SEVENTH FRAMEWORK PROGRAMME
FP7-SME-2011-1

ECOQUENCH

Project Title: Controlled Quenching and Heat Recovery from Thin walled, Complex High Performance, Hardened Al Alloy Extrusions

Project Number: **EcoQuench [286693]**

Publishable Summary

Report prepared by ISRI

Project Start Date: 1/11/11 Duration: 27 Months

Project Coordinator: Paul Tranter

Project Coordinator organisation: UK ISRI

Project co-funded by the European Commission within the Seventh Framework Programme		
Dissemination level		
PU	Public	
PP	Restricted to other programme participants (including Commission Services)	
RE	Restricted to a group specific by the consortium (including Commission Services)	
CO	Confidential, only for members of the consortium (including Commission Services)	**X**

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http://www.ecoquench.eu/

PUBLISHABLE SUMMARY

The EcoQuench project objectives were to research, investigate and develop a controlled quenching and heat recovery system for thin walled, complex high performance, hardened aluminium alloy extrusions. The aim of the EcoQuench system is to recover 50% of the energy wasted at the profile cooling stage and to reduce scrap produced at the profile cooling stage by 25%. This would in turn benefit the environment by reducing the amount of CO2 that is emitted during the aluminium extrusion process.

During period one of the project, the work performed included establishing the optimum cooling rate and characterizing candidate quenching oils. A representative range of extruded aluminium profiles were supplied to ITA by BOAL. Profile drawings were also supplied together with the relevant information i.e. current data and scrap rates. Using these details, ITA performed residual stress measurements, dimensional and mechanical characterizations to establish the optimum cooling rate for a selection of the samples.

The selection of suitable quenching fluids was challenging due to the high ambient temperature that the fluid would be exposed to on an aluminium extrusion line. This temperature was approximately 580˚C. At this stage in the project the use of mineral oils was ruled out because the oils that were available had low flash point temperatures and therefore they were not suited to the EcoQuench application. Creating blends of oils was also not recommended since emulsified oil blends would be difficult to remove from the surface of the aluminium profile after quenching. This was an important requirement for the end–user. Following extensive investigation, a suitable quenching fluid with the correct attributes was found by Lubriserv. This fluid was a synthetic ester which is used to quench engine valves at a production site in Italy. The fluid is exposed to temperatures in excess of 600̊C during the valve quenching process and therefore it was envisaged that it would be suitable for EcoQuench. The fluid is called Hardena S30 and data sheets which provide information about the operating conditions and the specific heat etc. were obtained. Only one quench fluid was selected due to the temperature constraints and consortium agreed that the system development would be based around the Hardena S30 ester.

In work package two, a thermal model of the thermal store and spray sub-systems was created by ISRI. The results formed the basis of the prototype system designs particularly the topology of the fluid spray quenching nozzles.

During the research into the thermal properties of the candidate fluid it was found that prolonged exposure of the fluid to temperatures over 100˚C would degrade the quality of the fluid very quickly. It was agreed that a change in the system design was appropriate to remedy this situation. The original specification in Annex 1 description of work was for the quench fluid to operate at 300̊C, this has proved to be impractical because of the degradation of the quench oil operating continuously in the system. The design was changed to incorporate a two fluid circuits. The primary would contain the quenching fluid (Hardena S30) and the secondary would contain a heat transfer fluid which has superior heat transfer specification than the quench fluid hence improving the performance. Heat would then be transferred from the quench fluid via a heat exchanger into the heat transfer fluid. The recovered heat would be utilised in one of the secondary sub-systems. Analysis of suitable exchanger designs was performed by ITA with the assistance of HTS and a heat exchanger was

