ptmc

The Centre for
Power Transmission
and Motion Control

The First 50 Years

By Professor Andrew Plummer

UNIVERSITY OF
BATH

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Contents

This page and main image right: Construction and completion of the Centre's new building, opened in 2004

In the beginning...

The Centre for Power Transmission and Motion Control was originally called the Fluid Power Centre, and was established in September 1968 as part of the School of Engineering in the Bath University of Technology. Fifty years later, and with a change of name and a broader remit, the Centre is still thriving, now as part of the Faculty of Engineering and Design at the University of Bath.

The Centre's 1968 home: Ashley Down, Bristol. Today it is part of City of Bristol College

When the Centre was founded, the University was based in Ashley Down, Bristol. The first site for the Fluid Power Laboratory was an old orphanage. The new facilities opened two years later at the current Claverton Down campus were a significant improvement, supplemented in 2003 by a dedicated research building, 8 East.

There have been significant changes during The Centre's fifty-year life time, but the broad objectives of the Centre have endured. In the first Annual Report in 1970 these objectives were stated as being to provide specialist courses in Fluid Power both for graduates entering the industry and for experienced technologists; to undertake consulting work; and to undertake research work in the field of fluid power. The involvement of industry in all of these activities was considered a priority. The balance between activities has shifted through the years with an increasing emphasis on research, and a diversification beyond fluid power. However, the elements remain the same with the beneficial effects of cross-fertilisation recognised from the early days. The strong commitment to industrial involvement is also unchanged.

The Centre was established with a grant of £17 000 from the UK government. The Centre was one of a number of similar bodies provided with "pump priming" funding at that time by the University Grants Committee in response to the Bosworth Report (1966), which sought to improve the training of graduates within manufacturing industry. The Centre was the only one of these bodies to survive five years, let alone fifty years.

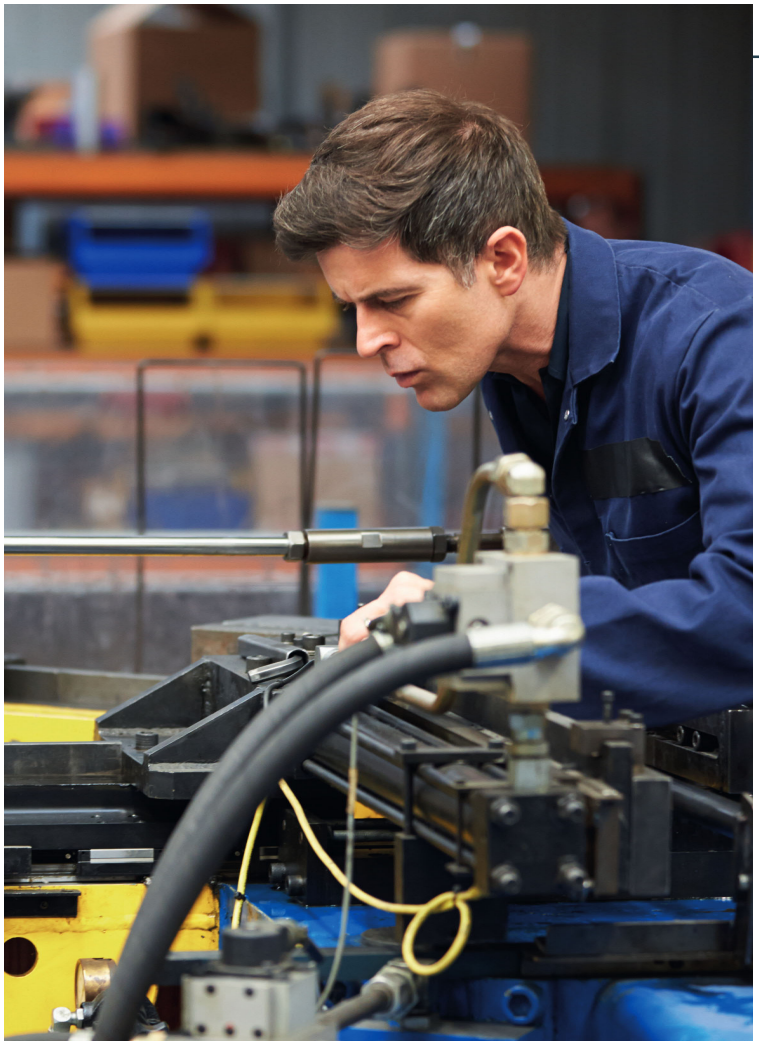
The founder and first Director of the Centre was Ted Bowns, and the success of the Centre owes much to his vision and energy. Following National Service in the Royal Navy as an aircraft engineer, Ted began his academic career in 1953 when he was an Assistant Lecturer at Nottingham and District Technical College. Three years later he took up the role of lecturer at Bristol College of Technology,

