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IMPROVEMENT OF BILLET QUALITY BY USE OF A HOT TOP MOLD WITH A TWO PHASE LUBRICATION

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Based on the cast shop proved conventional VAW Hot Top Mold system for billets a more advanced billet casting process was developed. The mold of this casting process applies a special defined mixture of oil and air for lubrication. This two phase lubrication mixture reduces significantly the heat extraction through the cooled mold wall. This paper will give the presentation of the new mold, the discussion of suitable casting conditions and the achieved billet quality improvements with this more advanced casting technique.

INTRODUCTION

Main part of d.c. casting development is the reduction of the heat extraction through the cooled mold wall in order to improve the surface and sub surface quality of the billets. The heat extraction through the cooled mold wall leads to the formation of the shell zone, which can exhibit some casting defects, especially the surface segregation. A further result is the formation of a poor surface. If parts of the sub surface of the billet are extruded, it may lead to defective surface areas of the extrusion profile and thus to rejection. On the basis of this fact, the defective part of the sub surface must be removed prior to processing or must be retained in the extrusion rest.

DEVELOPMENT

One of the most well known ways of reducing the heat extraction through the mold wall is the reduction of the effective mold length, i.e. the holding of a low metal level in the mold. This has led to the development of the hot top mold (1). The hot top mold allows the use of short mold lengths without the need of complicated regulation systems for the metal level. On the basis of these principles a short VAW Hot Top Mold was introduced into the cast houses during the seventies (2). The quality of the billets was therefore improved with respect to reduction of the surface segregations, the dendritic cell size and the homogeniety of the structure (3). The scalping of the billets could be eliminated even for critical products of low alloyed materials. The processing of these billets is significantly improved in comparison to the traditionally cast billets. There are limits set on the reduction of the metal level, especially when casting large dimensions in high alloyed material. Due to this for a further reduction of the heat extraction through the mold wall new methods are necessary.

A result of these efforts are the mold casting systems working with air, which are

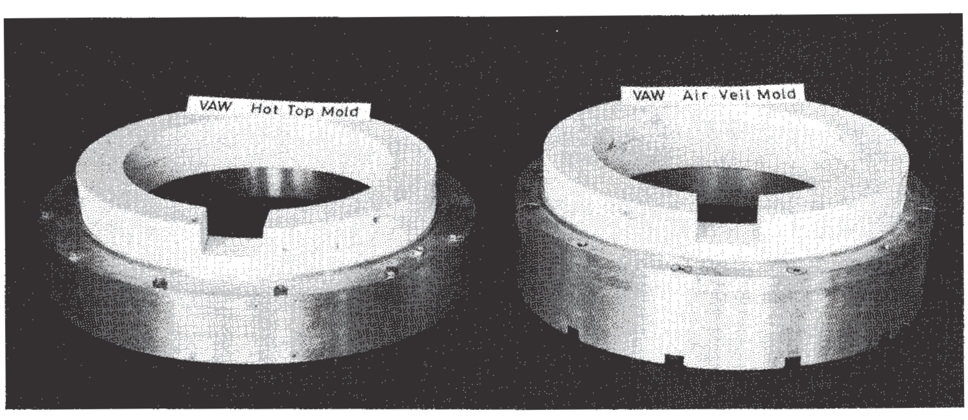

Figure 1 - External appearance of the VAW Hot Top Mold (left) and the VAW Air Veil Mold (right)

at the moment only used for casting of billets (4,5). Following a mold casting system will be presented, which works with a mixture of air and oil as lubrication between mold and melt. This newly developed mold was named VAW Air Veil Mold and is a further development of the cast house proved conventional VAW Hot Top Mold.

