Hand-arm vibration in foundries: furnace and ladle relining operations

Foundries Information Sheet No 11

Introduction

This information sheet was produced by HSE's Molten Metals National Interest Group in collaboration with Castings Technology International. The Foundries Industry Advisory Committee (FIAC) and its Noise and Vibration Subcommittee were consulted during its production.

Induction furnace relining

Induction furnaces generally have a multilayer lining consisting of:

- a more or less permanent lining protecting the induction coils and the water pipes;
- a slip plane (often of ceramic fibres); and
- a further inner ceramic lining (crucible) actually in contact with the metal.

This inner lining is gradually eroded and degraded in use, so that its routine renewal is necessary at regular but infrequent intervals. Its 'lifespan' is dependent on the metal melted, the amount of slag formed, and the melt temperature. If carried out manually as is usual with smaller or older furnaces, the lining removal operation can cause very high exposures to vibration, heat, dust and noise so it is best avoided.

The obvious way of doing this would be to use a **preformed** push-out crucible but at present this is probably not completely achievable, as linings are normally rammed in position. 'Push-out' is, however, possible on most modern furnaces including some that were not originally designed for this. Installing 'push-out' crucibles can:

- virtually eliminate exposure to heat, dust and noise;
- greatly reduce vibration exposure; and
- give economic benefits such as reduced downtime.

As and when technology allows, the use of preformed crucibles should be adopted. This should give:

- a more uniform lining with fewer weak or hot spots;
- greater ease of use; and
- fast turnaround.

A castable rather than rammed lining would be preferable in that ramming tools are not used. Presently, such castable linings are not technically feasible.

Cupolas

In principle, it should be possible to avoid the need for cupola fettling by using water-cooled, liningless cupolas and this is certainly an option for large cupolas. However, the relative cost of providing a cooling system increases as the cupola diameter goes down, and also the thermal efficiency decreases rapidly with decreasing diameter. Consequently, the smallest cupola for which this option could reasonably be considered in practice would be one melting about 9 tonnes/hour. In the long term, liningless cupolas are recommended, where practicable, to avoid exposures to vibration, heat, dust and noise.

Unfortunately, for smaller cupolas there is little that can be done to avoid the need for fettling, but this should be minimised by using good cupola operating practice to maximise the life of the lining:

- Using good quality linings may enable the campaign to be extended before fettling is needed.
- In some instances, it may be possible to just rake out the damaged lining rather than having to chip out the entire lining.
- Theoretically, a castable lining (to avoid ramming) could be used, but these are not yet available.

Ladles

As with any ceramic insulation in contact with molten metal, deterioration of ladle linings occurs over time and the lining needs to be removed, repaired or replaced at frequent intervals. Often a person is employed full-time on this operation, chipping out the old lining and ramming up the new. Exposure to dust, vibration and noise is often very high, especially the latter, as noise from the chipping hammers resonates in the hollow ladle.

Several foundries have had considerable success with either preformed push-out linings, or disposable lining boards in combination with a permanent safety lining. These offer several advantages as well as eliminating most of the normal ladle fettling problems. Such linings or lining boards are made from composite materials - these give much higher insulation than conventional ceramic rammed linings. They can provide operational advantages such as lower tapping temperatures (leading to reduced furnace lining wear and power savings) and possibly elimination of ladle preheating (creating fuel savings). They are also less likely to crumble and therefore can give cleaner metal.

For larger ladles, lining boards can give significant weight savings on the ladles allowing more metal per tap without overloading cranes. This approach can therefore provide:

- considerable financial savings;
- improvements in casting quality; and
- reduced health and safety problems.

A slip plane of ceramic fibre or micanite will be necessary between the permanent safety lining and the preform. Generally, it will be necessary to purchase new ladles when starting with this technique as preforms will not fit dented or other irregularly shaped ladles. For the same reason, ladles will need to be treated more carefully than is commonly the case to avoid ladle damage in use. Specialised ladles, such as those for use on pouring bogies, may need to be designed in two or more parts to allow fitting of the preform. Payback times can be very short.

The pattern of deterioration with use may be quite different from that of conventional linings so that the ladle utilisation regime may need to be changed. In particular, preforms may not be suitable for ladles which are only used occasionally.[1]

Final measures

If the above approaches cannot be used, then options include the following:

- Use of a higher quality castable liner can increase lining life, reducing the frequency of replacement.
- It may also be possible to use a more or less permanent lining and just rake out damaged bits and repair, rather than chipping out the entire lining and replacing.
- Vibration-reduced tools should be used for the remaining fettling.

Summary

In many foundries, furnace or ladle wrecking/relining is an area where there may be significant hand-arm vibration exposure. Possible approaches to reducing exposure include the following:

- use preformed linings or lining boards;
- use a push-out mechanism for removing spent linings;
- use castables in preference to rammed linings;
- use high-quality materials for longer life;
- use vibration-reduced chisels and rammers; and
- use management/environment controls such as ensuring adequate temperature, incorporating job rotation etc.[2]

References

1 M Brady ‘Modern Casting’ *The Foundryman* April 1997

2 *Preventing hand-arm vibration in foundry processes* HSE Books 2000 ISBN 0 7176 1798 X

Further reading

Hand-arm vibration HSG88 HSE Books 1994 ISBN 0 7176 0743 7

Buying new machinery: A short guide to the law and some information on what to do for anyone supplying machinery Leaflet INDG271 HSE Books 1998 Single copies free: also available in priced packs of 15 ISBN 0 7176 1559 6

A purchasing policy for vibration-reduced tools in foundries Foundries Information Sheet FNIS12 HSE Books 2002

While every effort has been made to ensure the accuracy of the references listed in this publication, their future availability cannot be guaranteed.

Further information

HSE priced and free publications are available by mail order from HSE Books, PO Box 1999, Sudbury, Suffolk CO10 2WA. Tel: 01787 881165 Fax: 01787 313995. Website: www.hsebooks.co.uk (HSE priced publications are also available from good booksellers.)

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This leaflet contains notes on good practice which are not compulsory but which you may find helpful in considering what you need to do.

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