First Director Ted Bowns (centre), and Senior Lecturer David McCandlish (far left) with course delegates, c1980

joining the fledgling Bath University of Technology in 1965. Ted retired in 1987, and was succeeded as Centre Director by Cliff Burrows, recruited from the University of Strathclyde. In 1992 Kevin Edge was appointed Deputy Director. Under Cliff's leadership, the national and international research profile of the Centre was greatly enhanced. Following Cliff's retirement as Director in 2005, Kevin acted in the role for a year before the appointment of Andrew Plummer. Patrick Keogh succeeded Kevin as Deputy Director in 2008, after the latter's appointment as the University's Deputy Vice Chancellor and subsequent retirement in 2015.

The Centre changed its name to Power Transmission and Motion Control in 1998. This was both to represent the breadth of expertise within the Centre more accurately, and also reflect the changing mix of technology being adopted by industry. Then in the year 2000, the success of the Centre was recognised through the award of the Queen's Anniversary Prize for Higher and Further Education.

Another milestone in 2000 was a successful bid for funds for a new research building to house the Centre's researchers. Completion of 8 East in 2003 was followed by its official opening by the Duke of Kent the year after. As well as office space, the building housed three laboratories, video conferencing facilities, a virtual reality suite, plus seminar and meeting rooms.



Continuing professional development courses for industrial engineers

The University Grants Committee had recommended that courses should be from one to three months long. In the first academic session 1969/70 a total of 20 students attended courses of mainly one-month duration. However, companies found it very difficult to release employees for such long periods. The series of one-week modular courses evolved at this stage and these were retained in this form until the mid-nineties when they were reduced to 4 day's duration. For the 1971 programme a total of 14 courses were held, five modules in hydraulics, five in pneumatics and two in control, with repeats of the introductory level courses. In the first year of the modular courses the total attendance was 160 delegate-weeks. The attendance figures reached a peak in the mid 1980s of over 350 delegates spread over 22 courses.

The pneumatics courses were always the least popular despite good support from the pneumatics manufacturers. From the five originally advertised the number gradually reduced until they were dropped entirely in 1984. The hydraulics courses remain the mainstay, but of course the detailed content has changed substantially over the years. An electrical drives course was one of the outcomes of a substantial 'Masters Training Package' grant in 1999. Another product of this funding was a popular distance learning CD (now flash drive) providing an introduction to hydraulics. A drop in annual delegate numbers in the mid-2000's to double figures was reversed, and after 50 years the CPD courses continue to successfully provide specialist education in hydraulics, electrical drives, control systems and dynamic simulation. For example, in 2017, 150 delegates were taught over ten (mostly) 4-day courses, including bespoke courses for Airbus (on landing gear modelling and simulation) and Mercedes F1 (introductory hydraulics).

It was recognised that the total coverage of the modules provided a good base for the development of an MSc course. The first two students registered in the 1973/74 session, and the course was soon recognised by the Science Research Council as eligible for studentships. The course had either a design or a technology bias which was principally developed through project work. Unfortunately the enrolments rapidly diminished in the early eighties despite strong industrial support through a bursary scheme. After the 1981/82 session the course was suspended after a total of over 40 students had graduated, several of whom subsequently obtained doctorates. Renewed interest in Masters courses later in the decade led to the introduction of a new MSc programme with the first students in the 1989/90 session. Again Science and Engineering Research Council support was obtained and for many years the course attracted a good intake from both full time and part time students. The Fluid Power MSc was supplemented by a broader programme in Power Transmission and Motion Control in 1999. However, take up for both courses again declined, partly because many engineering first degrees in the UK started to award a Masters level qualification (MEng) as the norm. The courses were suspended again in 2013. Nevertheless, it is gratifying that many graduates of the MSc programmes retained their enthusiasm for the subject and are now in senior industrial positions.

