Injection System for Silafont (Structure Alloy)

About Author:

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In his current position as Product Director it presents the opportunity for Ken to visit a wide spectrum of customers. It leads to broader and deeper understand of product and performance.

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INJECTION SYSTEM FOR SILAFONT (STRUCTURE ALLOY)

Today, there is a tremendous interest indie casting structural aluminum alloys for automotive to reduceweight and fuel consumption. The structural aluminum alloys have high yield strength and high toughness. For example, Silafont-36™, structural aluminum alloy, has almost three times higher strength than the " as-casted" aluminum alloys with excellent toughness. However, the aggressive chemistry and zero porosity requirementspose an enormous quality challenge.It is the biggest opportunity for die casters. In order to lower the scrap rates and make HPDC structural aluminum an economic manufacturing process; a holistic system approach from plunger tips, shot sleeves, lubrications to vacuum components is required. No single component should be examined or evaluated in isolation.

PLUNGER SYSTEM

The market for large castings is increasing; this is especially true for structural aluminum. Large castings require a plunger system with supreme thermal and dimensional stability to create consistent shot velocity, low cycle time, minimal contamination and zero porosity. The active clearance between plunger tip and shot sleeve must be maintained at 0.1mm at all timesotherwise, aluminum will blowby and cause excessive wear.

Conventional Plunger System

Figure 1 depicts the situation when the plunger tip is not thermally stable and the sleeve is not thermally regulated for a165.1 mm sleeve. Conventionally, a water jacket is installed at die end sleeve to assist biscuit cooling, which is un-necessary if not cause more problems.

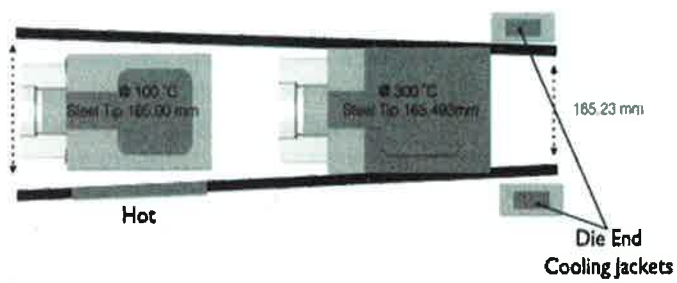

***Figure 1.** The plunger tip over expands and sleeve contracts near die end.*

The sleeve is very hot at the pour end (left end),due to direct impact of molten aluminum. The sleeve near pour end can reach 200°C and ID expands to 165.49mm. The die end sleeve is cooled byeither platen, or water jacket to assist biscuit cooling. If the initial clearance at the pour end is small to prevent penetration of the alloy past the tip of plunger, the plunger may seize in the sleeve before reaching the end of the stroke as the tip gets hotter and expands. This would lead to scorching marks due cold shot sleeve at the die end as shown in Figure 2.

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Figure 2. *Scorching marks due to plunger tip over expands and cold sleeve at die end.*

Castool Plunger

Castool Tooling Systems features a modular plunger tip (AMP-R) using forged ultra high strengthBeCu alloy plunger head for extreme thermal and dimensional stability. The plunger holder producesa high velocity turbulent flow of water formaximum cooling effect. This high coolinghigh heat transfer can reduce the cycle time of casting and productivity can be improved

A split wear ring made of hot work stool steel is heat-treated and nitride to provide optimal strength, flexibility and wear. The ring floats freely in a groove machined near the front of the plunger tip, to ensure a secure seal with shot sleeve walls. It can easily be removed and replaced with a special hand tool. The ring expands to meet any changing diameter or contour of the shot sleeve and makes continuous contact with the inside of the shot sleeve. The flash or blowby is essentially eliminated. Shot velocities are smooth and consistent. Copper is an ideal medium to dissipate heat from the plunger tip body to the cooling water. It is, however, not nearly as wear-resistant as the steel of the shot sleeve.The cost per casting is reduced since the consumable is the plunger head and split ring only. Figure 3 illustrates the temperature profile inside the plunger tip.

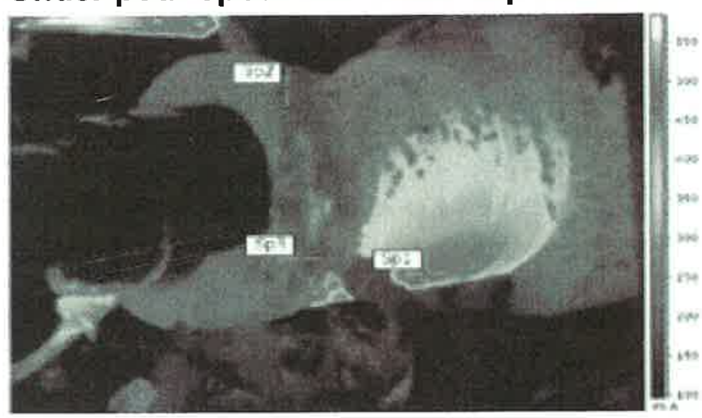
Figure 3. *Heat transfer calculation of a plunger tip*

SHOT SLEEVES

Regardless of the sleeve size, the maximum allowable gap, 0.1mm, must remain unchanged. The same increase in temperature of a twice size shot sleeve will result itin expanding twice as much as due to thermal expansion. The temperature control on a larger diameter plunger tip and sleeve becomes paramount.

