TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics and Mechanics
Vol. 54, Issue I, 2011

MAIN FUNCTIONS OF THE DIE LUBRICATION RESULTING FROM THE TECHNOLOGICAL NEEDS OF THE ALUMINIUM INJECTION PROCESS

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Abstract: *The process of aluminum die casting, called aluminum injection is a relatively new process, oriented towards the production of consumer goods in large and mass batches, with applications in all fields of manufacturing of complex products and equipment, which includes non-ferrous metal components. To make the extraction of casting part, without dimensional and structural deterioration is necessary to have a film of lubricant, having the role of facilitating the detachment of the part from the mold.*

Key words: *aluminum injection, lubricant, pressure die casting.*

1. INTRODUCTION

The main functions of the die lubrication resulting from the technological needs of the aluminum injection process, and from the mechanisms of lubricant film formation are:

- function of separating layer between the injected alloy and die;
- function of lubricant film;
- cooling function of the die.

Besides the needs related to technology, a great importance should be given to the extraction of the casted part. Thus, the amount of lubricant used should facilitate the die release with a minimal force.

A good lubricant application system, should allow the simultaneous fulfillment of all these functions, sometimes to a feasible requirement more or less. To make the extraction of casted part without dimensional and structural harms, it is necessary to have a film of lubricant, with the purpose to facilitate separation from the die.

For this, the lubricant has to preserve the essential characteristics even after contact with liquid metal. Some of the components of the lubricant are burning at the temperature of the liquid metal, leaving residues on the surface of the die or the casted part.

The lubricant should also provide a good process stability, good dimensional stability of the casted parts, an exterior aspect and a roughness corresponding to the technical specifications of the product.