PTMC The First 50 Years

Research

The research activities of the Centre have both strengthened and broadened significantly since the early days. There were four main areas of interest referred to in the first report: hydrostatic transmission dynamics; hydraulic stepping motors; the dynamics of hydrostatic bearings; and dynamics of pneumatic systems. Trials began in 1972 on gear, vane and piston pumps to discover the causes of noise, with a view to improving future designs. By 1974 there were ten full time research staff and students working within the centre.

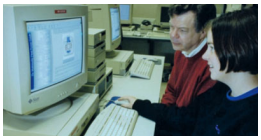
Within the next five years the research activities expanded to include the measurement and characterisation of contamination in hydraulic systems, transmission and attenuation of fluid borne noise, increasing the efficiency of pneumatic systems and simulation of split power and hydrostatic transmissions. Over the following years all of these activities grew and were supported by major grants from a variety of sources.

Work on the "Computer aided design of fluid power systems" started in 1975 in a project sponsored by the Ministry of Defence from their recently established Central Hydraulic Authority for the Royal Navy at Foxhill in Bath. The use of computer tools in design has been an important activity within the Centre from that time. The Hydraulic Automatic Simulation Package (HASP) developed into the simulation package Bathfp. When Bathfp developer Will Richards left in 1993 to join Imagine, he was instrumental in commercialising the package as AMESim, now a very widely used Siemens product. Most of the Centre's research projects over the last three decades have included simulation as an integral part, and AMESim along with several other commercial tools are now in use.

Other significant research areas have included magnetic bearing dynamics and control, and road vehicle dynamics. New methods for predicting fluid borne noise were developed, now available commercially as the software tool Prasp. Throughout the 1990s the government funded Engineering Design Centre in Fluid Power Systems provided a focus for research into system design. In 1999 the Engineering and Physical Sciences Research Council introduced its new Platform Grant scheme, designed to underpin major research groups. PTMC was one of six groups nationwide to receive this funding, which was renewed for a further five years in 2004. Several other major research groups have grown out of work initiated in PTMC, including the £25m Innovative Design and Manufacturing Research Centre from 2001 and 2011, and automotive powertrain developments in the 1990s which formed part of the Powertrain and Vehicle Research Centre, which itself is now developing the £60m Institute for Advanced Automotive Propulsion. In fact five current professors in the Department cut their early research teeth in the Fluid Power Centre: as well as Plummer and Keogh, these are Chris Brace, Sam Akehust and Marcelle McManus.

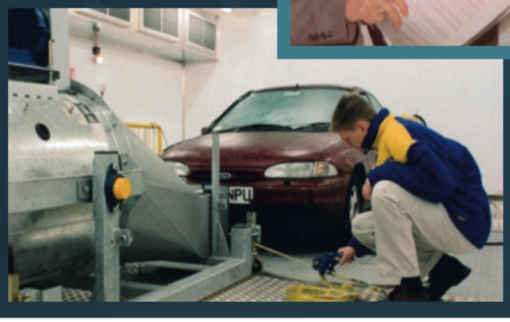
New research directions include piezoelectric actuation, smart rotors, robotics and autonomy, complementing our continuing fluid power interests for designing optimised, smarter and more efficient hydro-electro-mechanical machines.

Pictured below:
Four post rig, 1991



ulti-Axis
mulation Table
MAST), 2004

Visit by Chris Patten, when MP for Bath



Staff

To the CPD course delegates, the 'face' of the Centre is the course organiser. The first Course Supervisor, Ken Fisher, retired in 1980 and was succeeded by John Beauchamp. Peter Chapple took over in 1983 as the Centre Manager for 14 years, before taking up a professorial position in Norway. For 9 years from 1998 the courses were run by Mat Sokola. His duties were subsumed within the role of Technical Manager, a position which was filled by Michael Schlotter in December 2007. Following a major revamp of three of the courses, Michael left to work for Continental in Germany, and was replaced by Jens Rösner in 2014, who continued the course redevelopment. Jens is also responsible for managing the Centre's consultancy activities.