PROCESS PRINCIPLES

The external appearance as well as the cooling system and hot top form of the conventional VAW Hot Top Mold are maintained as seen in Figure 1. This means, that the Air Veil Mold also works with relatively small hot top heights. Figure 2 shows a schematic cross sectional depiction of the VAW Air Veil Mold. There was introduced an air feeding and distribution system. The oil will be transported under pressure through a special distribution system into the mold. Both media reach the mold wall through a ring channel between hot top and mold. In this ring channel a mixing of oil and air takes place before leaving the channel exit. The oil/air mixture is discharged into the mold chamber and moves downwards the mold wall. This oil/air mixture gives such a good insulation effect, that no or a very little heat extraction through the mold wall takes place. The amounts of oil and air should be added in a certain range of ratio in order to achieve the most favourable effect for the billet quality.

For a successful operation of such a mold a certain control has to be established Figure 3 shows schematically the air and oil feeding system with the respective measuring instruments. For the air regulation the use of measuring instruments for the air flow rate is important. It is advisable to install a pressure gauge in the connection between mold and measuring instrument of the air flow rate in order to measure the pressure build up in the connection due to the melt in the mold. This indicates if the mold works satisfactorily. For the oil feeding system a similar process principle exists, as can be seen in Figure 3.

CASTING AND PROCESS PARAMETERS

Additional to the design and equipment some casting and process parameters are important for the operation of the air veil mold. These parameters which influence significantly the billet quality are:

A: mold length

B: casting speed

C: cooling water volume

D: air volume

E: oil volume

F: hot top height

The influence of the above parameters with respect to the achievement of the favourable billet quality will be discussed in the case of the alloy AA 6063 as an example. The parameters mold length, casting speed and water volume will be compared to the conventional VAW Hot Top Mold. Table 1 contains comparable values for different billet diameters. It is to be seen, that the Air Veil Mold can be cast with comparable

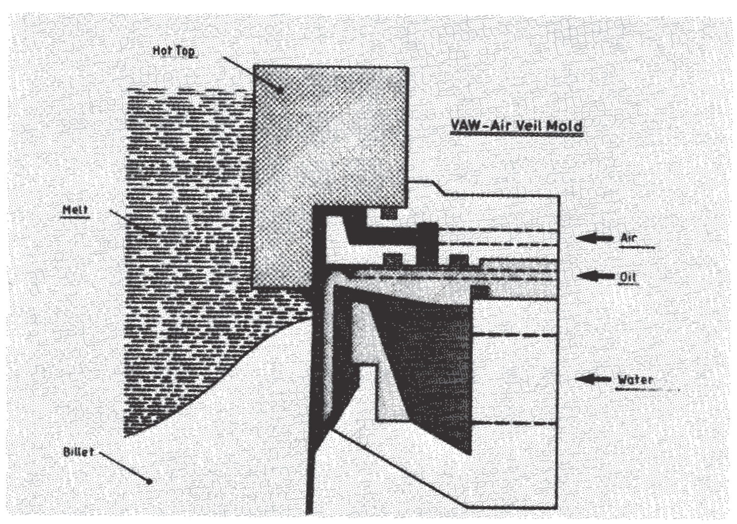

Figure 2 - Schematical depiction of the VAW Air Veil Mold

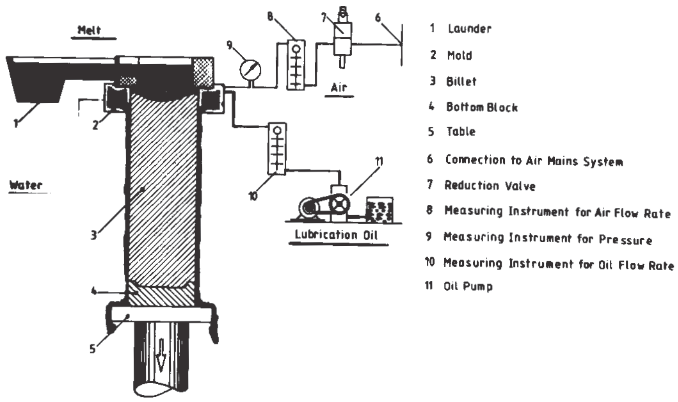

Figure 3 - Schematical depiction of the air and oil feeding system for a VAW Air Veil Mold

