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ASRC News

QUARTERLY NEWSLETTER OF THE AVIATION SERVICES RESEACH CENTRE

Message from Alexander Chao, Boeing China.

In 2019, I assumed leadership of Boeing Research and Technology in China, and one of my first tasks was to visit the ASRC in Hong Kong. I was impressed by the people I met, the technical achievements I saw, and how ASRC lives by their motto — *"from academia to application."*

Boeing has always championed applied industrial research in a university environment, and ASRC is a great example of that model. Over the years, we've seen ASRC leverage the capabilities and facilities of the HK Polytechnic University, and we value the close working relationship between ASRC, HAECO, HAESL, and Boeing. This relationship is strengthened through tangible results that ASRC has consistently produced, such as laser ablation and sealant removal tools.

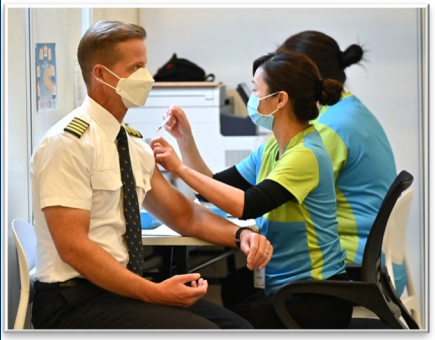
As the aviation industry positions itself for a post-pandemic recovery, ASRC is playing an important role in developing and implementing new technologies for a more sustainable future. I wish them all the success going forward as we beat this virus together.

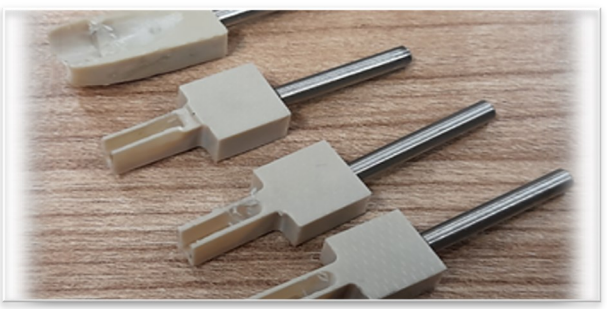
Testing Face shields with an artificial sneeze

Coping with the Pandemic

The PolyU in general and the ASRC in particular have been rather unlucky over the past 18 months. After having been exposed to a year of civil unrest, the Campus was occupied and besieged by the police meaning that we were all working from home. Immediately after returning, to pick up the pieces, we were again sent home due to the restrictions imposed by the COVID19 situation.

At the same time international travel virtually came to a halt. This had the effect of putting financial strain on our three industrial partners. A further issue was that the ITC who are our biggest supporters were also 'working from home'. Project proposals were delayed and the window for submission slipped meaning that little new funding for projects was received in the last year. Despite all this the ASRC has redoubled its efforts to get things moving by working closely with industrial partners to help them prepare for the days when, with global vaccination and hard work the pandemic will be over and we can not only return to work but return to flight!





Assorted PEEK cutters

In this big issue

Sealant Removal

The ASRC was requested by Boeing to develop tooling to speed up the sealant removal process to inspect the fasteners underneath inside an aircraft fuel tank. The aircraft fuel tank space is very confined for the mechanic to work inside, therefore the chosen tooling must be tiny, lightweight and very effective in this particular task. The chosen material must be hard enough to cut the sealant while not inducing any damage to the substrate material. PEEK (Polyether-ether-ketone) was the material selected due to its machinability, its strength and its Poisson ratio. It is chemical resistant and in line with all requirements for this task.

PEEK was verified by ASRC staff in the University laboratories and workshop and it passed per the BOEING requirement for the removal of sealant on Aluminium clad sheet.

HAECO have conducted several trial runs for this tooling both to remove sealant on the wing and on the fuselage. The feedback is very positive compared to the present legacy tooling. HAECO have expressed interest to procure several tool kits for their daily maintenance work. In the near future, the ASRC will develop further shapes of sealant removal bits to suit different needs and different substrate materials.

Technology Corner Thermal Imaging

Thermal Cameras were once the purview of the military and law enforcement, only seen by the public in movies. Not today however. Now read on ...

The Thermal Camera relies on specific rather expensive detectors which respond to the incident radiation in the wavelength range 8 –12 µm (long wave) or 3 – 5 µm (mid wave).

The detectors record radiation not temperature, the temperature is calculated from the emissivity of the body compared to black body emission.