There have been several members of academic staff who have worked within the Centre many years. The founder director Ted Bowns completed 20 years. Frank Sanville, also one of the founder members and the mainstay of the work in pneumatics, retired in 1985 after 18 years. Derek Longmore joined in 1968, retiring after 30 years. Another early recruit was Peter Chapple in 1969 but he slipped away for a six year break in industry before rejoining in 1983 and serving another 14 years. Other early recruits include Kevin Edge and Derek Tilley who joined as postgraduates in 1971 and 1972 respectively. Although Kevin started earlier than Derek, he has a slightly shorter period working within the Centre because he also returned to industry briefly after gaining his doctorate; Kevin moved into University management full time in 2008, and Derek retired in 2011. David McCandlish was another of the founder members who also completed 21 years service, and Nick Vaughan left in 2002 after 24 years. Nigel Johnston and Patrick Keogh were both appointed as lecturers in 1990, and are still here, but Nigel's association goes back longer as he was a researcher for several years beforehand. Likewise, Jos Darling rejoined from industry in 1988 following an earlier period of research. Necip Sahinkaya also joined the Centre over 30 years ago, but returned to Turkey for a 12 year period to manage a shipping company, and left again to take up a Chair at Kingston University in 2013. Although Andrew Plummer only joined 12 years ago, his association goes back to 1987, when he started his PhD in the Centre. Roger Ngwompo was appointed from INSA Lyon 18 years ago. In the last 10 years there has been a significant influx of new staff. Andy Hillis (appointed a little over 10 years ago) and Jon du Bois both have PhD's from Bristol and are now Senior Lecturers, as is Pejman Iravani who was appointed to support the Integrated Mechanical and Electrical Engineering degree when it kicked-off a decade ago. Lecturer Alan Hunter is a leading expert in underwater robotics and sensing, and Min Pan, Nicola Bailey and Ioannis Georgilas are probationary lecturers with interests in fluid power and robotics.

Long service is not confined to the academic staff; Chris Weiss and Jane Phippen both managed 12 years as Centre Secretary, and Gillian Elsworth has now been with us for 10 years. Andy Galloway was a technician within the Centre from 1972 until retirement nearly 40 years later, after which Alan Jefferis and now Graham Rattley became our Senior Technicians. And Experimental Office Bernard Roe, who looks after the CPD course labs as well as many other tasks, has now been with us for 20 years.

40th Anniversary Christmas meal

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Fluid Power Centre staff from 30 years ago

Industrial links

Close contact with industry has been maintained throughout the life of the Centre. An Industrial Advisory Committee was established which held its first meeting in March 1969. A Consortium of 12 companies was formed in 1993 to allow easy access to the Centre's training courses and expertise, and has existed ever since at a similar size. Research projects have almost always taken place with the collaboration of one or more industrial partners. Consultancy contacts have also provided excellent learning opportunities as well as some welcome income.

Last but not least, industry has often supplied equipment to the Centre on beneficial terms and there have been many instances of generous donations. Collaborators and donors over the past 10 years include Parker, Moog, Airbus, Rolls-Royce, Instron, Renishaw, Cobham, Blatchford, MP Filtri, JCB, Molins, Dynamatic, John Deere, Caterpillar, Niftylift, and Jaguar Land Rover amongst many others. Links with other external organisations have also been very strong, particularly the British Fluid Power Association, the IMechE and Standards organisations (ISO and BSI).

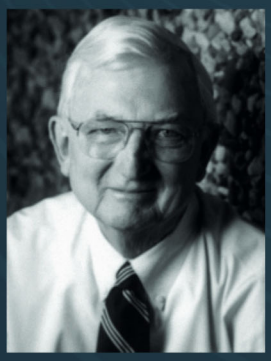
International symposium and networks

International links were also a feature of the early years, with the 1974 annual report highlighting exchange visits and other contacts with twelve countries, including China Japan and the USA as well as continental Europe. The international dimension has been maintained and strengthened ever since. Notably, the Centre was a founder member of the Fluid Power Centres of Europe (FPCE), a grouping of the leading European research laboratories, and instrumental in the merger of FPCE with Fluid Power Network International to form the Global Fluid Power Society. Launched at its PhD Symposium in South America in 2016, the GFPS has Directors from the USA, Europe and Asia. Andrew Plummer was elected Chair for a 4 year term in 2018.

The Centre has always welcomed PhD students and visiting scholars from around the world. One example is Huoyong Yang, who was awarded his Bath PhD in 1988, and went on to direct both the National Centre for Electrohydraulic Control and the State Key Lab for Fluid Power Transmission and Mechatronics at Zeijiang University. Another is Kim Stelson, who arrived as a visiting professor for a year in 2001, and went on to play a critical role in the resurgence of fluid power research in the US as Director of the National Science Foundation Engineering Research Center for Compact and Efficient Fluid Power (2006-2017).