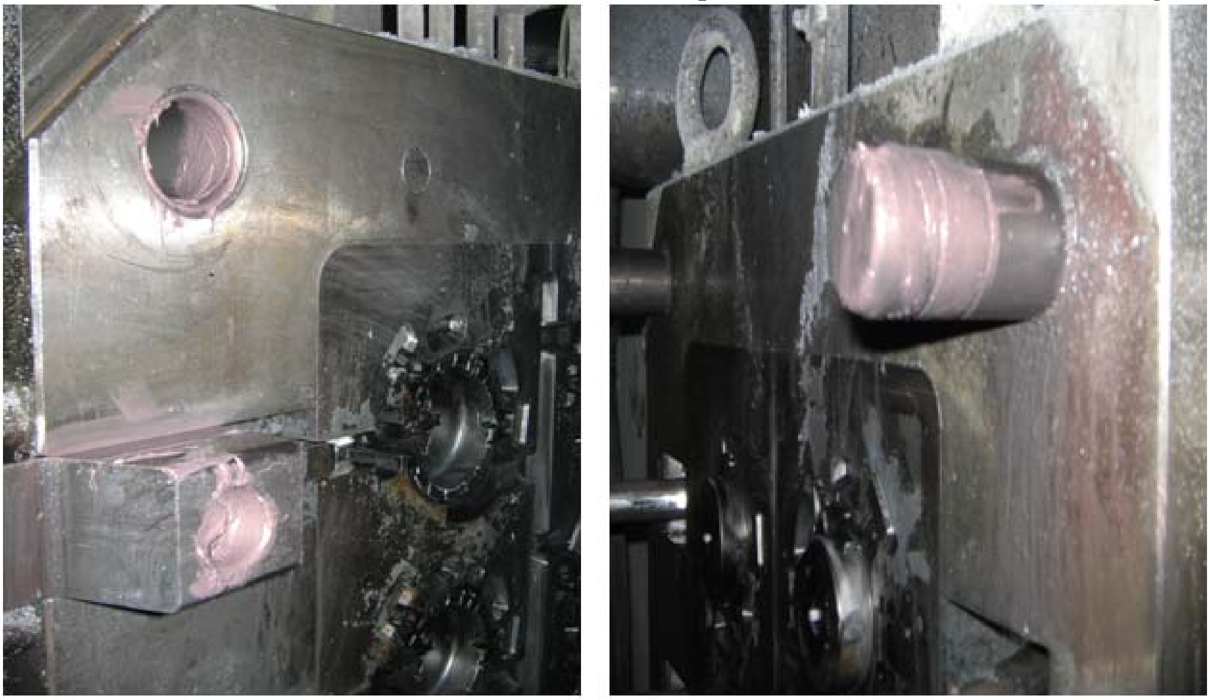
2. INFLUENCE OF LUBRICATION ON THE DIMENSIONAL ACCURACY OF CASTINGS

In practice it is observed that a proper construction of a die is not sufficient, the dimensional accuracy cannot be guaranteed without a proper functioning of it from the mechanical point of view.

Some of the part dimensions are directly controlled by an active element of the die. Inevitably during lubrication, the lubricant comes into contact with moving parts of the die located outside the active part of the die.

These parts (bushings and guiding pins, slides, carts, locking elements, etc.) during the temperature arrive at temperatures between 100 and 200 ^{o}C. In this case, we are dealing with a steel on steel friction. At 20 ^{o}C the coefficient of friction has a value of 0.39.

The demands on the lubricant, in this case are more modest, so that, in the phase of the die assembly, it is used a special paste, based on copper, lead, grease with graphite, or molybdenum disulfide. In the following part, it is discussed the influence of lubrication of moving parts and the separation plan, capability of injection process, watching the evolution of a rate achieved by creating a cavity between at least two active elements of a die. An example of such elements is shown in Figure 1.



a b

Fig. 1. Die for the injection of the "Body Burner" part

For this analysis, it is proposed "fast burner body 16 001" part (Fig. 2) achieved by the injection of aluminum with the die shown in Figure 1.

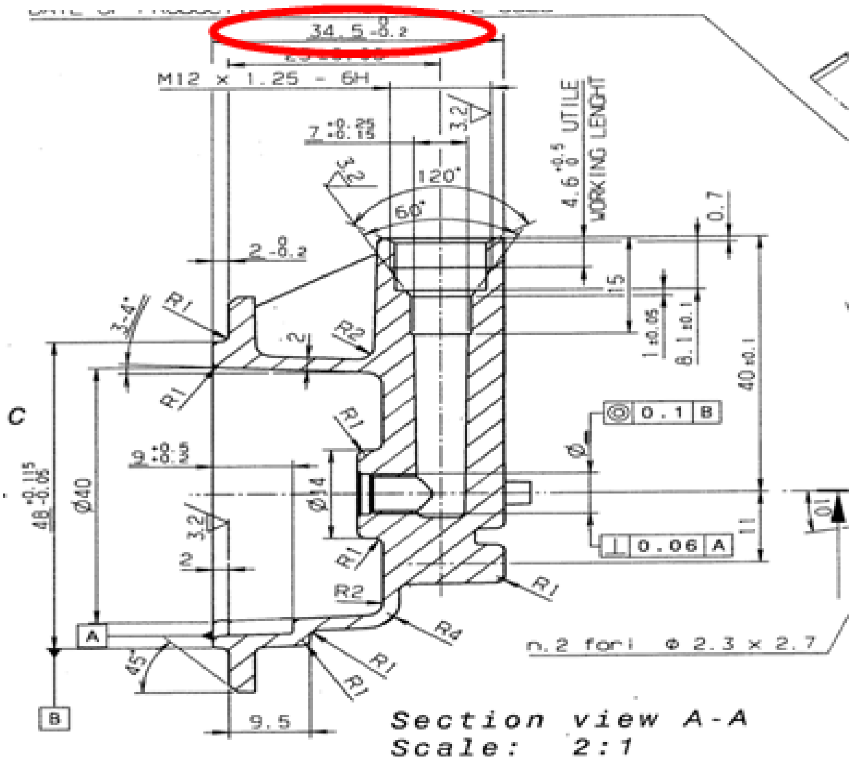


Fig. 2. Rapid burner body 16001

The die has been used for producing a total of 120,067 casts, the customer guarantee is 200,000 casts. In current mode, the guarantee of a die is 100000 ÷ 150000 castings.