Billet diameter in inch	Mold Length in mm		Casting Speed in mm/min		Water Volume in m³/h	
	Hot Top	Air Veil	Hot Top	Air Veil	Hot Top	Air Veil
6	25	25	140	145	3,5	4
8	30	35	95	95	4,5	5
10	35	45	80	80	5,5	6

Table 1 - Comparison of some casting and process parameters of AA 6063 billets cast by conventional VAW Hot Top Mold and VAW Air Veil Mold

casting speeds as the conventional Hot Top Mold, but slightly higher water volumes are needed. On the other hand larger mold lengths have to be used. The difference in the mold length to conventional hot top molds increases with increasing mold diameter.

Figure 4 shows the relationship between the mold diameter and the necessary air volume to achieve a defect free billet surface in alloy AA 6063. This figure does not only show the favourable air volumes for the achievement of an optimally insulating oil/

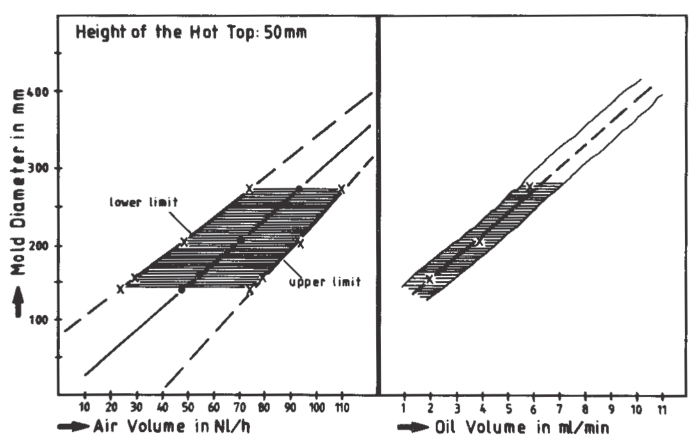

Figure 4 - Relationship between mold diameter and air and oil volume for achievement of a defect free surface of AA 6063 billets

air mixture, it also shows that an air volume range exists where a defect free surface can be cast. This effective range decreases with increasing mold diameter. Figure 4 also shows the required oil volume for the oil/air mixture. There also exists a working range, but this is more restricted. From Figure 4 it may be conducted, that the oil distribution for a sucessful operation of the mold and for the achievement of the favourable billet quality is more important than the air distribution.

An also significant parameter is the hot top height. Figure 5 shows the influence of the hot top height for the achievement of a defect free surface in the case of 8 inch billet of the alloy AA 6063. It can be seen from the figure, that the air volume range, which permits casting of a defect free surface, is narrowing with increasing hot top height. This influence is more pronounced for larger mold diameters. It can be therefore conducted, that the low hot top height of the VAW Air Veil Mold is favourable for sucessful operation and the billet quality.

IMPACTS ON THE BILLET QUALITY

The operation principles of the VAW Air Veil Mold influence mainly the billet parameters surface finish, shell zone and surface segregation. With respect to these parameters it was found, that if the favourable casting and process parameters are used, an ideally smooth surface finish of the billets can be achieved. Figure 6 shows examples of the surface finish of billets of the alloys AA 6063, AA 2024, AA 7075 and AA 5182 with a diameter of 8 inch. Furthermore it was found, that the formation of a defined shell zone will be suppressed and the extension of the surface segregations greatly reduced. A comparison of the surface segregation depth of conventional VAW Hot Top Mold and VAW Air Veil Mold cast billets in AA 6063 with different diameters is given in Figure 7. This Figure shows, that the Air Veil Mold cast billets have significantly reduced surface segregation depths and the influence of the billet diameter on the depth of the surface segregation is greatly reduced.