selected. In this system, the heat buffer storage is not required because the heat energy is stored in the fluid.
Addition experimental analysis was performed in order to select the correct spray nozzle for the quench fluid which provided the optimum spray pattern for this application. An alternative spray nozzle layout was used from that described in the Annex 1 DoW. This was made up of a passive nozzle which was connected to an electric variable proportional valve which was software controlled. This type of nozzle layout is suitable for high temperature environments and has a cost saving advantage over alternative designs.
Another important change to the development was the addition of a primary air quench module at the front end of the system to initially cool the profile before the fluid quench; this was implemented for reasons of safety. The primary air blowers would cool the profile by approximately 100˚C before it enters the quench fluid, reducing the fire risk, but also help to improve the novelty of our system.
Specifications and designs for the spray nozzles, primary air quench and the wash-off & recirculation sub-systems were further developed during period two. A bench-scale oil wash-off system was developed and trialled and results were obtained, this used a specially developed 360 degree air knife which is not only capable of fluid wash off but also contributes to the overall cooling capacity of the system.
A section of heat transfer racking was designed based on the existing racks used at BOAL and a representative section model was constructed and tested to evaluate the heat transfer characteristics. It was planned that this would be connected to the prototype system to reuse the heat recovered but this was not possible due to limitations of the fluids on heat recover and logistical restrictions within the operational environment,. None the less the potential of the racking system to limit thermal loading during the aging process and potentially limit distortion is still of interest. The performance of the racking system was evaluated in a lab environment using a hot water supply and we suggest future implementation in an extrusion plant would be worthwhile to assess the real life gains; this system could still help to meet the overall objectives of energy & waste reduction if used as an independent subsystem. The racking system would need to be developed and evaluated in the future before it could be implemented in an extrusion plant.
During work package three, the monitoring and control system was developed. The thermal camera system was developed with the thermal cameras provided by AST and integrated by ISRI. A profile dimension measuring system was investigated and developed and also integrated into the system. The controls for the system are located in a cabinet which contains the PLC controller and variable speed drives. A PC is used for the graphical user interface. The control and monitoring were developed with the collaboration of ISRI, Technosam and AST. The software was produced and tested to control the air blowers in the primary air quench and the spray nozzles in the primary fluid quenching systems.
The system components were integrated in work package four with ISRI, Norton, Technosam and Lubriserv and the system was wet commissioned. Validation tests were carried out in preparation for the testing and evaluation of the system performance which took place in work package five. This was performed at a special test site selected by BOAL due to the safety risk.

Expected final results and potential impacts

The scientific approach which produced the results of this project may be of great benefit to the aluminium profile extrusion industry and help to increase efficiency with the added benefit of being more environmentally friendly.

The final results of the project are a more efficient and cost effect method of cooling extruded aluminium profiles. This will prevent waste and reduce the energy usage in the extrusion factory and also less aluminium will have to be reworked into new billets for extruding.
The consortium worked throughout the project to achieve the objective as set out in the Annex 1 description of work. The investigations identified the difficulties with finding a quench fluid that would be able operate safely at temperature of 580° on an extrusion line. The synthetic ester that was ultimately selected had been used previously for high temperature applications, however to ensure the safety of various stakeholders an additional test phase was proposed prior to full scale testing in a production environment. An additional system was developed in the final months of RP2 and tests were performed under controlled conditions to evaluate the fire performance. Unfortunately the synthetic ester finally proved to be unsuitable Other non-oil based fluids were considered but these were either unsuitable for heat recovery, unsuitable due to contamination issues, or could not be processed by the prototype hardware. These developments meant that demonstration of the heat recovery features was not possible within this project. Nevertheless, the consortium worked hard to ensure the controlled cooling and scrap reduction potential could be evaluated: The adapted prototype system incorporated a primary air quench, followed by an oil quench stage and an air blow-off system. A fully integrated closed feedback control system utilised thermal and dimensional cameras to adjust the spray parameters. The system was evaluated with aluminium profile sections and results were obtained which showed that profile temperatures reduced as calculated when passed through the different sections of the system.
The results obtained so far have indicated that the prototype system is capable of quickly reducing the profile temperature in controlled manner which should have the effect of significantly reducing the amount of rework and save costs.
It was not possible to install the system on an extrusion therefore the possible savings in scrapped profiles could not be evaluated accurately.
Further development of the heat recovery system would be required but early tests have shown that there is potential for this with further development in the future if a suitable quenching fluid can be found.

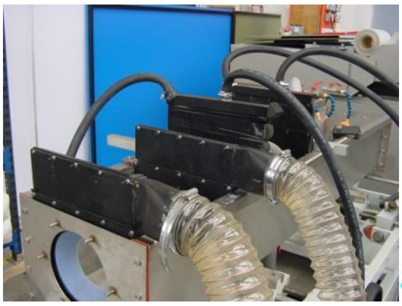
The modular nature of the system will enable different configurations of the system to be trialled with the view to achieving the most effective cooling for a typical range of profiles.
The end user partner; BOAL is committed to trialling sections of the prototype system on a real aluminium extrusion line at their plant in Loughborough, UK. This has already begun. The SME partners have been updated with the progress and may contribute to further developments of the system at the request of BOAL.

Project meetings were well attended by the majority of the consortium members and participation during the project was good especially during the building of the prototype. This collaboration ensured that a working prototype system was produced and tested by the end of the project with end-user partner committed to implementing parts of the EcoQuench system on an actual extrusion line for evaluation and further development going forward.

