High performance metal delivery systems

As energy costs and quality concerns rise, and the competitive nature of the business forces aluminium casters to drive costs down, more and more casters are paying attention to their launder systems.

Severe heat loss, high maintenance cost, short life and long preheat times plague this industry. Newer materials, designs, preheat technology and backup insulation emerged in the early 1990's. Improvements in these technologies since then now offer aluminium casters high performance metal delivery systems with minimal heat loss, long life, ease of maintenance and superior preheating when needed.

By definition, a High Performance Metal Delivery System (HPMDS) consists of a launder refractory, backup insulation, and support structure designed to deliver molten metal from the furnace to the casting centre with superior, predictable, and reproducible quality. In general, an HPMDS will have the following attributes:

- Temperature losses < 0.50 °C / metre
- Steel shell temperature < 75 °C
- Optimised metal velocity
- Non-turbulent flow design
- Robust steel shell design
- Modular approach
- Easy maintenance.

Elements of success

The key factors in the design of a high performance metal delivery system are: primary liner material selection, backup material selection, design of the launder, steel structure, covers, and the preheating system. These factors will now be discussed in detail:

Material Selection: This is probably the most important consideration when deciding on an HPMDS. There are 3 primary launder materials available in the market today:

- Pyroform HP (based on ceramic fibre)
- Fused Silica (most containing > 70 % SiO_2)
- Dense Castable (with > 65 % Al_2O_3).

Pyroform HP is a high strength ceramic fibre material exclusively manufactured by Rex Material Group. This material is widely used in Wagstaff billet and rolling slab casting tables because of its low thermal mass and good insulating properties.

Fused Silica materials are made by several suppliers. Differences in these materials range from chemistry to aluminium resistance to densities. Rex Materials' Fusion SL fused silica is a high-purity, non-wetting material with a good balance of thermal and mechanical properties. Castables are made by numerous suppliers and have a much broader range of properties.

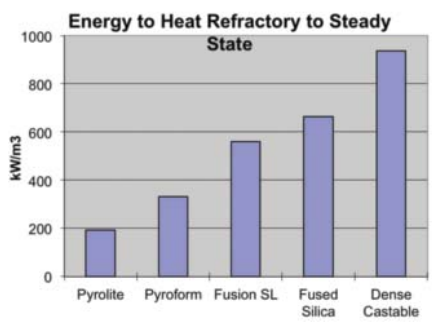
The important factors in selecting the refractory for an HPMDS are:

- Thermal conductivity
- Density

1 Example of Rex Materials' HPMDS with heated covers.

- Thermal mass
- Durability/abrasion resistance
- Ease of maintenance.

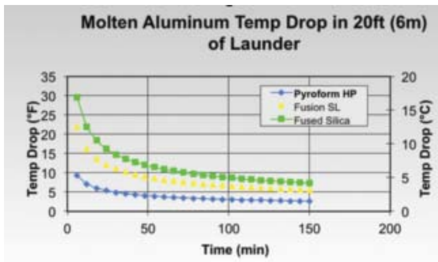
Thermal conductivity, density, and thermal mass are determining factors in startup and steady state heat loss across a system. Given in fig 2 is the energy to heat these refractories to steady state. This is very important, especially at the beginning of a cast. When the aluminium starts flowing down the launder, energy is lost to the refractory to heat it up. Usually, the lower the density of a material, the less energy it takes to raise its temperature, meaning holding furnace temperatures can be decreased.



2 Energy to heat refractory to steady state.

The benefits of lower startup energy are further highlighted in the graph shown in Figure 2. This depicts an actual case study where the temperature drop across a 20 foot (6 metre) launder section was measured using different materials with similar backup insulation.

The graph in fig 3 demonstrates the point above, as Pyroform HP lost 3 times less temperature at the beginning of the cast. Even the high purity (less dense) Fusion SL lost 30 % less temperature than regular cement bonded fused silicas. Dense castable was not tested in this case, but you can imagine how much temperature drop would occur in this scenario.

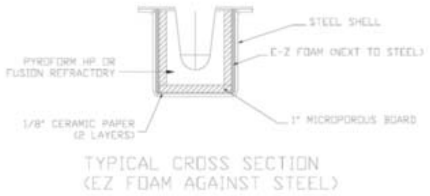


3 Molten aluminium temperature drop in 20 ft (6 m) of launder.

Life of the refractory and ease of maintenance are also important factors in choosing a material. Typically the denser the material, the better the wear resistance is. However, denser materials often leave a thicker skull and, unless the material has excellent non-wetting properties, skull removal will pull grains of the refractory with it. Besides density, overall life depends on the non-wetting properties of the material, material grain size, and between-cast maintenance practices.

Pyroform HP is the lowest density of all launder materials. If maintained correctly, it will give long service life comparable to higher density materials. Likewise, Fusion SL, RMG's high purity, non-wetting fused silica, has demonstrated longer life than denser fused silicas because of its smaller grain size, excellent thermal shock resistance, and tremendous non-wetting properties.

Backup Material Selection: Backup insulation is a must for HPMDS to achieve temperature losses < 0.50 °C / metre and to obtain a steel shell temperature < 75 °C near steady state. Currently, options available are: 1) no backup insulation, 2) ceramic blanket, 3) boards out of ceramic fibre or calcium silicate, 4) microporous boards, 5) ceramic foams, 6) insulating fillers, or 7) combinations of these items. The optimum solution developed by RMG is to combine 25 mm of microporous board along with a ceramic foam such as E-Z Foam offered by RMG. In cases where the molten aluminium flow rate is low, under 8 t/hr, 50 mm of microporous board may be required to reach a desired cold face temperature. In fig 4 is an optimised solution for backup insulation.



