ACRONYM Riblet
Title Riblet 325919

State of the art – Background

It is known in the natural world that a textured surface (containing an exactly controlled riblet structure) can impart benefits in regard to air flow and liquid flow along a surface. At the commencement of this project the complexity and scale of the optimum textured surface exceeded the capabilities of commercial application. This project employs state of the art techniques to reproduce a continuous landscape of discrete riblets that are evenly spaced and capable of being applied to both new aircraft surfaces and retrofitted to existing aircraft.
This project is an integral part of a larger project to combine riblet production with controlled application.

Objectives

The project created a design for large scale embossing moulds containing riblets that could be cut and welded into cylindrical sleeves without a disruptive welding seam.
The moulds will be used as the starting point to create a series of embossed application belts that will be attached to specialist applicators (produced in a different project) to create a lacquered riblet surface across the aircraft.

Description of work

The project deliverables were as follows:

- Explore and create seamless welding of nickel shims and determine the optimum metal thickness for sleeves.
- Develop a design for a riblet patterned shim that could be created and cut to 1250mm x 500mm to form a continuous cylinder compatible with the proposed applicator.
- To laser engrave a one piece polymer shim with an agreed riblet structure.
- To convert the polymer shim into a nickel master shim.

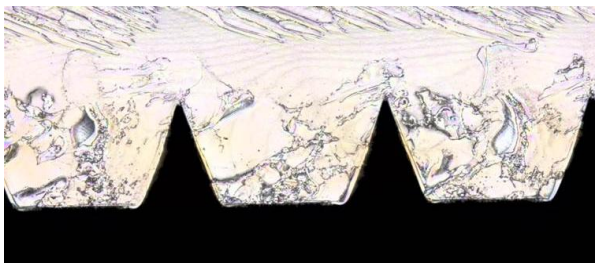
The project partners were as follows:

MK Fluidics Oy – seamless welding
Machovia Technology Innovations – design, technical specifications & technical management.
Crealas – Polymer shim laser engraving
3DAG – Electrolytic metal shim production
Axess Technologies – Project management

Results

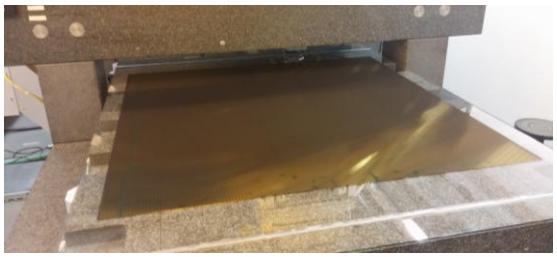
The Partners have pushed the limits of nano-sized riblet structured shim production to well beyond the known capabilities at the commencement of the project.
Initially it was thought that the riblet areas would be created on narrow strips of shims that would require welding together to create a master shim. This project has proven that it is possible to manufacture, in one piece, a massive 1,350mm x 1,350mm shim that can be cut down (to remove edge effects) to 1,250mm x 1,250mm allowing master moulds of 1250mm x 500mm in each riblet orientation to be produced. These could then be welded together to produce a continuous cylindrical shim with only a single welded seam. In addition, the Partners have demonstrated that micro welding can be achieved that creates a virtually seamless join. It was known at the outset of the project that welding seams can be the cause of air flow disruption and therefore should be minimised. This advance in welding techniques has proved to be a significant achievement of the project.

The riblet construction and format target for the project was initially set by IFAM to 48 microns high and a pitch of 96 microns. This produced a polymer construction of:



Following the successful production of samples, IFAM changed the riblet dimension specification to 51 micron height but maintained the pitch of the riblets and tip angle of 45 degrees.

The final giant polymer shim was manufactured and is shown here on the chuck of the laser system:



The target was to create a tip radius of less than 0.5 microns and this was achieved in the initial samples. In the full size master shim a double tip was created that may be a consequence of the change in specification. This double tip (which did not manifest in the original samples) was unexpected and surprisingly results in a tip angle (for a single peak) much narrower than could have been anticipated at the outset of the project. This demonstrates that the project has created structures beyond what was considered technically possible when the project first started. The Partners are confident from their experience that the full specified geometry can be achieved at the next attempt

a) Timeline & main milestones

Initially the project was allocated a total time of 12 months. It was discovered that the scale of the shims was so large that current equipment could not cope with extended machine time and optics contamination occurred. This resulted in new bespoke optical equipment being purchased with the final consequence that the project was completed in 31 months.
The main milestones were as follows:

- Welding seam study and evaluation
- Design of riblet structure and shims.
- IFAM evaluation of welding seams.
- Production of giant metal shims
- Delivery of sub-master shims to IFAM
- Project management and final report

b) Environmental benefits

Including riblets into the surface profile of an aircraft will improve the air flow past the surface which will reduce fuel consumption. To date only laboratory scale tests have been done and these indicate fuel savings of between 1 – 3%.
Until the shims have been fitted to applicators and the riblets applied directly to a lacquered surface of an aircraft and tested over a protracted period of use it will not be possible to accurately determine the full extent of the benefit. Riblets consume no power when included onto an airframe surface and may be retrofitted to an existing aircraft.

c) Dissemination / exploitation of results

Because the production of riblet application shims is only part of a much larger project then dissemination of this aspect only was considered undesirable until all other aspects (lacquer selection, applicator design and build) are also complete.
As a consequence of the project the knowledge of seamless nickel shim welding, large scale and consistent polymer ablation and the creation of massive nickel shims has been greatly enhanced. Several obstacles were encountered during the project that required major developments in

equipment control and methodologies. These incurred some serious project delays due to replacement equipment lead times that involved major capital investment by project Partners in polymer ablation optical systems. Clean Sky were very supportive of these delays recognising the cutting edge skills required to complete this ambitious project. These enhancements in experience and skill can be transferred to other applications. The project partners are keen to promote and exploit the knowledge they have gained from this project and would like to remain part of the total riblet application project moving forward.

d) Communication

The Project Coordinator was:

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Project Summary

Acronym:	Riblet
Name of proposal:	The Development and Construction of a master mould for Riblet Construction
Involved ITD	Smart Fixed Wing Aircraft ITD
Grant Agreement:	325919
Instrument:	Clean Sky
Total Cost:	€ 349,992
Clean Sky contribution:	€ 262,494
Call:	Joint Technology Initiatives – Clean Sky (SP1-JTI-CS-2012-02
Starting date:	1st March 2013
Ending date:	30th September 2015 (with agreed extensions)
Duration:	31 Months (with agreed extensions)
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