There will be made a study of the process capability to achieve the dimension 34 0/-0,2. It will be done 50 consecutive castings, at a time, without any prior training. It will be measured the same figure, in the same point.

As the result of the process capability shows, we are dealing with an extremely stable process. In current mode, even in the auto industry, it is considered a stable process with:

$$C_{pK} \geq 1.33. \quad (1)$$

In the study, the achieved process capability is $C_{pK} \geq 1.67$.

A crucial role in achieving these results was just the type of lubricant used, in powder form, and its correct application and dosage.

3. INFLUENCE OF LUBRICATION ON THE SURFACE QUALITY OF THE INJECTED PART

The most common quality problems caused by variation of the quantity of the applied lubricant on the die surface, in order and frequency of their occurrence may be:

- spots on the surface of the product;
- problems in extraction, covering, surface irregularity;
- variations of surface roughness;
- variations of the superficial layer aspect.

3.1. Spots appearance on the part surface

For this particular analysis it was chosen the "dissipator F 300", which is a product of complex shape.

It is found that an almost imperceptible variation in the amount of lubricant applied, change the appearance of the part from an extreme situation, closed to lack of lubricant, to other extreme, the excess of lubricant followed by the appearance of burned lubricant spots (Fig.3 - Fig.6).

Due to the very small amount of lubricant applied, it cannot make a direct determination of it, it cannot make a clear technical specification, with reference only to a casting or to a low number.

It can only be done an indirect determination of the medium quantity, over an exchange or a batch production. For a good running of the process, the only guarantee remains the operator skill.

3.2 Extraction of the part from the die

The main difficulty remains the impossibility of direct determination of the amount of applied lubricant.

In case of the lubricant excess, burned lubricant spots appear on the part, and if there is scarcity of oil, metallization is produced, followed by deformation and deterioration of the surface integrity (Fig. 7 and 8).

