School of Mechanical and
Aerospace Engineering

PhD Project 2019-2020

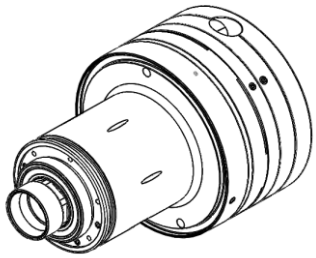
Title: Design and productionisation of aerodynamic bearings using foil and hybrid air bearing technology for high speed turbo-machinery applications

WESTWIND
A Novanta Company

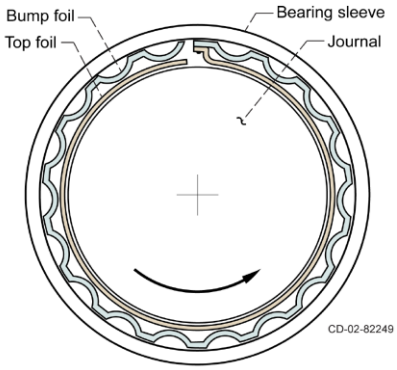
EPSRC
Engineering and Physical Sciences Research Council

Background:
The project is funded by EPSRC and Westwind Ltd, which is the world's leading specialist air bearing designer and manufacturer. Westwind air bearing spindles make the difference in PCB manufacturing, automotive coating, semiconductor manufacturing equipment, and many other markets where performance needs are outside the scope of conventional bearing technology. The company has advanced high precision manufacturing capabilities at their facility based in Poole, in South England. Their market is international, with many customers in Asia.

Air bearings are used in high-value applications such as ultra-high precision machining (micro-electrical and optical industries), medical applications and space technology due to their extreme precision, high rotational speeds, minimal friction and oil-free operation. Foil air bearings are self-acting, hydrodynamic fluid film bearings that use air as their lubricant. They are capable of supporting lightly loaded, high-speed rotating shafts. The load-bearing film is generated by the viscous pumping action of the moving shaft surface. The fluid film forms between the moving surface and a thin, flexible sheet metal foil layer that is supported by a series of spring foils. Foil air bearings have been used in small quantities aircraft cooling systems, but these are hand-made and assembled individually; consequently they are high cost. There are other high-volume applications where air bearings would be advantageous, but a new air bearing concept is needed for high-volume, low-cost manufacture. For future applications such as microturbine generators (e.g. vehicle range extenders and remote telecoms masts) and fuel cell blowers, low price and high volume are essential. In particular, the collaborator has identified an opportunity with fuel cell blowers, electric boost compressors and even turbochargers. This project aims to develop a new compliant foil air bearing design that is suitable for high-volume manufacturing.



Atomiser Spindle



Cross section of foil air bearing

Project description:
This project will investigate new foil and hybrid air bearing concepts that exploit recent advances in manufacturing methods, such as designing a foil support structure that could be produced using additive manufacturing or laser surface machining. In order to use these techniques a different approach must be taken to the bearing design. Generating new concepts for a foil air bearing for high-volume manufacture depends on fundamental understanding of the fluid-structural interactions. This project will use 3D aero-elastic modelling methods (coupled CFD and FEA) to analyse and understand the fluid film generated by the viscous action of the moving surface to generate the hydrodynamic pressure to support the shaft, while modelling the deformation of the compliant foil and supporting spring structure. Recent advances in manufacturing will be assessed to see which techniques could be exploited to produce alternative compliant structures and achieve automated high-volume manufacture, thereby transforming the cost of conventional foil air bearings.

Key qualifications/skills required for the post:
Applicants must have a strong 1st class honours degree in mechanical or aerospace engineering, or an equivalent qualification at Masters level. Candidates should be able to demonstrate that they are highly motivated, have excellent communication skills, and be able to undertake challenging tasks under their own initiative. Any experience relevant to aerodynamics or turbomachinery would be advantageous, but is not essential.

This 3.5 year studentship is funded by EPSRC and is open to students who have been resident in the UK (ref. EPSRC eligibility requirements).

Key transferable skills that will be developed during the PhD:
The project will use advanced multi-physics engineering simulation along with experimental performance testing. 3D aerodynamic and structural modelling work will be carried out using the industry leading ANSYS CFX, Blade-Modeller and Mechanical software suite. Performance testing in the QUB Turbo Lab and at the company will use advanced instrumentation, National Instruments data-logging equipment and LabVIEW software. Professional skills will also be developed, including leadership, project management, technical writing and presentation skills. The skill set is not limited to the air bearing application and will be very transferrable into other manufacturing, turbomachinery and energy industries.

The PhD student will work closely with the industry supervisor, undertake a 3 month industrial placement at the company, and also visit the company twice a year for formal project review meetings. The project may also require a visit to other customer locations in North America and Asia. PhD students in the Turbomachinery Research Group are expected to participate in the international technical community by attending conferences in North America, Europe and Asia. It is also expected that high quality technical papers will be presented by the student at the leading conferences – ASME Turbo Expo, the Global Power and Propulsion Forum, the European Turbomachinery Conference and the IMechE Turbocharger Conference. These events will provide a platform to develop a network of professional contacts for further career progression.

Applying:
Applicants should apply online at http:/go.qub.ac.uk/pgapply. A covering letter and CV should be uploaded. Closing date for receipt of applications: Tuesday 30th April 2019. [NOTE: This studentship is subject to a selection process and the approval of the industrial collaborator.]

Lead supervisor:	Dr Prof Stephen Spence (s.w.spence@qub.ac.uk)
Other supervisor(s):	TBA
Guaranteed stipend:	The studentship covers fees (for students eligible for UK home fees) and includes a tax-free income of £19,925 per annum (comprising a £14,925 basic stipend plus a performance related industrial top-up of up to £5,000, subject to satisfying the company's expectations). There is also the opportunity to undertake teaching and demonstration duties within the School to earn additional income.
Conditional top-up available:	A performance related industrial top-up of up to £5,000 in addition to the basic stipend of £14,925, subject to satisfying the company's expectations of progress.

PhD students in the School have the opportunity to apply to be demonstrators on undergraduate modules. Compensation for this can amount to in excess of £2,400 per year.

Queens University Belfast is a diverse and international institution which is strongly committed to equality and diversity, and to selection on merit. Currently women are under-represented in research positions in the School and accordingly applications from women are particularly welcome.