SEVENTH FRAMEWORK PROGRAMME

HOTWIRE

PROJECT PERIOD 2 PUBLISHABLE SUMMARY

Grant Agreement number: 315592

Project acronym: Hotwire

Project title: System to significantly increase the effective yield of Calcium (and other alloying elements) in the treatment of specialty steels, while reducing impurities in the melt.

Funding Scheme: Research for SME

Date of latest version of Annex I against which the assessment will be made: 13 July 2012

Periodic report: 1st □ **2nd ■ 3rd** □

Period covered: From 1st October 2013 – 31st December 2014

Name, title and organisation of the scientific representative of the project's coordinator:

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3.1 Publishable Summary

Summary of Project

This report covers the work carried out during reporting period 2 of the Hotwire project. More detailed reports can be found in the specific deliverable documents.

Calcium metal is a key additive in the final treatment (in-ladle metallurgy) of virtually all steels, and represents a significant cost to the steel producer.

Calcium metal is added to the melt to convert insoluble inter-metallic inclusions of alumina that clog nozzles, into lower melting point soluble oxides that allow smooth pouring/casting. One of the main problems of in-ladle metallurgy is to introduce into the molten steel (with consistent, high recovery/yield) many elements which are light, reactive, or easily oxidized.

Calcium has a low density; it floats on the molten steel and is readily oxidized. It has a very low solubility in steel and is gaseous when it comes into contact with the molten steel. However, adding these elements deep in the ladle minimizes oxidation by air and slag, increases the time and surface area of contact with the liquid steel and so delays vaporization (escaping to atmosphere) and ultimately increases yield – the amount of calcium in steel post-cast versus amount introduced.

The evaporation temperature of calcium (1,480ºC) is much lower than the molten steel (~1,600ºC) and so it vaporises on the surface, if added loose. Therefore, calcium is usually added in the form of a steel sheathed calcium wire. The integrity of the steel sheath must be retained long enough under the heat of the molten steel to push the steel wrapped calcium to the bottom of the ladle.

By increasing the time prior to evaporation in the liquid steel, the calcium yield in the final products will be improved. This will reduce the costs of manufacturing the steel.

Such a reduction in costs will improve Europe’s competitiveness in the world steel market.

Context and Objectives

Current techniques of injecting calcium into liquid steel suffer from low yield, as the calcium evaporates before it can be useful in the melt.

Calcium is currently injected into liquid steel by encasing calcium chips into a steel sheath. This forms a wire that can be fed into the liquid steel.

The Hotwire project has researched mechanisms of retarding calcium melting and evaporation during the process of injection. We believe that the project results will lead to an economic way of successfully treating the liquid steel, whilst reducing the amount of calcium required.

Description of Work Performed

Research into the control of evaporation of calcium when exposed to ~1,600ºC was carried out by the following techniques:

- Extensive literature review on current techniques of injecting calcium in liquid steel to identify potentially novels methods of injection.
- Extensive literature review of methods of controlling the evaporation point of metallic calcium chips.
- Experiments to prove that the evaporation time of the calcium can be safely extended. Results from these experiments show a significant increase in the evaporation time of the calcium.

- Experiments to develop techniques to retard the melting and evaporation time of the injection wire. The results have shown improvements in this area.

- Design and development of the techniques and equipment needed to treat the calcium and wire, in line with the research.

- Investigation and development of techniques and equipment to inject the calcium loaded wire into the liquid steel at various positions. A novel method of delivering the wire into the ladle more effectively has been developed and successfully validated.

Main Results of the project

The work completed has led to the selection of techniques to retard the evaporation of the calcium in the liquid steel. This includes the testing and selection of appropriate coating solutions for application to the calcium particles and an outer wire sheath.

Several different types of coating for the calcium particle were explored before deciding on the final method. The validation of the method was performed by coating a quantity of calcium with the selected coating material which was then used to produce the conventional calcium loaded wire. This was tested under normal ladle conditions and the results gained indicated that the melting point of the calcium had increased significantly; hence improving the way calcium is added to molten steel.

A practical method of coating of the steel sheath was investigated in detail and several options were evaluated. The final method chosen proved to be the most robust given the harsh operating environment that the wire is exposed to in a steel works. The suitability of the method for mass production was also evaluate during the trials stage which showed that additional machinery required could be added to the existing line to enable the coating of wire with the existing geometry.