Fig. 3. Minimum jet of lubricant


Fig. 4. Parts with high roughness, limit metallization process

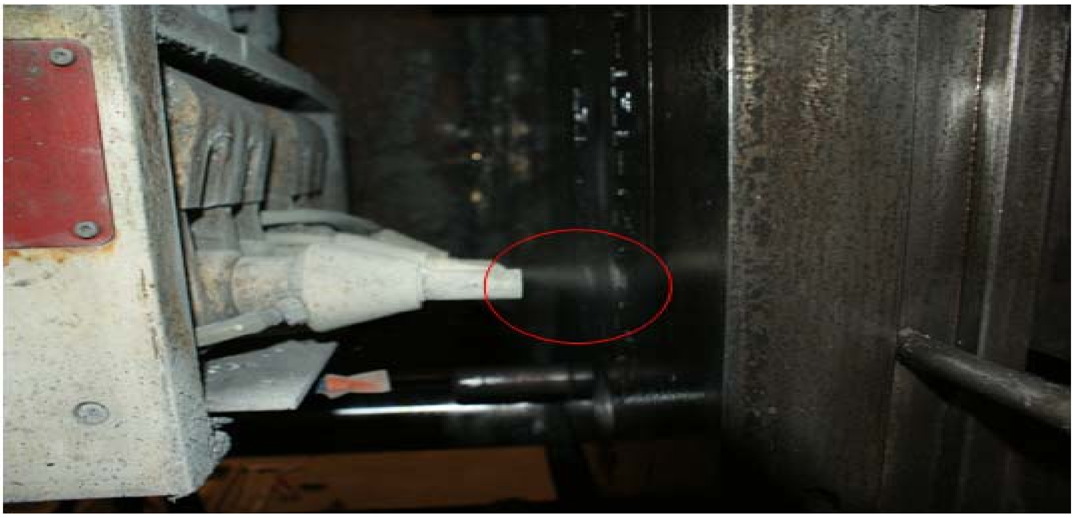


Fig. 5. Maximum jet of lubricant


Fig. 6. Stained parts, excess oil burned

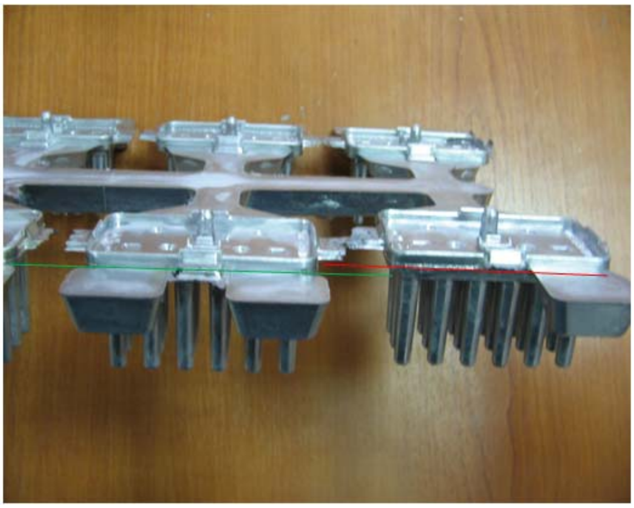


Fig. 7. Deformation appearance due to Al metallization on the die surface

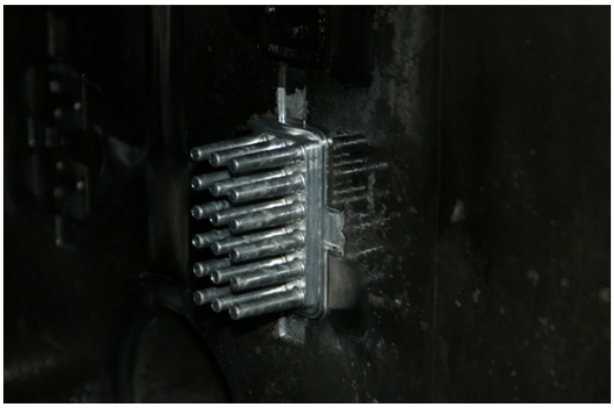


Fig. 8. After the appearance of deformation, at the following casting, the metallization has occurred (product sticking) on die surface

3.3 Influence of the lubrication on the roughness of the injected part surface

The qualitative aspects presented in the previous sections are easily detectable through visual inspection.

One cannot say the same about the roughness of the product. This is measurable only in laboratory conditions, according to the specifications control plan specific to each product.

For this reason it requires an in-depth study and finding a correlation between the amount of applied lubricant and surface roughness. To simplify the study there are applied two simplifying assumptions:

- It is considered a stable thermal regime, with temperatures between 280 ÷ 300 ^{0}C;
- It is considered the dies with active part dimensions up to 650 x 500 mm, weight of the bunch being poured 1.5 ÷ 2 kg.

One performs the monitoring of the consumption and quantities produced during the three days of production (equivalent to 9 working shifts). Roughness measurement is made with a Mitutoyo instrument shown in Figure 9.

Fig.9. Roughness measurement

Recorded values of roughness "Rz" are presented in Table 1. Figure 10 shows the roughness variation depending on oil consumption.

Table 1

Measured values of roughness "Rz"

Day	Shift	Lubricant consumption (g)	Casting number	Lubricant consumption on casting (g)	R_Z (µm)			R_Z average per shift (µm)	
1	I	500	510	0.98	3,6	3,8	3,8	3,8	**3,75**
	II	750	798	0.94	3,9	3,8	3,7	3,5	**3,73**

	III	700	823	0.85	3,6	3,8	3,6	3,5	**3,63**
2	I	700	810	0.86	3,4	3,2	3,5	3,2	**3,33**
	II	700	835	0.84	3,3	3,3	3,5	3,3	**3,35**
	III	700	828	0.85	3,2	3,4	3,3	3,2	**3,28**
3	I	625	790	0.79	4,8	5,2	5,0	5,4	**5,10**
	II	600	785	0.76	5,8	5,8	6,2	6,0	**5,95**
	III	610	778	0.78	5,8	6,3	6,8	6,8	**6,43**

