Project Number: COOP-CT-2004-512833
Project Acronym: Alamo
Project Title:

Development of innovative high performance anodised aluminium moulding tools for the thermoplastic processing sector to achieve competitive advantage.

Instrument:	Co-operative Research Project
Thematic Priority:	Frame Work 6 RESEARCH ACTIVITIES INVOLVING SMES CO-OPERATIVE RESEARCH Nanotechnologies and nano-sciences, knowledge based multifunctional materials and new production processes and devices

PUBLISHABLE FINAL (24 MONTH) ACTIVITY REPORT

Period covered	November 1st 2004 to October 31st 2006
Start date of Project	November 1st 2004
Duration	24M
Project coordinator	Chris Hare
Coordinator organisation	Rapra Technology

INTRODUCTION

The use of aluminium tooling for the processing of plastics is widespread within the EU as it has some very desirable characteristics such as high thermal conductivity, low weight and quick machinability. Its expansion is limited however by its relatively poor wear, abrasion and chemical corrosion resistance. It is used commonly for low volume or prototype manufacture in high and low pressure processes.
The anodising process developed in the ALAMO project overcomes these shortcomings to achieve anodised aluminium tools which can compete with steel stools in the injection, blow and rotational moulding sectors.

The partners in this project represent a wide range of anodising, tooling, testing, manufacturing and research companies across the plastics industry:

- Rapra Technology RTD and Coordinator
- Andalplast Moulder
- Si2M Toolmaker
- ASE Anodiser
- HMF Anodiser
- PPA Moulder
- Alcan Material supplier
- Sigma Analysis
- QUB RTD
- Armines RTD
- Ascamm RTD

The project started in November 2004, and the main objectives were to produce tooling with

- High wear resistance
- Good thermal conductivity
- Good corrosion resistance

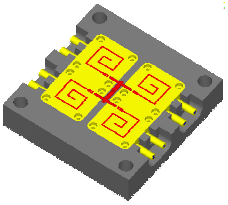
In addition, the tools would be lighter and quicker to manufacture than steel and also less expensive. The quicker production moulding cycle times achieved would also reduce component manufacturing costs and result in greater competitiveness in the global market by way of licensed technology.

Work Performed

Two processes, Injection moulding and Rotational moulding were selected for trials and two corresponding state-of-the-art aluminium alloys were chosen to make anodised tools from. AW 7010 was chosen for injection moulding – a state of the art 'hard' alloy material introduced recently to replace AW 7075 and AW 6082 for rotational moulding – a 'soft' alloy with excellent corrosion resistance and lower cost (50% cheaper) than AW 7010/7075.
The two streams of investigation would produce a 'High emissivity' formulation for rotational (and blow) moulding, where pressures are low and efficient cooling/heating is essential to slash long cycle times and a 'High wear 'formulation for injection mould tools, that can withstand high injection pressure and clamping forces.

A Design of Experiment process was followed to create a series of test plaques which defined then optimum parameters to achieve the desired properties such as hardness, wear resistance, emissivity, thermal conductivity and compressive resistance. The results were promising and the project progressed to the stage of making test tools in order to trial on a small scale the effect of anodising aluminium surfaces.

For the injection moulding tests a four-impression test tool was manufactured which tested steel and aluminium substrates, anodised and un-anodised. The part manufactured was designed to create high wear areas by means of narrowing cavities and sharp corners.



Running concurrently with the tool manufacture a CAD simulation was created to investigate the theoretical differences that anodising would make to filling, temperature, velocity, pressure and so on. The results for the test tool showed good commonality between the actual and theoretical data.

For the rotational moulding test two 300mm cube tools were manufactured, one anodised and one in natural aluminium. Comparative tests were run and various parameters were measured, internal and external to the tool. It could be clearly seen that there was a substantial reduction in cycle time between anodised and non-

anodised tools and this was later quantified as a 15 to 20 % reduction in cycle time from treated to non treated aluminium.

Because of the reduction in cycle time there is also a commensurate reduction in gas and electricity usage. The energy used to anodise an average tool is saved in approximately 7 mouldings. The calculation is by no means a Life Cycle Analysis but it shows the order of energy saving for rotational mould tools is extremely worthwhile.

For both injection and rotational trials the resultant mouldings were subjected to an array of tests such as GPC, Colour, Gloss, Density and DSC in order to discover whether the improved processing efficiency had affected the properties of the mouldings. No changes were detected which was positive, showing that tool performance hadn't been gained at the expense of material properties.

The test tools were highly successful and showed the impressive potential of anodised tools and so the next stage was embarked upon which was to make industrial tools more akin to real life situations.

For the injection tool an ambitious and quite complicated fan moulding tool was manufactured in anodised aluminium, replicating an existing steel tool. The exercise proved invaluable in learning about the details of how anodising affects the process of high precision tool making, how the tolerances are affected, the provision for standard inserts and tool matching. This particular tool showed that although the anodising is only 30 microns thick it affects the fit of tooling components and provision needs to be made at the machining stage or the anodising stage for this, and techniques were proposed and trialled. The anodising was successful in the aspects of appearance, wear and hardness. Much was also learned about the specification and finishing of tools with regards to anodising and also a proposed, simple, solution was proposed for future use by the anodising companies (involving controlled etching of the tool). The complexity of the tool did not cause problems for the anodising process but it the moulding trials were curtailed as the release of parts from the tool was difficult. The anodised surface may have had no influence on this problem but in the course of releasing the parts from the tool the formic acid used to dissolve the polymer over many days also damaged the anodised surface ending the trials in the time available.

At the final meeting of the consortium it was agreed that the use of anodised aluminium tooling should be considered, as any other parameter, on a job by job basis, taking into account part geometry, surface area to thickness ratio, size, draw

angles, surface finish, moving parts, ejection and so on. The software, tooling and moulding experience gained in ALAMO will help this decision.

The industrial tool for the anodising process was based on the test tool but with the addition of MECH (ceramic electrical heating panels), the latest innovation for rotomoulding tools. It was evident, as expected, that the cycle time benefits experienced in the industry standard oven-heating manufacturing method did not apply to the contact-heating method but the hardness, wear and corrosion resistance were beneficial.

Again, samples of mouldings were taken from the industrial trials, tested in detail, and showed no discernable differences between non-anodised and anodised tooling production showing that the benefits accrued have not been a t the expense of material properties.

Summary

The project was completed with good results and partners were agreed on the benefit from the knowledge gained. They are now free to utilise the techniques gained and the anodisers have in fact completed commercial projects. A large company, Fujikura, will promote the technology within Europe via the partners involved, under the trade name of Primal. It is extremely encouraging that, as a result of the dissemination work carried out, a global automotive company has enquired about the benefits of anodised aluminium tooling and is in discussion about possible uses. The ALAMO project has proved the viability of the combined technologies of aluminium tooling and anodised surfaces and the further development of the techniques will lead to many new applications.