocations) are seen on the surface, while as it goes up to 1.1 ml, the surface defects increase and affect the surface geometry. When sufficient lubrication amount is provided for pressure injection, the injection process should be continued without changing the lubrication angle and amount. The amount of lubrication should only be changed when the weather temperatures, working with different molds, changing the oil used or the machines used are changed.

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