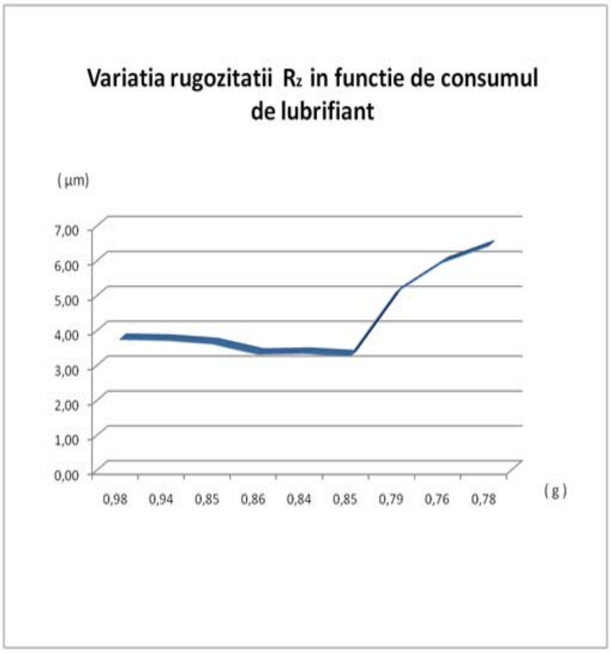


Fig. 10. Variation of roughness "R_Z" as a dependence on the oil consumption

3.4 Influence of the lubrication on the aspect of the superficial layer

For this study a representative product is considered "dissipator 059”. After the casting and trimming phase, the product undergoes a vibro-smoothing process.

This process at the client request can be replaced by blasting of the product; it is considered that a Rz surface roughness between 16 µm and 25 µm significantly improves the heat transfer (Figure 11).

In the initial version of the production cycle, the waste on casting phase was in line with quality objectives, namely between 1.5 ÷ 2%, and the total waste ~ 5%.

Since the beginning of a new cycle is considered a waste of 30%; the wasted parts are showing a marked tendency of exfoliation (Fig. 12).

Due to the cast part appearance, uneven lubrication is suspected, with lubricant excess embedded in the superficial product layer (Fig. 13). As f urther analysis of R_X shows that the part has

Fig. 11. Parts of "dissipator 059" having the roughness between 16 and 25 µm

Fig. 12. Part with exfoliations

no porosity or other casting defects, it is considered that no intervention on the parameters of the casting is necessary.

Therefore, it is proposed to optimize the amount of lubricant applied in the sense of better distribution and a less amount.

Fig. 13. Improperly appearance of the external surface

4. SIMULATION OF THE TECHNOLOGICAL PARAMETERS OF THE INJECTION PROCESS

The realized experiments have not positive results in a significant improvement in the appearance of castings. So that was ruled out the assumption as the reason of nonconformities would be the presence in the superficial layer of a quantity of oil in excess.

In this situation it is necessary to check the technical parameters of the injection process; the verification relies on a flow simulation using MagmaSoft. Figure 14 shows several stages of the injection process simulated using this software.

From the images presented above one may notice that the main culpable of the inadequate appearance of the superficial layer is the regime of casting (technological parameters), theoretically chosen and calculated, the inadequate intervention of phases 2 and 3 of the casting.

The non-compliance was not caused by the possible involvement in a superficial layer of oil in excess, but the entry of aluminum in the die cavities in the form of successive waves at inappropriate moments.

