DEVELOPMENT OF MORE EFFICIENT STRUCTURES FOR LADLE AND TUNDISHES MONOLITHIC COVERS

Eng. Julio Gonzalez Bernaldo de Quiros[1]
[1]Cuaribar S. A., Buenos Aires, Argentina

ABSTRACT

After years of work and research in the steel industry, we had found some weaknesses in designs and structures of monolithic covers for molten steel containing vessels. We have therefore developed and successfully tested a low cost design for steel ladle covers and we are expanding this technology not only to the steel industry, but also to other industries. For this design we use alumina silica castable refractories with a steel structure and stainless steel anchors.

Our design consists on lightweight and ventilated metal structures, that allow the user to work with lower temperature in the metal structure, preserving the refractory and achieving a better and extended performance compared to the designs which have been used for more than 40 years.

Since the first test, this product has reached more than two times the life cycles of the traditional alternative. For this reason and because of the low cost, we are now expanding this development to other applications expecting better results on each area.

Key-words: Ventilated metal structures, refractory covers for vessels, improved performance.

Fig.1: Ladle and cover in operation

INTRODUCTION

In steel industry it is necessary to transport molten steel in a liquid state. For this purpose liquid steel containing vessels are employed. In order to reduce the heat loss, a cover is commonly used while the molten steel is being transported (fig.1). The cover basically consists in a steel structure that supports the refractory coating. This refractory coat is at the bottom of the cover, directly in contact with the inside part of the ladle containing the liquid steel.

For more than 40 years, until now, the covers have been designed compound by a sheet steel reinforced on the top with steel profiles joint by welding (fig.2). On the inside of the cover (at the bottom of the structure), steel anchors are welded to the sheet steel (fig.3) and a refractory coating is installed attached to the anchors.

This design is based on a overweighed and extremely rigid steel structure in intimate contact with the refractory lining.

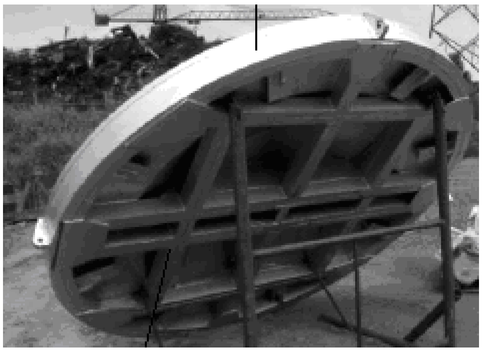

Fig.2: Cover -Traditional design - Top

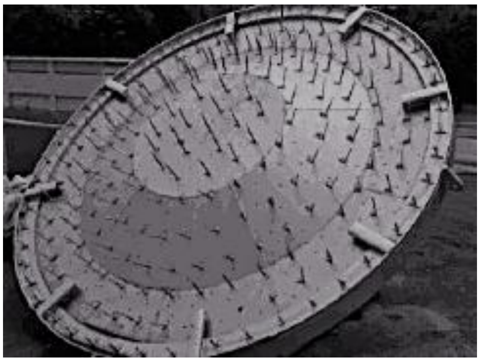

Fig.3: Sheet steel with anchors - Bottom

PROBLEM

During operation, the temperature of the inside of the cover (composed by the refractory lining) rapidly increases due to heat radiation from liquid steel (the temperature is over 1.500 ºC). The high level of heat transfer due to conduction causes the steel structure to work at a very high temperature. This temperature increase causes the thermal expansion of both materials.

Within these conditions, we can observe three technical difficulties for this traditional design:

1. There is an excessive temperature in the metal structure that causes a deformation in the sheet steel that supports the metal anchors for the refractory lining.
2. The coefficient of thermal expansion of steel is many times higher than the coefficients for refractory materials, and both materials are in intimate contact at high temperatures.
3. There aren’t enough degrees of freedom between both parts of the cover to absorb the difference of expansion within operation.

As a result of these three issues, cracks are generated in the refractory lining. As consequence of cracks the heat transfer rises, with the corresponding loss of strength until the metal structure finally suffers plastic deformation, which the refractory materials cannot absorb. All these facts end causing more and more cracks and the unbinding of the refractory, entering into a vicious circle.

On top of these three technical factors, there is a fourth economic factor that must be considered: the metal structure for this design is too heavy and the cost is too high for such a short life time. In fact, in the traditional ladle covers used until now the weight of the metal structure is usually greater than the weight of the refractory lining. This oversized metal structure only serves for handling. However, during operation, too much metal at high temperatures causes a short duration of the cover. In the past, this leaded to users trying to extend the lifetime of traditional covers through maintenance and re-building of parts, with an extra cost and a complex logistics inside the steel plant. Nowadays users need a more durable product allowing more free space within the factory and less resource use for other destinations than the steel production itself.

ANALYSIS

Prior to re-designing the cover we start with a simple analysis of the metal structure and the refractory lining:

Metal structure:

- The purpose of the metal structure is to give support to the cover and to allow the handling and movement of the monolithic piece.
- The advantages of the metal structure are its strength and tenacity.
- The disadvantages of the metal structure are its high coefficient of thermal expansion and it's deformation at high temperatures.

Refractory lining:

- The purpose of the refractory lining is to resist the high temperature and the radiation of the liquid steel.
- The advantage of the refractory lining is indeed its refractoriness.
- The disadvantage of the refractory lining is its fragility.