The detectors don't differentiate between different wavelengths and all the energy in the wavelength range is recorded.

The original camera's would scan a single detector ($Hg_{(1-x)}Cd_{(x)}Te$) across the field of view and build up an image from these signals. The scanning was accomplished with a combination of polygon mirrors and folding mirrors making the entire Thermal Imaging Common Module (TICM) rather bulky and sensitive. The detector had to be cooled electrically or by the use of liquid N_2. This seriously limited the applicability of the Thermal camera and it was restricted to military and security fields. These instruments were very high resolution and very highly sensitive and hence were ideal for the task at hand.

By the mid 90s uncooled focal plane bolometric arrays (Vanadium Oxides) had been developed that allowed for reasonable spatial resolution with good sensitivity.
This enabled the thermal camera to be used widely in commercial applications giving the, by now familiar, black and white or false colour images we see in fever and temperature checking applications.

Tony Mannion is Leader of the Data, Materials and Instrumentation Stream of the ASRC.

Machining Distortion Minimisation

In the process of manufacturing aero structures, a considerable amount of material is removed from the blank material to create a monolithic structure. This of course requires substantial machining on a multi axis machining centre. One drawback in the production of these monolithic structures is that the machining process can leave behind some stresses which manifest as distortion in the part.
This project aims to develop a machining strategy for both three and five axis machines that will minimise the remaining distortion. The parts will be measured 'on-machine' for strain during final cuts and the data from the machine will be added to this to create a model of the process. This can be run in a digital twin to make predictions on the changes resulting from modification of the machining parameters such as feed, speed and depth of cut (among others). The residual stresses in the final part will be measured by incremental hole drilling through strain gauge rosettes and this information will also be used to verify the model. We shall endeavour to make use of the local (Guangdong) China Spallation Neutron Source to do neutron diffraction measurements and get a value of the stress in the core of the blank or even the finished structure. The ASRC are uniquely positioned to carry out this project as we have the use of a high speed machine and a high torque machine in the centre.

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.

Project Descriptions

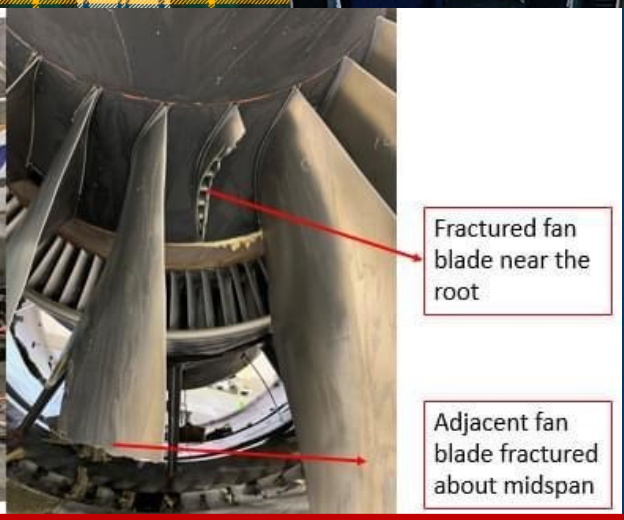
ITC funded Open source projects underway in the ASRC

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 Centre will devise 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 grate challenge to find the solution to this type of problem.
In addition we will be looking at novel surface finishing methods to improve surface roughness in 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 regime 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 application.
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 maximizing the utilization of heat generated upon the impact of powder governed by the physics of adiabatic shear instability.
R&D work at the Centre will be carried out to identify the critical particle velocity tolerance window for successful repairs on selected components in relation to spray particles of interest.



Importance of Testing in Engine Parts — Recent United 777 incident

Aviation Classics — Hawker Siddeley Trident

BEA Trident — late 60s

Around the late 50s there was great interest in three engine aircraft for short range European flights and the British effort was the Hawker Siddeley Trident with three Rolls Royce Spey low-bypass turbofan engines. The aircraft was specified by BEA for its short haul European flights and was comparable to a B727. The first flight of the Trident was in 1961, it entered service in 1964 and it was withdrawn from service finally in 1995. A total of only 117 aircraft of all variants were produced compared to 1,832 B727s. Failure to capitalize on a breakthrough idea being a recurring theme the history of British engineering.

The Trident was the first aircraft to fly with a three engine configuration and was the first aircraft to be able to make an instruments only landing due to its large and advanced avionics package which gave rise to its unusual offset front wheel.