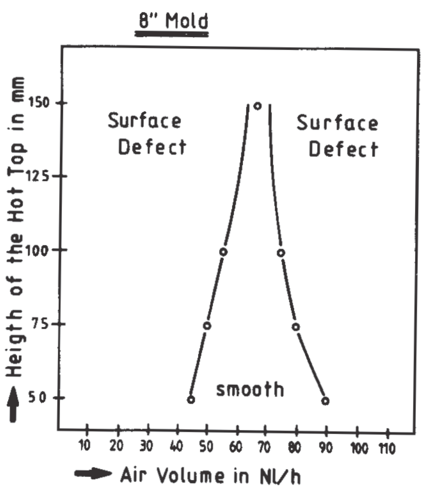

Figure 5 - Relationship between air volume and hot top height for a defect free surface of AA 6063 billets with 8 inch diameter

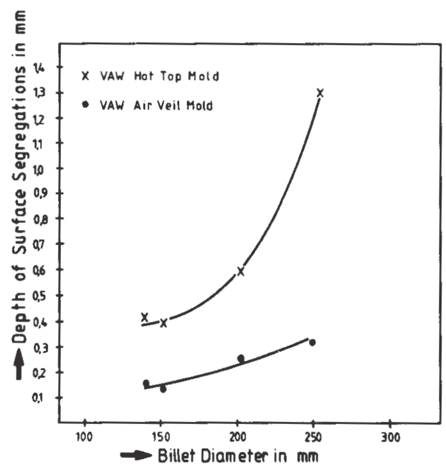

Figure 7 - Relationship between surface segregation depth and billet diameter for the alloy AA 6063, cast with Hot Top Mold and Air Veil Mold

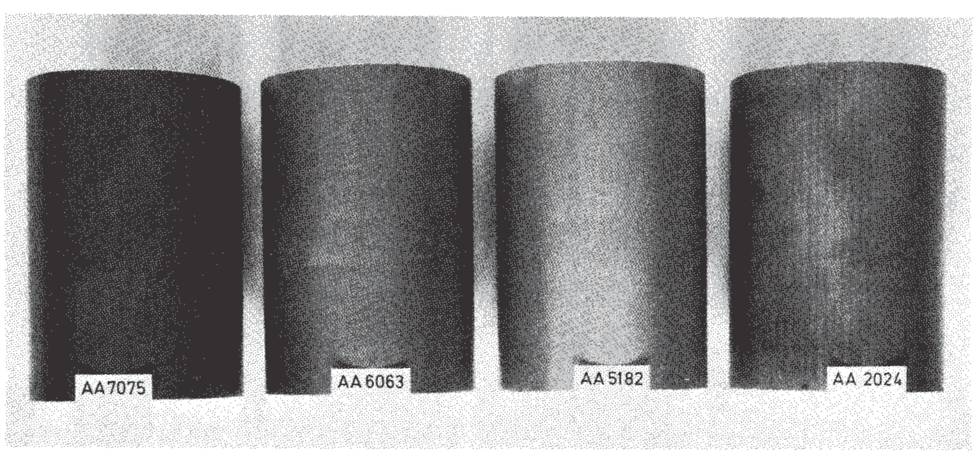

Figure 6 - Surface finish of 8 inch billets of different alloys, cast with the VAW Air Veil Mold

Examples of the formation of billet sub surface structures of different alloys and diameters are shown in Figure 8. It can be seen, that only a very small surface segregation depth exist. The maximum depth of segregation does not exceed 0.3 mm and is independent of billet diameter and alloy.