Of this analysis arises that, in order to stop the vicious circle of thermal deformation of the metal structure and the cracking of the refractory lining (that ends up in a short life of the cover), the aim is to find a commitment solution that seizes the advantages of each material while minimizes the impact of the disadvantages.

NEW DESIGN

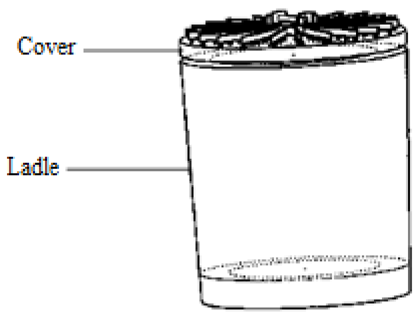

Fig.4: Ladle and cover – New design

With the basics previously exposed, we developed a new design for ladle covers (fig.4) according to the following concepts:

1. The metal structure must be ventilated.
2. The shape of the metal structure must minimize the thermo-mechanical stresses.
3. The metal structure must be as strong and light as possible.
4. The refractory lining must have good properties for thermal shock and high temperatures.

Thus, the new design includes:

1. The addition of an air gap between the metal structure and the refractory lining (fig.5).
2. A steel ring core that bears radial profiles to form a more efficient structure (fig.6).
3. Anchors welded directly to a steel profile structure, with no sheet steel, allowing natural convection ventilation and preserving a solid, strong and light metal structure (fig.7).
4. A refractory lining specially formulated for thermal shock and temperatures up to 1650°C.

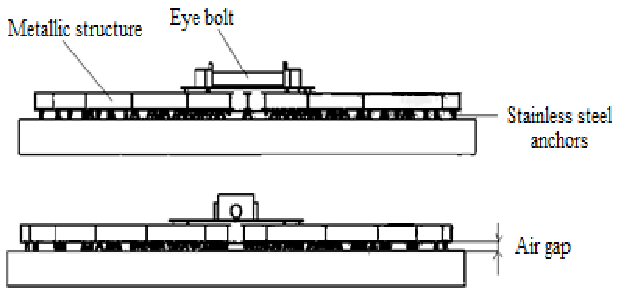

Fig.5: Cover – New design – Side View

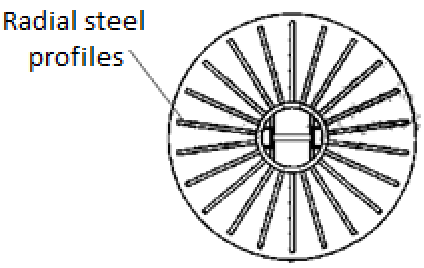

Fig.6: Cover – New design – Top View

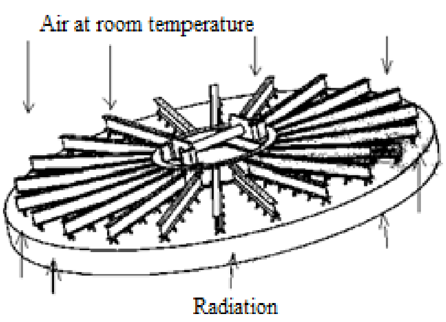

Fig.7: Ventilated metal structure – Natural convection

RESULTS

Since the first test this product has reached more than two times the life cycles of the traditional alternative. By the time traditional covers are taken out of service, this new designed covers remain practically intact as shown (fig.8 and fig,9).

Fig.8: Cover – New design after traditional lifetime

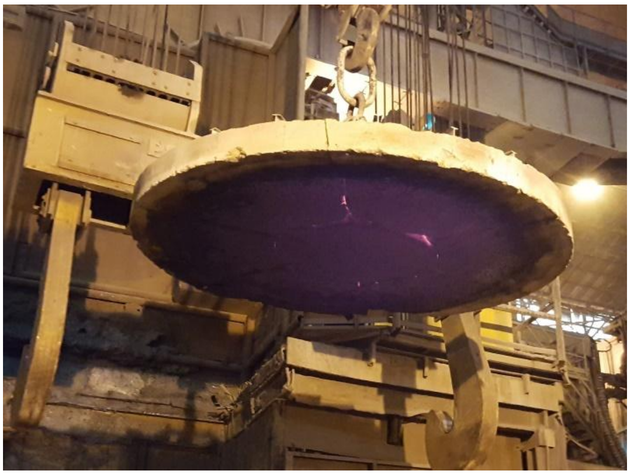

Fig.9: Cover – New design after traditional lifetime

CONCLUSIONS

This new design has proved to last more than the traditional one. In fact, wear is more attributable to handling than to operation. During operation no wear was observed. The breaks observed during its useful life mainly came from blows due to a mismanagement of the crane. This possibly occurs because the operators are still accustomed to working with the traditional design, which usually makes the cover to be seen as a metal part rather than as a refractory. In spite of this, it is quite clear that this new design is more efficient. We expect that once operators get used to working with the new design, these covers will last many times more than the lifetime of the traditional ones.

After excellent results for steel ladle covers, we have recently developed tundish monolithic covers which are currently in the test stage.

Because of the low cost and best performance of this new design concept for monolithic covers, we are now expanding this development to other applications expecting better results on each area.

CONTACT

E-mail: juliogb@cuaribar.com.ar, juliogb82@gmail.com
Phone: +5491150140680