The area underneath the pour hole of the shot sleeve is much hotter than the top part of the sleeve, leading to unequal thermal expansion and shot sleeve distortion. Figure 4 shows a thermal image taken at a shot sleeve without proper thermal control.

Under pour spout 500°C and Top 176°C



Spot 1:500°C   Spot 2:16.1°C   Spot 3:200.3°C

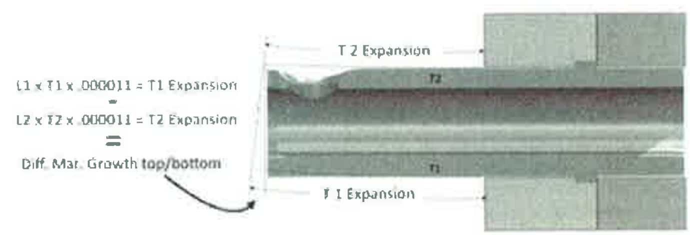


Figure 4. *Shot sleeve distortion due to unequal thermal expansion*

The sleeve is bowed and oval instead of straight and round, causing premature wear of both the tip and sleeve. To avoid too much variation in thermal expansion; a series of gun-drilled holes are positioned along the length of the shot sleeve under the pour spout, and are connected to another series of holes around the die end of sleeve. The areas where the pouring alloy temperature impacts the sleeve the most can be regulated. Figure 5 represents the thermally regulated shot sleeve with optimal sleeve temperature

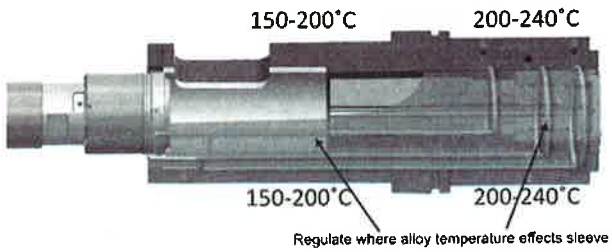


Figure 5. *Thermally regulated shot with optimal sleeve temperature*

Shot sleeve wear, and consequent replacement, can be an ongoing and costly problem for die casters. Many mistakenly assume that sleeve wear result primarily from the abrasive contact and wear of plunger and the shot sleeve; as a result of unequal thermal expansion. Actually, the opposite is true. If the temperatures of both the shot sleeve and the plunger tip are not constantly and accurately controlled; the clearance may increase sufficiently to allow the aluminum alloy to penetrate the gap, where liquid aluminum dissolves into shot sleeve and forms the Al_5Fe_2 brittle intermetallic compound. The brittle compound breaks away by the movement of the plunger tip. The repeated formation and break of brittle compound results in the erosion of the shot sleeve.

Effectively managing the clearance between the plunger and the shot sleeve is a prerequisite for any successful light metal die casting system. Clearance problems can only be resolved by good design and thermal management.

SHOT SLEEVE WASHOUT

The surface temperature of sleeve directly under the pour hole can reach as high as 680°C during pouring, especially true for Silafont alloys. Such a high temperature destroys the mechanical integrity of sleeve. A typical hot working steel, H13 (1.2344), has a working temperature at 585°C. The surface of H13 (1.2344) sleeve would heat check and erode at such high temperature during pour. Castool works with steel manufacturers to produce modified 1.2367 steel, 1.2367H, with high Molybdenum content. The addition of Molybdenum improves high temperature strength and hardness. It resists the tendency of steel to heat check and soften in a high temperature environment. The 1.2367H steel has working temperature up to 630°C. In addition experimental study shows molybdenum only loses 2mg/hr compare to H13 loses 37mg/hr in liquid aluminum for 24hrs at 750°C. Figure 6 shows corrosion of H13 and molybdenum ally in liquid aluminum.

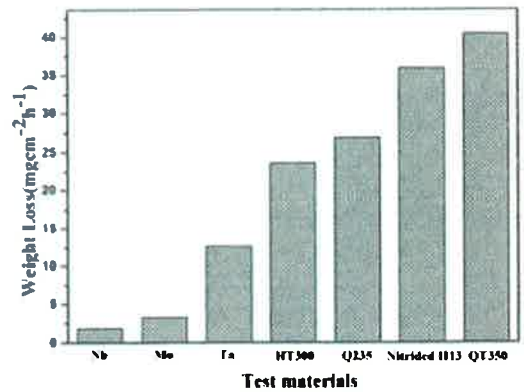


Figure 6. *Corrosion of H13 and molybdenum in liquid aluminum*

In addition, the 1.2367H steel has very good toughness, the Charpy test results on the 1.2367H is 14J on average, which is the same as premium H13 (1.2344) grade steel.

