ASRC News

QUARTERLY NEWSLETTER OF THE AVIATION SERVICES REASEACH CENTRE

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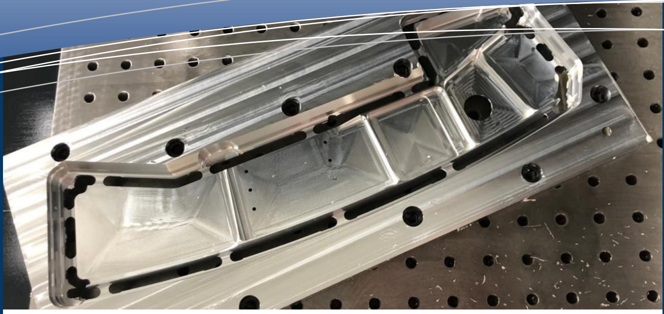
SOCIAL DISTANCING ISSUE

Message from Louis LAI (Executive General Manager (AFS, HAECO HK)

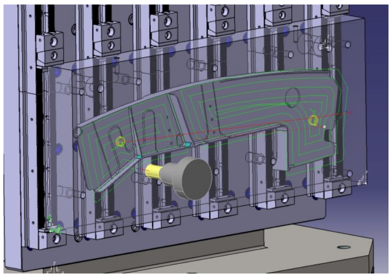
HAECO is a founding member of the ASRC and it has been a pleasure to work with them for over six years. Personally I have been involved in both my capacity here in Hong Kong and in Xiamen in the PRC. I can honestly say that the assistance of the ASRC in project development and implementation has been tremendous. It is most useful to have an offsite unit like the ASRC involved in process improvement and development who can make use of the academic resources of the PolyU and still have an experienced eye on the day to day practicalities of aircraft maintenance with all its convoluted regulations and requirements. Innovation and Technology will be the way forward for the Aviation industry. The ASRC continue to surprise us with novel solutions to existing problems and we look forward to working with them in the future.



ASRC Increases Manufacturing Capability

Despite the COVID-19 Pandemic, the Design & Manufacturing Technologies stream of the ASRC has been expanding its manufacturing capability, specifically relating to the machining of Aerostructure parts on our ECOSPEED F HT2 1010 High Speed Machining Centre. This is to further enhance our ability to help support aircraft part manufacture within China and South East Asia. Key technologies being targeted are digital manufacturing, machining strategies, optimised material removal rates, specialised cutting tool geometries and cutting parameters, part holding methodologies, as well as part distortion minimisation and part rework reduction.

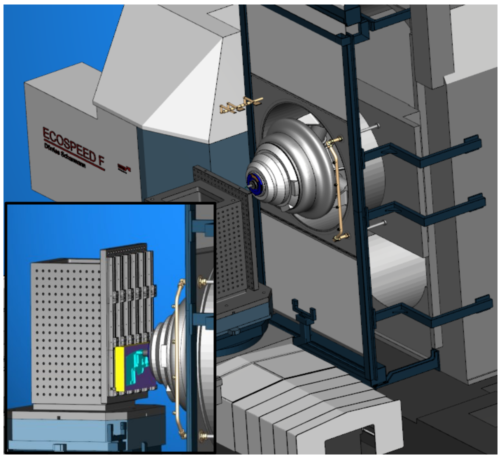
A series of Aluminium Alloy parts were programmed and machined using high speed machining techniques via stratified multiple machining and trochoidal milling, to produce optimal material removal while avoiding any excessive concentration of heat in order to improve heat dissipation and reduce thermal deformation, ensuring part flatness can be better controlled, and where the force applied to the parts will be more uniform and the probability of deformation will be smaller. A variety of component holding methods have also been adopted to try to reduce shop rework and deburr post machining, increasing profitability.