CAAC Airlines Trident at Kai Tak

Around 35 Tridents were sold to the PRC and some were used by the PLAAF, indeed it was a Trident 2E that was used as the official aircraft of Mao Zedong and Zhou Enlai in the late 60s and early 70s.

A trident 2B with CAAC slipped off the runway at Kai Tak on 31st August 1988. It fell into the sea and tragically 7 people lost their lives.

ASRC Equipment — Residual Stress Determination Rig

The ASRC has the capability to measure residual stress near the surface of a part to a depth in the order of 1 mm using the method of incremental hole drilling through strain gauge rosettes. The machine is an Italian SINT MTS3000 and we make use of HBM and Vishay Gauges.

The incremental method of hole drilling uses a high speed air turbine driving an inverted conical milling tool. Speeds of 400,000 rpm are used to cut into the material producing minimal additional stress. After each drilled depth a reading is taken on the strain gauges by the software controlling the machine and after a delay of 5 seconds the next drilled depth is made.

Evaluation of the Residual stress is performed by back calculation of the observed strains. All calculations conform to ASTM E837-13A. There are a number of methods of doing this but all rely on integral calculations and coefficients found previously from FEA calculations.

Incremental Drilling Machine

Strain gauge in place

Applications:- Determination of the residual stress in machined parts, welded parts and blank materials. In principle the machine can be used off-site to make measurements on parts 'in-situ'.

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

中国南方航空
CHINA SOUTHERN

China Southern Airlines

China Southern Airlines are the largest of the state owned Chinese airlines and operate a number of international long haul flights. They are the only airline in China who operate the A380 aircraft. The airline split from CAAC when the Government decided to rearrange the national carrier into four separate airlines. They still required government permission to operate overseas flights and initially focused on the Paris route but in the end ran the A380s to America and Australia. The airline found profitable use of these aircraft on the HK –Beijing route as well. China Southern offers 485 flights a day from its Guangzhou hub and 221 from its Beijing hub.

Staff Profile:

Robert C Voyle

Robert was one of the first staff to join the Aviation Services Research Centre in January 2015 and he is currently the Head of the Design & Manufacturing Technologies Group. He has over 20 years of experience in the Aerospace industry, having worked for AIRBUS and GKN Aerospace in the UK, and EADS and Eurocopter in Germany. During that time, he was a lead member of a manufacturing systems engineering project team. He was responsible for manufacturing and automated assembly as well as the design for manufacture needs and requirements for new product introduction. This included the Eurofighter Typhoon, A340-500/600, A318, A380, A400M, and more recently A350XWB. He has experience of working within and managing the NC Programming and Automation Teams for machined and assembled aerostructures in both metallic and composite materials, as well as being the interface with the design groups as part of the Product Lifecycle Management process. He has worked on the specifications for and managed the introduction of large-scale equipment as part of the production system to meet the design intent, quality requirements, and production demands of the aircraft programme to be delivered.

Activities

08 FEB — Training on amplifier software and hardware for strain and displacement gauges

11 FEB — Demonstration and discussion with Prof HC MAN on face shield design testing

25 FEB — Filming at the ASRC workshop for PolyU publicity. A star is born?...

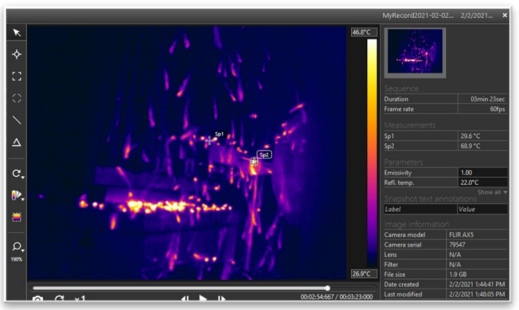
2 MAR — Technical Committee meeting

2 MAR — FAT by HAESL on turbine blade inspection machine

Turbine blades — automatic inspection device

Socially distant in – house training

Discussions with Prof HC MAN



Thermal imaging of machining processes

Staff Achievements

Shehzaad Mohammad (Centre) with his team

Mr. Shehzaad Mohammad, a researcher with us at the ASRC recently won a top award in a competition at the Hong Kong science park in the Hong Kong 'Techathon' competition.

He and his team from the PolyU designed and manufactured an 'add-on' for a smart phone like a battery pack case, which translates incoming text into braille for the benefit of the visually impaired. In addition to the prestige of wining first prize in the Social Impact and Health category, he and his team shared a check for HK$5,000. Congratulations from all of us!

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