To further protect the underlying shot sleeve, a special nitride process is developed. This nitride layer is less brittle and stable up to 680°C. The combination of modified W. Nr. 1.2367M steel with special nitride layer will eliminate the issue of having pour hole erosion in large structural casting. Figure 7 illustrates the thermal stabilities of different shot sleeves and iron nitrides. The hardness of the nitride can reach as high as 72 HRc.The 1.2367H steel has a good combination of high surface hardness and high toughness

Figure 7. *Thermal stabilities of different shot sleeves and iron nitrides*

With both the shot sleeve and the plunger tip thermally and therefore physically stabilized; an unusually extended operating life can be reasonably anticipated; providing the area of interaction completely and effectively lubricated.

CHILL VENTS

In cold chamber die casting, the alloy is forced into the mold cavity with such force and velocity that small quantities of air and gases are often trapped in the casting. If the casting is structural, heat treated, or porosity sensitive, air or gas inclusions usually result in rejection. This impacts directly on the die caster's bottom line. In today's competitive market, this preventable problem is no longer acceptable.

A vacuum is drawn in both the shot sleeve and the mold cavity and maintained until the injection cycle is completed. Almost all of the air is positively evacuated from the mold. A good vacuum in the mold cavity enables the alloy to flow into blind recesses in complex shapes. It also allows the front of the molten metal to merge freely. One of the biggest problems with vacuum is the downtime related to vacuum valve. Vacuum valve hasmany moving components and prone to component failure. The cost and downtime and maintenance makes the use of vacuum valve prohibitive.

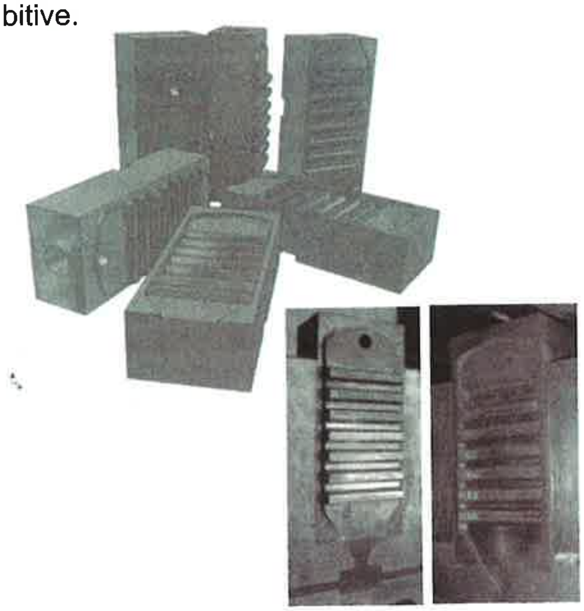


Figure 8. *Copper chill vents requires no water cooling and ejector-pin*

A properly designed copper chill vent with higher thermal conductivity has no moving part, requires no additional water-cooling and no ejector-pin. Figure 8 shows copper chill vent with no water cooling and ejector-pin. The venting section of chill vent can be as high as 150 mm^2. Also 20-40,000 shots can be expected before maintenance is required. A problem that is shared by most die casters, is the unplanned downtime that occurs when casting must be discontinued before the scheduled production run has been completed.

LUBRICATION

The primary purpose of the shot sleeve lubricant is to reduce the friction between the sleeve and the plunger;to thus ensure the smooth passage of the plunger through the sleeve. This is essential for consistent shot velocities and to extend the operating life of both the shot sleeve and the plunger tip.The amount of lubricant used must be adequate, but care should be taken to avoid any excess. Lubrication should therefore be kept to an absolute minimum.

Every effort must be made to eliminate the possibility of any non-metallic substance getting into the mold. Graphite-based lubricants, for example, can cause porosity in the casting.

Lubricant should be applied only where it is needed. Any excess lubricant is an unnecessary cost, and a work place pollutant.

Boron Nitride is now universally accepted as the most effective lubricant available for the aluminum die-casting industry. Its unmatched lubricity far exceeds that of traditionally used lubricants. It is also completely benign and produces non-toxic fumes.

For larger and longer sleeves, it is difficult to adequately lubricate the complete interior of shot sleeve. This can be accomplished with a Lube system developed by Castool. A carefully measured amount of liquid boron nitride is applied between ring and sleeve. In addition, liquid boron nitride is sprayed to protect the impact zone right under the pour hole. This ensures complete coverage without costly overspray. A controlled dosage injection pump provides the precise amount of lubricant required for each process cycle. This controlled dosage prevents the danger of contaminating the casting with excessive lubricant.

SUMMARY

The problem of high scrap rate has proven to be greatly reduced and often completely eliminated by the adoption of modular plunger, thermally controlled shot sleeves, an effective lubrication system and chill vent. Each contributes to improved productivity. Combined, these interactive components combat a number of costly problems. The HPDC aluminum will be the biggest opportunity for die casters when a holistic plunger system is applied.