4 Optimum backup insulation recommendation.

The microporous board provides a superior heat barrier, minimising heat loss and shell temperatures. E-Z Foam serves several purposes, including insulation, a non-wetting barrier to protect the steel, and stabilising the refractory to reduce crack propagation and increase service life.

Launder Design: The ultimate goals in a given launder design are to: 1) maximise the metal velocity for a given flow rate without creating turbulence or excessive wear on the refractory, 2) minimise the area where the molten aluminium is exposed to air, 3) maximise the area where the molten aluminium is exposed to the refractory, and 4) make it easy to paddle and clean. Rex Materials has a proprietary standard design to accomplish these goals. The basic shape or contour stays the same while the dimensions change in a way which optimises the metal velocity at any given flow rate. It also minimises radiant heat losses by reducing the surface area of the metal exposed. Rex Materials currently has 8 sizes (or styles) to cover a broad range of casting flow rates. This design ultimately results in the lowest possible temperature drop. The faster the metal travels and the less area exposed to the air, the lower the heat loss in any given system.

Steel Structure: The purpose of the steel structure is to provide proper elevations and connections with adequate drainage. It has to withstand the cast house environment and have virtually no deflection under load. It must be easy to assemble yet have adjustability. The structure provides the needed protection to launder material and backup insulation. Reducing the steel temperatures as mentioned above is critical to eliminate distortion of the steel from excess heat. Rex Materials recommends that launder systems be designed with a 0.5° maximum slope (5 mm / metre max., 2-3 mm/metre recommended). Greater slope angles can contribute to turbulent flow conditions and result in the need to increase the launder section size on long launder systems.

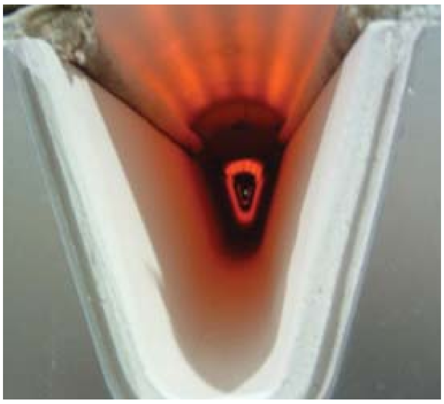
The desired angle will provide just enough slope to facilitate metal drainage at the end of the cast without the need for paddling or scraping the launders. RMG recommends that residual metal skull be allowed to freeze in the launder, while being broken into manageable sections for easy removal using dams or pads of blanket. All Rex Materials' launder materials are highly non-wetting to molten metal given routine release coating, so the skull shrinks away from the refractory and is easily removed for remelting. Application of release coatings will improve upon the inherent non-wetting properties of all launder materials.

Covers: Whether using an HPMDS or an old launder system with dense castable, the addition of covers will reduce the heat loss by up to 60 % depending on the flow rate and other parameters. They are also safer to work around. Rex Materials provides a variety of covers including hinged, lift off or pushback for easy access. Rex Materials can offer pneumatic operations, counter balancing, or any feature one desires. They use fully retained lightweight Pyrolite® ceramic fibre board or insulating blanket in a steel shell. Pyrolite is very buoyant in aluminium and hence has never been associated with molten metal inclusions. An example is given in fig 5.

5 Insulated covers with a pneumatic lifting system.

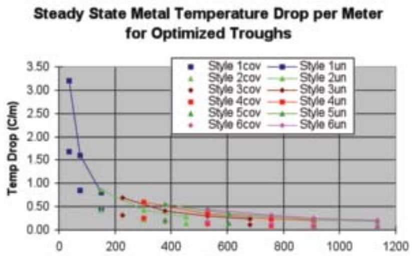
Preheating System: Depending on the flow rate of a system, preheating may be required. Preheating a launder system reduces heat loss on start up. The traditional preheat method uses a gas flame via torches to heat the refractory. Rex Materials does not recommend this practice and advises if done, only use a lazy blue flame. Overheating a refractory can degrade non-wetting agents and shorten its life. Rex Materials recommends using an electrical heated cover system or hot air blowers for preheating. With higher flow rates, Pyroform HP, and in some cases, Fusion SL, absorbs so little energy at the start that preheating of the launder can be eliminated except when drying or when very accurate process control is required. The elimination of preheating may also reduce process cycle time.

Electrical Heated Covers: These launder covers incorporate heating elements. Not only do they provide preheating, but they can also be used when very precise temperature control is called for by the process. RMG heaters are capable of heating systems to near steady state conditions, if required. Various control strategies are available. An actual cover in service is shown in fig 6.



6 RMG electrical heated cover in service.

Thermal Performance: The real-world, bottom line measurement of thermal performance is the metal temperature drop per foot or metre of launder length at a given flow rate. The results of using Rex Materials' HPMDS are shown in fig 7.



7 Temperature drop per metre at different flow rates with different size launders (styles) both covered and uncovered.

High performance metal delivery systems can significantly reduce energy usage and operating cost while increasing worker safety in the cast house. The key factors in the high performance of a metal delivery system are: primary liner material selection, backup material selection, design of the launder, the steel structure, covers, and the preheating system. By selecting the correct materials and design, holding furnace temperature can be reduced by as much as 50°C when compared to a launder system using other materials. The energy savings alone can provide a significant cost reduction and frequently a payback in a matter of months. Lowered furnace temperatures also provide metallurgical benefits such as less hydrogen absorption, fewer oxides generated, and fewer starting defects. By eliminating the variables of launder preheating and "super-heating", they provide a small, highly predictable, and consistent temperature gradient from the furnace to the casting centre and from the first mold position to the last. Temperature drops of less than 0.5°C / m of launder are routinely achieved with Rex Materials' HPMDS.

Reader Reply No.

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