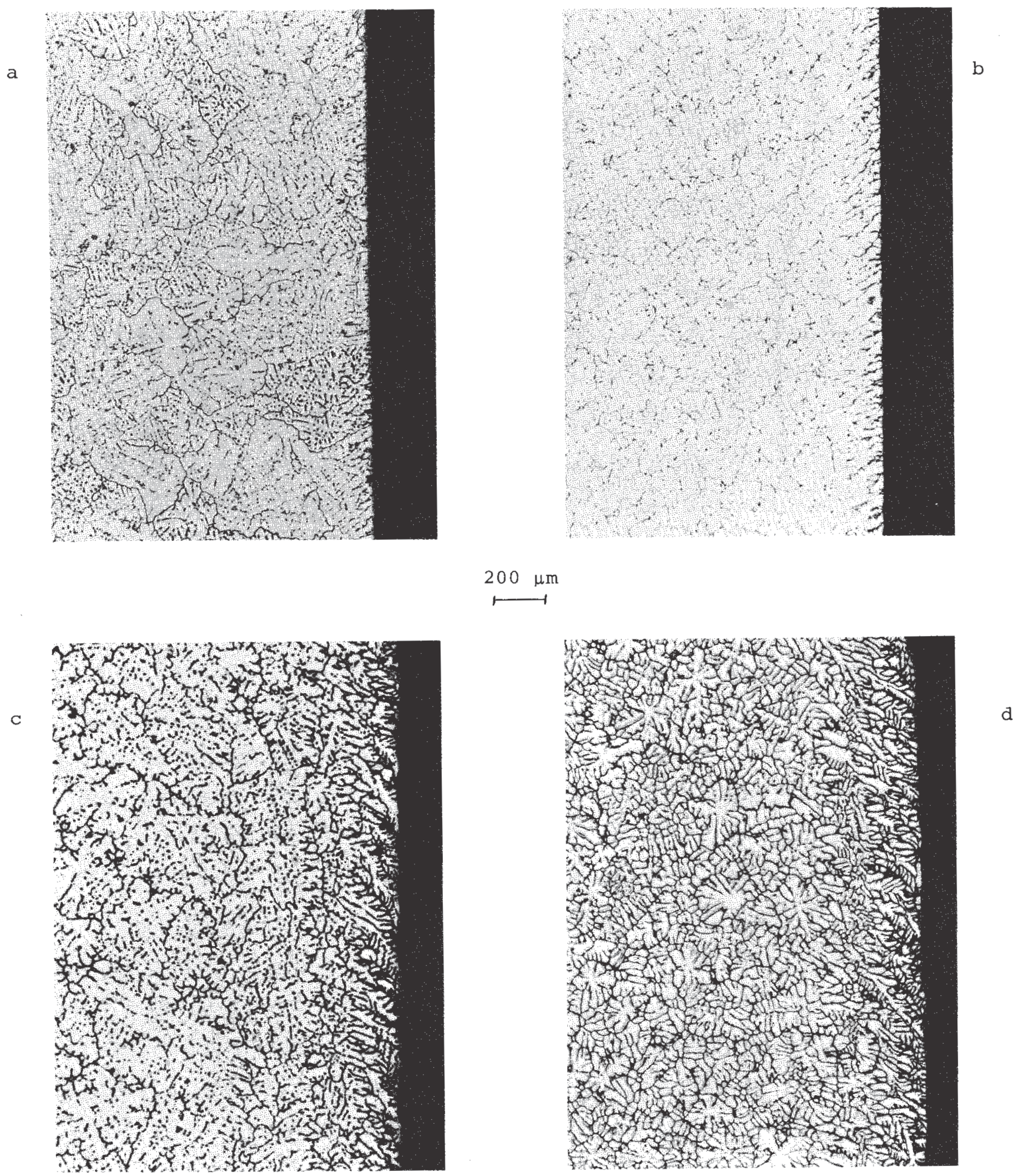

Figure 8 - Sub surface structure of billets of different diameters and alloys, cast with the VAW Air Veil Mold

a) AA 6063 - 6 inch diameter b) AA 6063 - 8 inch diameter

c) AA 7075 - 10 inch diameter d) AA 2024 - 8 inch diameter

CONCLUSIONS

Billets with significantly improved surface and sub surface quality can be cast with the VAW Air Veil Mold. The reason for this is the use of a two phase lubrication, a mixture of air and oil, which reduces the heat extraction through the mold wall significantly.

For practical operation of the Air Veil Mold a certain additional expenditure control devices is necessary. Cast houses using multiple mold units must ensure, that the air and oil distribution system is designed that way that all molds are supplied with the same air and oil volume. VAW cast houses are presently using the air veil mold in multiple mold units for casting billets up to a diameter of 10 inch.

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