REDUCTION OF INGOT BOTTOM "BOWING AND BUMPING" IN LARGE SHEET INGOT CASTING

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Abstract

semi-continuous casting of large sheet ingots using the vertical Direct ll Process gives rise to severe bowing of the butt during the initial ge of the pour. This produces run-outs on the narrow faces, cold shuts the rolling faces, and sometimes butt cracks. The development and im- mentation of "Pulsed Water" cooling by Alcan has contributed significantly the reduction of such defects, by reducing the initial cooling rate. It permitted slower starts without generating cold shuts, has eliminated -outs, reduced the bowing by 50%, and made the start-up more consistent safer.

urther problem related to the start-up of large sheet ingots is a verti- displacement or "bumping" of the ingot on the stool cap. This phenomenon most pronounced with the high magnesium alloys. The movement is severe ugh to disturb the liquid metal meniscus, causing surface defects such corner and end cracks. The portion of the ingot most affected by "bumping" be up to 20 inches from the butt end, necessitating a larger than mal butt crop before rolling. The use of a self-draining stool cap, gether with "Pulsed Water", has eliminated "bumping" to the extent that bottom portion of the ingot is now acceptable, resulting in higher re- eries.

"Pulsed Water" technique is particularly compatible with automatic ntrol, and therefore has been incorporated in the Alcan "Autocast" stem.

INTRODUCTION

During the past ten year period, Alcan has vigorously pursued the u of short D.C. moulds in its cast houses for their inherent advantages ingot quality and casting productivity.

The implementation of short moulds into production was not without problems, some were a direct consequence of the shorter mould length.

For example, short moulds (3 inches and less) generally make the starting period more critical. The short mould wall restricts the in- sertion distance of the stool into the mould. Thus the first metal fr ing on the stool cap "feels" the strong direct chill cooling effect soo than it would when longer moulds are used. As a result, the butt of an got emerging from a short mould is more prone to "bowing" (thermal war than the butt of an ingot emerging from a long mould, which is general thicker, and hence more resistant to warping.

During "bowing", which occurs as the butt is emerging from the moul the ends of the butt shrink upwards off the stool cap, and inwards away from the ends of the mould. The upward movement restrains the flow of metal to the ingot ends, causing cold shuts. The inward movement resul in a reduction in the width of the ingot, and the opening up of a gap b the ends of the mould and the freezing shell, through which liquid meta escapes. These "run-outs" then freeze upon contacting the cooling wate the form of long, sharp,"icicle" like projections which must be removed

The curvature of the underside of the butt also generates tensile stresses which frequently result in butt cracks.

All these defects become more prevalent as ingot size increases. N withstanding, the advantages of short moulds were considered important enough to justify the development of techniques to overcome the starti problems. A further constraint was the need to retain the existing sto design, a flat-topped stool with a shallow rim forming a recess. The advantages of this design are low cost and the ability to quickly re-si the rim to fit the increasing width of the mould as the mould is re-pol during its working life.

Production Experience with "Pulsed Water" Cooling

Laboratory work on the starting problems led to the development of "Pulsed Water"(1) cooling technique, now in production use in Alcan cas houses producing large sheet ingot. A technical description of the "Pu Water" technique has been published elsewhere, (2) it is the intention this paper to describe production experience and benefits from the oper viewpoint, after some ten years of in-plant use by Alcan. Simply state "Pulsed Water" is the intentional interruption of the cooling water flo a regular on-off program, by varying the ratio of water on time, to wat off time, the heat transfer rate can be modulated over a wide range.

The simplicity of "Pulsed Water" lends itself to installation even on existing D.C. machines of any size. Operating costs and maintenance are low. Because the cooling water flow is pulsed before entering the mould table, only one pulsing valve is required and no changes in mould or stool design are usually needed. The technique is particularly suit to automatic control, and has been incorporated in the Alcan "Autocast" system, described in the Session II paper by G. Lucas on "Auto Control D.C. Casting Operations".

The major economic gain resulting from the use of "Pulsed Water" i an increase in the tonnage of large sheet ingot which can be rolled "butts-on". With ingot sizes constantly increasing, the time taken to fill the mould before beginning the drop becomes excessively long. As result the liquid metal becomes too cold, causing starting difficulties and poor butt quality. If the starting speed is accelerated in order t help overcome these problems, excessive butt cracking results. By usin "Pulsed Water", the start can be slowed down without any danger of over cooling and excellent butt quality is assured.

An initially unsuspected, but now highly rated, benefit of "Pulsed Water" concerns safety - particularly with regard to ingots "hanging-up or sticking in the mould during starting. The "Pulsed Water" technique virtually eliminates the possibility of "hang-ups", as ingot butts are devoid of the run-outs and icicles which can cause the butt to jam and stick in the mould during starting. The potential danger from a sticki ingot at the start is well known to every cast house operator as a majo cause of molten metal - water explosions.

The "Bumping" Phenomenon

A second problem, of considerable economic importance in the casti of large Al-Mg alloy sheet ingot, is the phenomenon known as "bumping". The term vividly describes a sometimes violent up and down movement of the ingot on the stool, usually reaching a peak after one to two feet o ingot has been cast. Aside from its disconcerting effects on the machi operators, "bumping" can affect hot mill recoveries. By disturbing the liquid metal meniscus, "bumping" can cause deep cold shuts and cracks o the ends of the ingot. The resulting cracks in the hot mill slab are frequently too deep to be completely removed by the normal edge trimmin and abnormally long end scrap cuts must be used to remove the defective material.

The cause of "bumping" was readily seen to be steam formation unde neath the butt. The recessed stool retains enough water which eventuall boils, as the stool heats up during the start. Sufficient pressure can built up to lift the ingot up and down with considerable amplitude.

The solution was to prevent water from accumulating in the stool r A number of water drain holes are drilled through the stool. Before starting to cast, the holes are covered with aluminum plugs, about 2 to inches in diameter and 1 inch thick. The plugs are cast by the machine operators in the same manner as spectrographic disc samples. As the me fills the stool at the start, the plugs are frozen into the bottom of t butt. The warping of the butt during the start then lifts the plugs aw from the drain holes, thus preventing water from accumulating in the st No steam can form and "bumping" is eliminated.

The cost of the stool modifications and the plugs is minimal. The modified stools[3] have been in production use for some time in a numbe of Alcan's cast houses.

Summary

The foregoing examples of process technology development have assi in permitting large sheet ingot to be cast using short moulds, with imp recoveries and increased safety.

References

(1) U.S. Patent 3,441,079

(2) Canadian Metallurgical Quarterly 7 (1), pages 55-59, 1968

(3) U.S. Patent 3,702,152