During trials to establish the effectiveness of the sheath coating, the results show that by using the coating, the melting point of the calcium would be increased which would delay the melting of the calcium.

A modified method of delivering the calcium loaded wire into the furnace ladle was developed. The aim was to allow a more even distribution of the wire into the ladle which could have the effect of increase the yield. A wire delivery head which could be articulated was designed and constructed. The design took into consideration the operating conditions above a typical ladle of molten steel. Validation testing proved that this development has the potential to add value to the overall delivery of the wire into the ladle.

Expected Final Results

The project has achieved the following goals:

A suitable coating material has been selected for coating calcium particles and the method of coating has been successfully validated. The outcome of trials using the coated particles has shown that the coating provides enough of a heat barrier to increase temperature at which the calcium melts.

A coating method for the calcium loaded wire has been developed which includes the development of a specialised coating material and a coating applicator device. The feasibility of including the coating method into an existing production line has been explored

The manner in which the calcium loaded wire is injected into the ladle of molten steel was researched and a method for improving this by enabling a more even distribution of calcium in the ladle was developed. The design, build and validation of an articulating delivery head was a key part of the project.

Combining the three developments described above will have a dramatic effect on improving the modifications of aluminium inclusions in molten steel.

The benefit of collaborating within the consortium has been important and has succeeded in opening new avenues of business development for all members.

Lead by the project coordinator, a clear future exploitation and future funding strategy has been developed in order to promote and introduce the Hot-wire concepts to the steel industry.

Project Website

A Website has been created to explain the project aims and objectives and to disseminate information about project activities and results. As a dissemination vehicle, the website provides information to the wider community. The Hotwire website has been designed to be attractive and easy to use, with intuitive navigation. It has been updated regularly during the project.

The project website can be found at www.injectionhotwire.com.

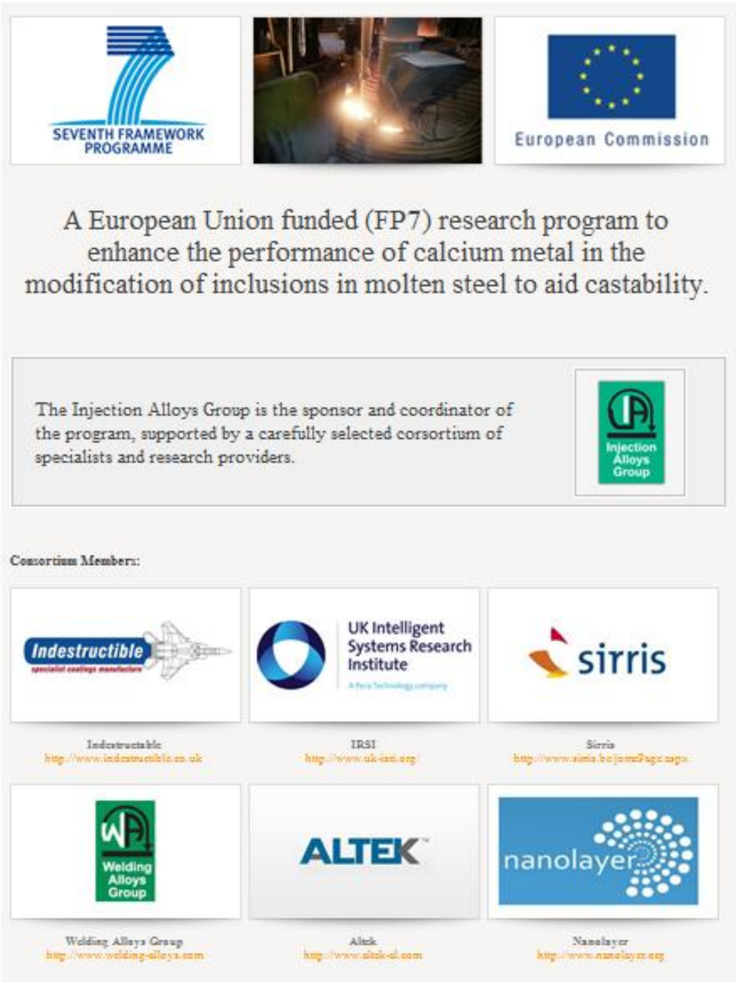

Figure 1: Website front page

(Ref figure 1 in attached document)

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