Information regarding the project can be found on the project website.

http://www.ecoquench.eu/

ECOQUENCH SYSTEM AND COMPONENTS

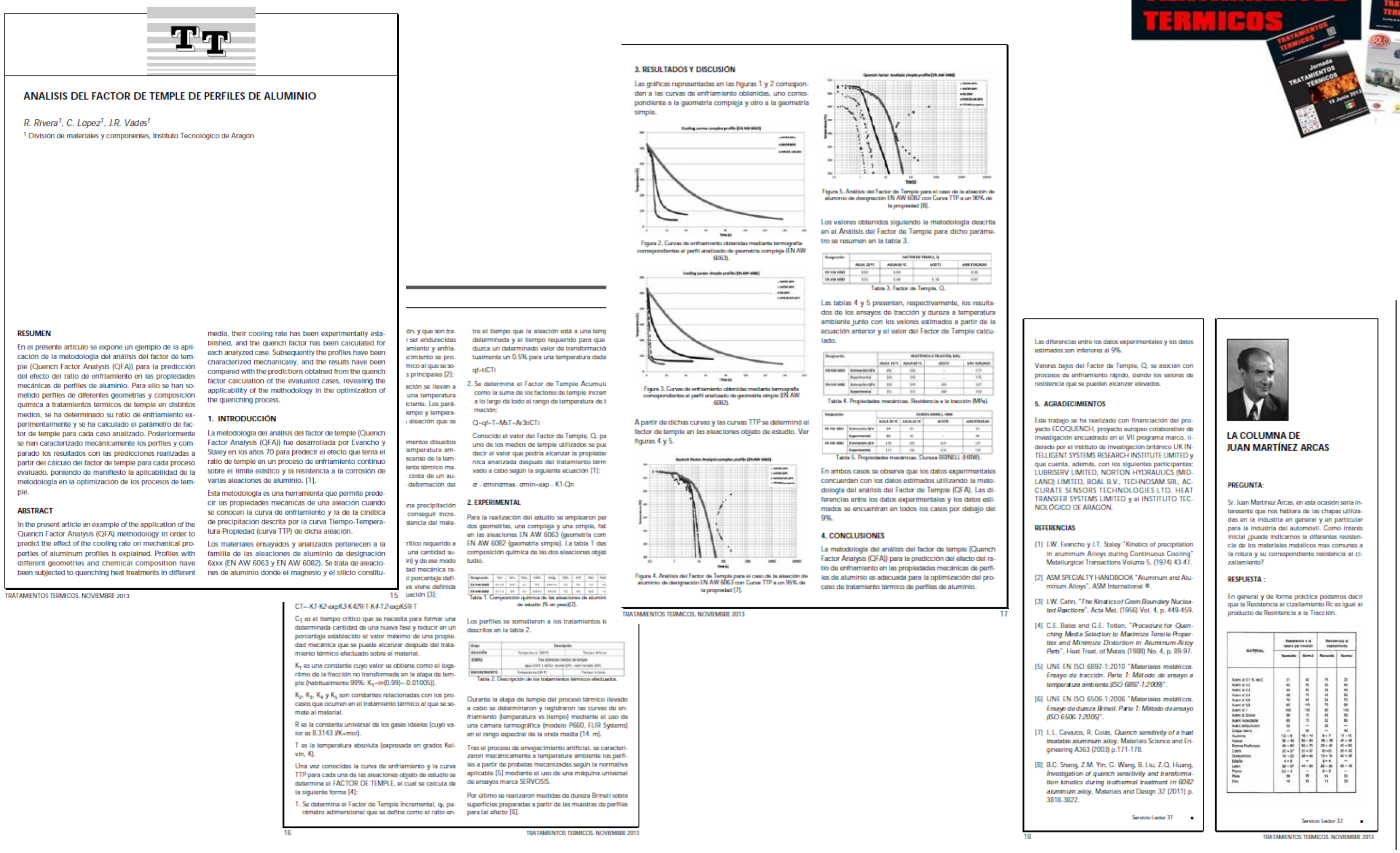


DISPLAY BANNER AND LOGO

PUBLICATIONS

- **Publication in magazine “TRATAMIENTOS TÉRMICOS (HEAT TREATMENTS)” November 2013, Nº 140. ISNN: 1132-0346.**

“Análisis del factor de temple de perfiles de aluminio (*Analysis of the quench factor in Aluminum profiles*)” R.Rivera, C. López, J.R


ANALISIS DEL FACTOR DE TEMPLE DE PERFILES DE ALUMINIO

R. Rivera[1], C. Lopez[1], J.R. Vades[1]

[1] División de materiales y componentes, Instituto Tecnológico de Aragón

- **Press release in local newspaper “Heraldo de Aragon” (Publishing on week 6, 2014)**

Example:


HERALDO DE ARAGON

TERCERMILENIO

PREVENCIÓN DE ALUDES>TECNOLOGÍAS QUE LEEN EL FUTURO DE LA NIEVE

En invierno y primavera, las zonas de montaña esconden peligros entre su belleza. La prevención de aludes empieza por leer el futuro de la nieve, estrechamente unido a las condiciones meteorológicas. La tecnología extrae, del completo silencio del manto blanco, datos que permiten predecir cuándo y dónde ocurrirá un alud y, así, evitar riesgos.

EN PORTADA

CÓMO NOS DEFENDEMOS