In 1988 the Centre organised a one-day Workshop on Pumps. From that modest start, the Bath International Fluid Power Workshop became an annual event of three-day's duration. The format continued for the Power Transmission and Motion Control Workshop (then Symposium) from 1998, and the Bath/ASME Fluid Power and Motion Control Symposium from 2008. It attracts researchers and practitioners from all over the world and provides a forum for the discussion and dissemination of the latest developments in the field. The adoption of the Symposium by the American Society of Mechanical Engineers as its main forum for the dissemination of fluid power research is in recognition of the event's reputation as the leading research conference in the field. In 2009 and 2011 the Bath/ASME symposium was held in Hollywood and Arlington (Washington) respectively, alongside ASME's Dynamic Systems and Control Conference. However the US event really found its feet when held as a standalone event in Sarasota (Florida) in 2013, Chicago in 2015, and back in Sarasota in 2017. On even years the event in Bath continues to promote genuine discussion and community networking, as well as attracting papers form leading researchers. With 110 submissions and 70 accepted papers, the 2018 event will be the largest ever FPMC Symposium in the UK, but we hope to maintain its informal, friendly atmosphere.

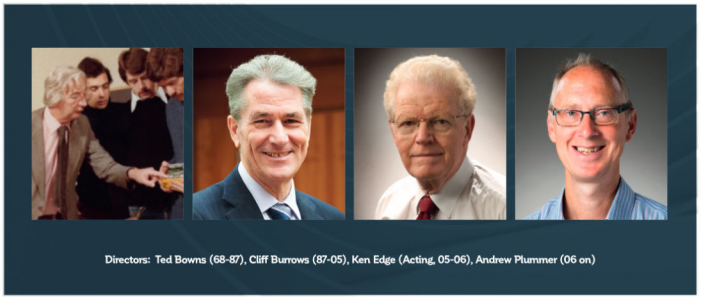
Bob Koski was a great supporter of the Symposium over many years, as well as successfully re-energising fluid power research and education in the US. We were delighted that he made it to the 2008 Symposium shortly before his death, and was able to see the award of the 2007 and 2008 ASME Koski Medals. The first of these went to Wolfgang Backé, another long time supporter of the symposium, and in many ways the founding father of European fluid power research.



Mr Koski co-founded Sun Hydraulics in 1970 with John Allen. In 2007, the ASME inaugurated the Robert E. Koski Medal to "recognise individuals who have advanced the art and practice of fluid power motion and control through education and/or innovation." He was instrumental in forming the ASME 36th Division -- The Fluid Power Systems and Technology Division. In 1992, he was awarded the Joseph Bramah Medal by the Institution of Mechanical Engineers for his "contribution to the resurgence of interest in Fluid Power in the USA and beyond."

Past, present and future

The success of the Centre over its 50 year life is undoubtedly due to the dedication of its staff, most of whom have not been mentioned here. This includes all the research students and research officers, technical support and secretarial staff. For the future, the Centre will continue to engage in research and teaching activities in the realm of power transmission and motion control, embracing new technologies, techniques and applications, and further to contributing to scientific knowledge, wellbeing and wealth creation.



Directors: Ted Bowns (68-87), Cliff Burrows (87-05), Ken Edge (Acting, 05-06), Andrew Plummer (06 on)

FluidPower at Bath

Centre for Power Transmission and Motion Control

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Acknowledgement: This description is in part based on 'The First Twenty-five Years' by Nick Vaughan (Fluid Power Centre Annual Report, 1993)

Fluid power workshop to Bath/ASME Fluid power and motion control symposium

10th Symposium, 1997

20th Symposium, 2007

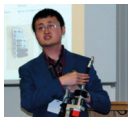
29th Symposium, 2016. Kevin Edge receiving an honorary degree.

Symposia best paper prizes

As voted for by the delegates

2017 **Divya Thiagarajan, Andrea Bratto and Andrea Vacca Maha**
Fluid Power Research Center, Purdue University, USA

2016 **Tian Yu, Andrew Plummer, Pejman Iravani, Jawaad Bhatti, Saeed Zahedi and David Moser**
Centre for PTMC, Bath, and Chas. A Blatchford & Sons Ltd, Basingstoke, UK



2015 **Stefan Heitzig, Gregor Bultel, and Hubertus Murrenhoff**
Institute for Fluid Power Drives and Controls of RWTH Aachen University

2014 **Johannes Willkomm, Matthias Wahler and Jürgen Weber**
Bosch Rexroth AG, Germany & IFD, TU Dresden. (Received on their behalf)