A key area of interest for the ASRC and its members, is the reduction in part distortion during the machining process. The use of monolithic structural components in the Aerospace Industry gives significant practical advantages such as the reduction of weight in the parts and assemblies and improvements of efficiency in aircraft. However, one of the most challenging issues during the manufacturing of structural parts is distortion. This problem is one of the most common phenomena that directly affect the manufacturing life of aircraft structures because it produces non-conforming parts in the product lifecycle, causing significant financial issues for aircraft component manufacturers. Part distortion occurs when the workpiece material of a component experiences several types of loads in its manufacturing processes, which include thermal gradients, mechanical loads, metallurgical phase transformation and/or their coupling effects, resulting in plastic deformation and residual stresses in the component. This means that the original geometric design intent for the aircraft-structures cannot be obtained, since the parts experience a deviation from the desired dimensions as a direct effect of residual stresses.

In this big issue

The residual stresses play a fundamental role in the part distortion, where these stresses are either inherent in the raw material of a workpiece or induced by the machining processes. Regarding the induced residual stresses, the correct machining variables such as part location, cutting speed, feed per tooth, reduction of tool wear, axial and radial engagement, as well as machining strategies can be controlled in the manufacturing process to reduce part distortion. Where the raw material residual stresses are usually controlled by additional processing after machining.

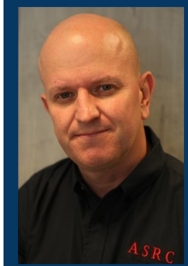


The economic losses generated by part distortion is a subject of many studies by companies in both the automotive and the aerospace industries, where Boeing have estimated that the rework and the scrap costs come to more than USD290 million per annum, whereas a study by the German automotive sector led to a valuation of an economic loss of EUR850 million per annum due to part distortion in several of their products. These two main cases show that many companies could benefit from new engineering research in relation to part distortion phenomenon.

Technology Corner
CAD / CAM

Computer Aided Design and Manufacture is an ubiquitous aspect of modern production. It is an acronym widely used and poorly understood. In these short notes we try to show the importance of this manufacturing process.

The phrase "computer-aided design" was coined by Douglas T. Ross, a researcher at MIT in the early 1950s who saw the potential in military radar technology to create designs on a computer display system, where other researchers such as Dr. Patrick J. Hanratty of GM assisted its development with Design Automated by Computer (DAC). Though the first true 3D CAD/CAM program was created in 1968 by Pierre Bézier, an engineer at Renault. His UNISURF CAD system transformed design and manufacturing, moving the vehicle design process from manual drawing boards to computer-aided design and is regarded as the original model for many generations of CAD programs. As computers became more affordable and shrank in size CAD/CAM spread beyond just the automotive, aerospace, and electronics industries to enjoy near-universal usage. The 1970s and 1980s witnessed the emergence of 3D modelling and 3D designs, with programs including Romulus, Uni-Solid, and CATIA. By this point, CAD/CAM was also being used to design industrial tools. Manufacturers valued CAM for its speed and precision and ability to optimise the manufacturing process, decrease material waste, shorten turnaround times, and provide clear visualisations. By the 1990s, algorithms had grown increasingly sophisticated, with engines capable of advanced parametric techniques. By 1994 over one million units of AutoCAD had been sold, with over 350,000 users of CAD/CAM reported worldwide. Today, the CAD software market is faced with the emergence of free and open-source CAD software, where CAD/CAM is used across dozens of specialties including aeronautical, architectural, civil, electrical, electronics, mechanical, pipeline, and photovoltaic. The efficiency and user-friendliness of CAD/CAM software has evolved to the point where the career of the trained user may one day be threatened by software that anyone can use, and where artificial intelligence in design software allows the automation of design tasks and enhances quality control by anticipating design errors and with machine learning paves the way for the creation of unique designs without human input. Where cloud technology allows CAD/CAM to move beyond a single computer at a workplace to universal access through a software as a service model. This will mean several people can work on the same project at once while sharing across departments and geographies improving concurrent and collaborative engineering.



Robert Voyle is a Principal Research Fellow in the Design & Manufacturing Technologies Stream of the ASRC.