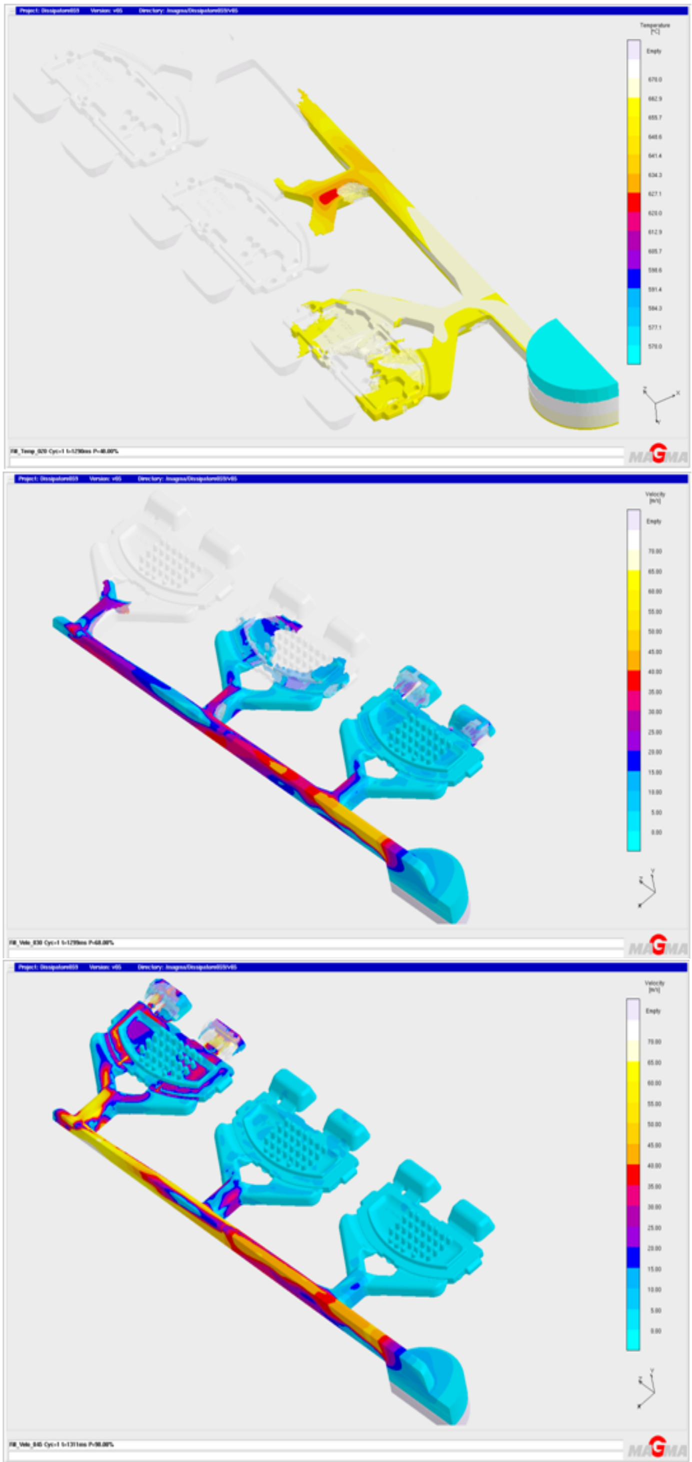


Fig. 14. Stages of the injection process simulated using MagmaSoft

5. CONCLUSION

Using powdered lubricant is a modern technological solution with the following advantages:

- to obtain a very low intern porosity of the parts;

- disappearance of thermal shock, so by default no cracks on the die surface, extending the life of the die, leading to its duplication;
- need a transport agent powder, very simple, without particular problems in exploitation, there it is only the compressed air;
- does not require epuration plants, thereby significantly reducing the cost of investments, no harmful effects on the environment;
- it is ensured a proper die filling in all its cavities;
- there are used very small quantities of oil, as compared with the previous method, recording consumption between 0.5 and 2 g per injection, depending on the size and complexity of the part, of injected alloy and of the powder type.

It was also shown that this type of lubrication gives a very good stability, in terms of dimensional aspects, of aluminum injection process. Using a properly constructed die, allows the achievement of a process capability $C_{PK} \geq 1.67$. The obtained surface roughness is very good, and is directly influenced by the polishing level of the die, and it is relatively easy to maintain at a relatively constant level.

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FUNCȚIILE PRINCIPALE ALE LUBRIFICĂRII MATRIȚEI REZULTATE DIN NECESITĂȚILE TEHNOLOGICE ALE PROCESULUI DE INJECȚIE A ALUMINIULUI

Rezumat: Procesul de turnare a aluminiu în matriță, numit de injectarea a aluminiului este un proces relativ nou, orientat spre producția de bunuri de consum în loturi mari și de masă, cu aplicații în toate domeniile de fabricație de produse complexe și echipamente care include componente metalice neferoase. Peliculă de lubrifiant are rolul de de facilita extragerea din matriță fără deteriorare dimensionale și de structură.

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