2013 **Johannes Schmitz, Milos Vukovic and Hubertus Murrenhoff**
IFAS - Institute for Fluid Power Drives and Controls, RWTH Aachen University, Germany

2012 **Henrik C Pedersen, Anders H Hansen, Rico H Hansen, Torben O Andersen and Michael M Bech**
Department of Energy Technology, Aalborg University, Denmark

2011 **Matteo Pelosi and Monika Ivantysynova**
Purdue University, USA

2010 **Rico Hansen, Torben Andersen and Henrik Pedersen**
Aalborg University, Denmark

2009 **Joshua Zimmerman and Monika Ivantysynova**
Purdue University, USA

2008 **José Riofrío and Eric Barth**
Vanderbilt University, USA

2007 **Matthias Liermann**
IFAS-RWTH, Aachen University, Germany

2006 **Maxim Reichert**
RWTH Aachen University, Germany

2005 **Monika Ivantysynova**
Purdue University, USA

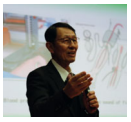
2004 **Bernhard Manhartsgruber**
Johannes Kepler University, Austria

2003 **Changchun Huang**
Technical University of Hamburg-Harburg, Germany (received by Jean-Claude Ossyra)

2002 **Andreas Johansson**
Linköping University, Sweden

2001 **Andrew Plummer**
Instron Ltd, High Wycombe, UK

2000 **Toshiharu Kagawa**
Tokyo Institute of Technology, Japan



1999 **Michael Garstenaur**
Johannes Kepler University Linz, Austria

1998 **Eizo Urata**
Kanagawa University, Japan

1997 **Pär-Erik Wikland**
RIT Sweden

1996 **Petter Krus**
Linköping University, Sweden

1995 **Brian Surgenor, Nick Vaughan and Matthias Uebig**
Queens University Canada, and University of Bath

1994 **R. Piché, A. Ellman and M. Vilenius**
Tampere University of Technology, Finland

1993 **Jonathan Gamble**
University of Bath

1992 **Andreas Klein and Wolfgang Backé**
IHP Aachen, Germany

1991 **19 – 20th September**
'Systems'
No award

1990 **13 -14th September**
'Computers in Fluid Power'
No award

1989 **21 - 22nd September**
'Components and Systems'
No award

1989 **8th September**
Workshop on 'Pumps'

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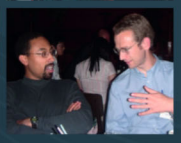
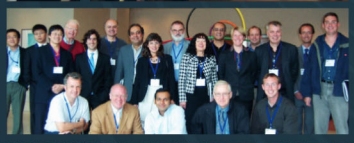
2003-2006





2009



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2012









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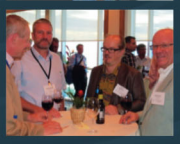





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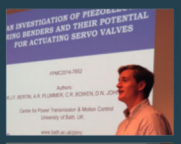
2014

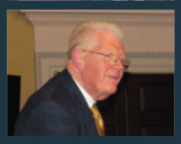


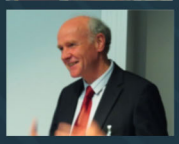













2015



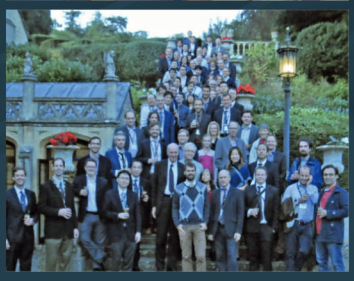





2016



2017



PTMC The First 50 Years

The institution of mechanical engineers' Joseph Bramah medal

The Bramah Medal was established in 1968 at the instigation of Mr Frank Towler, a Fellow of the Institution (1932-1977), who arranged for its support by industry to commemorate Joseph Bramah, the inventor of the hydraulic press and other machines concerned with pumps, water supply, the manufacture of pipes and tubes, and locks. The award is for outstanding achievement tending to advance the science of mechanical engineering, particularly in the field of hydraulic engineering. The medal has no formal link with Bath, but due to its relevance to hydraulics several of the Centre's academics have been involved in the IMechE Board responsible for nominating candidates over the last 3 decades. The Medal has frequently been presented at the Bath symposium.

Past Winners

2017 **Professor Huoyong Yang**, for academic leadership in fluid power transmission and mechatronics.