NDI of fuel tank fasteners

Within the wing fuel tanks there are a large number of fasteners which are covered with an organic sealant. This sealant prevents leakages but must be removed every 6 years to check if the structure underneath is damaged. This project proposes to automatically remove the sealant and to use advanced non-destructive inspection (NDI). The effectors will be conveyed inside the fuel tanks using a robot arm small enough to go through the manhole and to reach the areas to be processed. The delivered system shall alleviate the need for fuel tank entry by an operator, thus avoiding many dangers.
The sealant removal technologies investigated by the ASRC include dry-ice blasting and mechanical removal via polymeric cutting tools. The applied research aims to determine the most appropriate method for surface preparation. The focus will be set on achieving the highest possible sealant removal rate. The dry-ice blasting has shown to be very promising as it is a contact-free method leaving virtually no residues. Depending on the pellet size and the applied air pressure, the abrasion can be either gentle or strong.
As for NDI, the developed technology must detect cracks as small as 5mm. The use of a coil to induce heat into the area to inspect along with a thermal camera (infrared) is currently the preferred method. The objective is to use temperature variations to reveal crack tips.

Automated Surface Preparation and Inspection

Paint removal of aircraft components prior to inspection, repair or repainting is usually a time consuming and messy process involving unhealthy chemicals or manual sanding methods and is conducted either in the hangar or in a specialised workshop environment at a great expense of floor space. The aim is to use laser ablation to remove paint and other coatings with an integrated real time inspection system to avoid damage to the substrate material. An autonomous vehicle will also be developed to de-paint and clean seat tracks in the cabin using a portable laser system with onboard power supply and extraction.
The ability to remove aircraft coatings by an automated feedback laser ablation system will have the following advantages for the local MRO industries: aircraft turnaround time will be significantly reduced, MRO capacity will be increased, aircraft weight saving resulting in better fuel economy (approx. 0.25 tonnes per livery), reduced damage to the composite skin through the preservation of the primer coat and Improved working environment with less use of harmful chemicals and the associated waste.

These factors would greatly increase the commercial advantage of the local MRO companies over their competitors.

Project Descriptions

ITC funded Open source projects underway in the ASRC

Advanced Blade Dynamics

Correct surface finishing of the blades and vanes in a jet engine is critical to the efficient running of the engine over its service life. Furthermore the components, on return to the engine body, must be balanced correctly to minimize or nullify vibration and wear.
The ASRC are devising a method to balance the blades with relation to their mass and the second moment of area. This is a step change in the way that the finished blades are processed and adds a degree of complexity resulting in an astronomical number of permutations. It is a great challenge to find the solution to this type of problem.
In addition we are looking at novel surface finishing methods to improve surface roughness by a deterministic method. We are fortunate to have available the services of the Advanced Optics Manufacturing Centre in the University who will assist us in devising a non contact method of fine surface finishing of the blades with no impact on surface geometry.

Cold Metal Spray Deposition

Firing metallic, ceramic or composite alloyed powders in the supersonic speed range of 600 - 1200 m/s as a depositional repair process may sound like science fiction, but cold spraying is very much science fact that will bring benefits to aviation component repair in spraying applications.
The dynamic work-hardening process involved enables large areas to be bonded rapidly with purely mechanical clean adhesion; heat produced from the powder and substrate (work-piece) collision to plastic deformation is retained in the zone where it is created, resulting in negligible residual stress with initial physical and chemical material properties retained.
The challenge however remains in maximising the utilisation of heat generated upon the impact of powder governed by the physics of adiabatic shear instability. R&D work at the Centre is being carried out to identify the critical particle velocity tolerance window for successful repairs on selected components in relation to spray particles of interest.

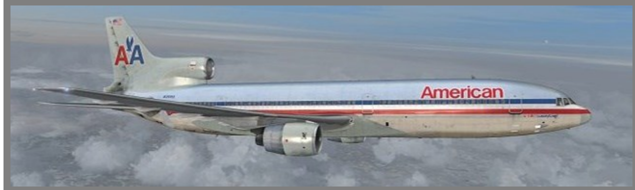
Advanced Digital Manufacturing Overview of Aerostructure Parts for HAESL and IC

Aviation Classics — The Lockheed L - 10 11 'Tristar'

CX Tristar, VR—HHW at Kai Tak, late 80s

CX Tristar… Note the MAS DC-10 in the background with clearly different number 2 engine

The first Tristar took to the skies in 1970 and the first plane was delivered to American Airlines in 1972. By any measure it was a plane ahead of its time. It was conceived to fill the gap between the B747 and the B737 to give a plane with wide body medium range that was able to carry around 400 passengers. It's competitor was the venerable DC10. The Tristar, however was packed with electronics and was capable of not only automatic take off but also automatic landing. It had the largest cockpit of any aircraft—larger that a B747 or A380 and had room for two pilots, a flight engineer and two observers. It was easily differentiated from the DC 10 by its S-bend intake for the number 2 (rear) engine.



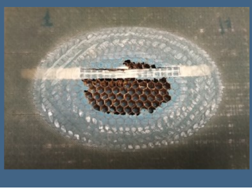
The aircraft was very popular with local carrier Cathay Pacific, who used it on all its Asian routes, especially into China at the time that China was opening up under Deng Xiaoping. It was a great workhorse for the airline and highly profitable. Cathay operated 20 such aircraft with only 2 being new purchases, the rest were bought from other airlines who experienced difficulties at that time. An interesting history of the aircraft in service with Cathay Pacific can be found at www.asianaviationphotography.com/acatalog/The_Cathay_Tristar_Story.html

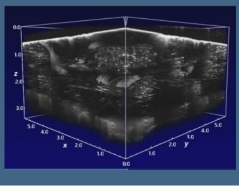
ASRC Equipment — Thorlabs Optical Coherence Tomography Microscope

Features of the OCT Microscope

- The Optical Coherence Tomography (OCT) Microscope is a powerful tool that allows us to view 3D images of components that are transparent to the near infra red spectrum. Originally developed to aid Ophthalmologists and Cardiologists to view human tissue, it turns out to be very good at producing volumetric images of glass fibre composites and other such materials.
- The ASRC have used this technology in determining fibre direction in GFRP as several layers of composite can be resolved with this technology
- Focal length 18 mm or 36 mm
- Wavelength centred at 930 nm
- FFT to convert from frequency to spatial domain in real time
- 4 micrometre axial resolution in water-like material
- Intuitive image interpretation

Applications:-
Medicine, metrology, 3D imaging, inspection.





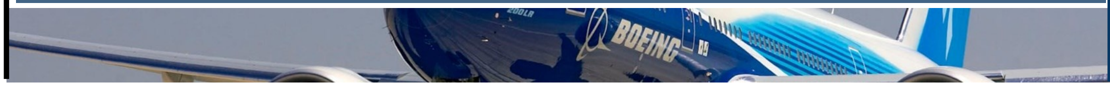
Membership Benefits of the ASRC

Companies who join the ASRC as members should have a primary involvement in Aircraft Maintenance, Repair and Overhaul or should benefit from involvement and investment in technologies which may spin off from this field of research and development.
If you feel you are in one of these categories and would like more information on benefits and details on how to join, have a look at the website at www.asrc.hk or contact our Director, Prof. Stephen O'Brien. (Stephen.Obrien@polyu.edu.hk)
In principle there are different levels of membership with different levels of access to research in the ASRC. Almost certainly there is a membership level that is a good match for your company.

Asian Airlines Profiles

CATHAY PACIFIC

Cathay Pacific Airways is the flag carrier of Hong Kong and principal operator out of the Chek Lap Kok Asian Hub Airport. Cathay Pacific were formed in Shanghai in 1946 but moved to Hong Kong after only a few months. They have grown to be the 10th largest airline company in the world and likely the largest air cargo company. Cathay operate a fleet of 133 aircraft consisting of A330, A350 and B777 passenger aircraft. Operating a number of Asian routes with their partner Cathay Dragon is the bread and butter of the business. They also have transpolar routes to New York and trans Pacific flights to the West coast of USA in addition to long haul routes to Europe and the Antipodes; Cathay Pacific truly cover the globe with their hub and their heart in Hong Kong.



Staff Profile:

Mr. Nicholas Duke

Nick is a Principal Research Fellow in the Materials, Data and Instrumentation Stream. He joined the ASRC in late 2014. Nick has a Bachelor's degree in Mathematically-based Computing and is a Chartered Engineer (C.Eng.). On entering industry Nick worked in this roll for many blue-chip companies including Rolls Royce, BAE Systems, Jaguar Land Rover, GEC and many others. These companies required an efficient professional who could Specify, Create, Document, Service and Maintain a System while keeping to a budget.

Nick specialises in working on the tangled web of communications between the 'Internet of Things' and Supervisory Control and Data Acquisition systems, but frequently has to develop the applications end-to-end as the 'Things' are often bespoke for each application and the Supervisory Control human is increasingly being replaced by AI. In addition to developing Systems for the ASRC such as 'The Booth', 'Tool Tracking' and a 'Corrosion Assessment Device', his role is to create an environment for the researchers where they can easily and simply develop software for their projects in a reliable environment on a secure platform.

Activities

All APR — All ASRC Staff Members were requested by the PolyU to work from home

4 MAY — Partial return to work

11 MAY — Composite layup training

21 MAY — Senior Staff (HAECO) Visit

27 MAY— Advanced Digital Manufacturing Overview for IC & HAECO

28 MAY— 4D Inspect training with HAESL

11 JUN— TechMan Robot Training

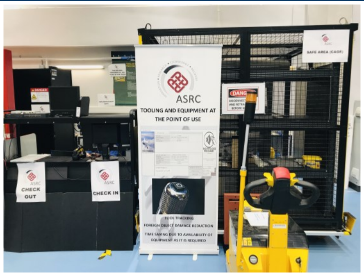
18 JUN— Testing of Corrosion Assessment Detection Scanner at HAECO

19 JUN— Visit by former PolyU Council Chairlady, Ms Marjorie Yang and Prof. Alex Wai (DP)

Dr. HP Tang explains the blade balancing project to HAECO Senior Staff

HAESL and ASRC staff at the training session of the 4D InSpec

Who's doing What, and Where's my stuff!!!



The ASRC offers a comprehensive range of Project Planning tools which can be integrated into an Enterprise Project Planning Solution. We also offer our unique Tool Tracking system which allows Tools, Equipment and Kits-of-Parts to be tracked through an environment.

In a modern factory or factory-like environment, the use of Assets and Resource through Enterprise Project Planning (EPP) is essential. We offer a range of EPP which can be tailored to your requirements and allow the company to track workflow and assess productivity.

Allocated Jobs or Tasks can be managed through a local system which is available at a departmental level. Our range of Task Management tools are built to fulfil your requirements and allow smooth workflow and increased throughput.

Once authorized, Jobs or Tasks are performed by the Engineers and they can receive or update their task status through a software system which is highly integrated with the production environment. Our "Production Environment" is, naturally, specialised in the field of Maintenance, Repair and Overhaul of Aircraft.

It is vital to know where Tools, Equipment and Kits of Tools (TEK) are in an Aircraft MRO environment. This can prevent problems with tools left in aircraft or equipment being left in a dangerous place and creating Foreign Object Damage (FOD).

Our Tool Tracking tools allow TEK to be allocated from a Central Stores against a job/task to a responsible engineer. This is the first stage of a Tool Tracking system.

ASRC uses a unique system of "safe areas" to allow parking of the TEK within a job/task. This can reduce strain on the engineer as they can take regular breaks and store the equipment mid-task.

We also have smart enclosures to allow storage and ease of movement of the TEK within a job/task. This can keep expensive tools together in a set package as well as tracking them for efficient usage and to prevent FOD.

Please contact Andrew Gridley at Andrew.Gridley@polyu.edu.hk for information.

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