2016 **Professor Andrew Plummer**, for contributions to fluid power and control research and education, particularly in servohydraulics.

2015 **John Savage**, the National Fluid Power Centre at North Nottinghamshire College, for his outstanding contribution to fluid power education and training.

2014 **Professor Win Rampen**, Artemis Intelligent Power and University of Edinburgh, for his development of Digital Displacement hydraulic pumps and motors.

2013 **Professor Richard T. Burton**, University of Saskatchewan, for an outstanding contribution to fluid power research and education.

2011 **Professor Shinichi Yokota**, Tokyo Institute of Technology, for outstanding contributions to fluid power research, particularly in the field of microhydraulic actuation and control.

2010 **Professor Rudolf Scheidl**, Johannes Kepler University, in recognition of his fundamental and applied research into mechatronic systems and hydraulic drives.

2009 **Professor Monika Ivantysynova**, Purdue University, for outstanding commitment to international fluid power research and education, particularly in the field of hydrostatic pumps and motors.

2008 **Professor Siegfried Helduser**, Technical University of Dresden, in recognition of his numerous contributions to the development of the fluid power industry through his research, teaching and professional activities.

2007 **Dr Peter Achten**, Innas BV in recognition of his exceptional innovation in the field of fluid power.

2006 **Professor Serge Scavarda**, INSA Lyon, for his work in fluid power, particularly his

contributions to pneumatics coupled with his seminal research in Bond Graphs and his work on inverse design.

2005 **Professor Matti J. Vilenius**, Head of IHA TUT / IHA, for 'Outstanding Achievement Particularly in the Field of Hydraulic Engineering'.

2004 **Prof Hans-Heinrich Harms**, Director of the Institute Für Landmaschinen und Fluidtechnik, Technical University, Braunschweig, Germany. As the result of Prof Harms' outstanding technical ability and his excellent leadership, the Institute is the leading Centre in Germany for research into Agricultural Machinery and more generally in the area of construction machines.

2003 **Mr Roy Cuthbert** AMIMechE

2002 **Mr John Bentley**, for outstanding achievements in the advancement of high pressure hydraulics and water-based fluid components and systems.

2001 **Prof Murrenhoff**, for his internationally renowned research in the field of fluid power engineering.

1999 **Professor J Watton** CEng FIMechE

1998 **M D Kelley**

1997 **Professor Jan-Ove Palmberg**

1996 **Mr N Way BSc**, for outstanding service to the industry.

1995 **Dr W Dieter**, for his key role in the growth of the Fluid Power Industry

1994 **P J Wilson**, for his contribution to the Fluid Power Industry (Technical Director, Vickers).

1993 **Professor C Burrows** FREng CEng FIMechE, for his achievements in the field of hydraulics.

1992 **R Koski**, for his contribution to the resurgence of interest in Fluid Power in the USA and beyond.

1991 **Professor Dr Ing W Backe**, for his achievement in the field of hydraulics.

1990 **Dr K A Edge CEng FIMechE**, for his contributions to the Science of Fluid Power.

1989 **G Allison**, for his continuous effort over the past several years towards the eradication of leaks from hydraulics.

1988 **R B Walters CEng FIMechE**, for his activity in the hydraulic industry since 1954, resulting in over 40 patented inventions, a textbook, and simulation software.

1987 **R E Knight FCGI BSc**, for a lifetime's work promoting pneumatics in industry

1986 **F B Levetus OBE CEng FIMechE**, for his contribution to advancing the Science of Mechanical Engineering,

particularly in the field of Hydraulic Mechanisms, Hydrostatic Transmission and Servomechanisms.

1985 **J F Nosworthy**, for his services to the hydraulics industry.

1984 **G C Knight**, for his work with the National Coal Board in developing a testing laboratory, for contributions to BS, ISO and IMECO Committees, and for his work with fire resistant fluids in mining.

1982 **M J Fisher**, for his work on hydraulic research with BHRA

1981 **F W Baggett CEng FIMechE**, for his outstanding contributions to the advancement of mechanical engineering, particularly in hydraulics

1980 **D Bick BSc MIMechE**, for his outstanding contributions to the advancement of mechanical engineering, particularly in hydraulics.

1979 **E H Bowers CEng FIMechE**, for his contributions to the development of piston pumps and hydrostatic transmissions, power matched systems, and directional control valves and for his work on standardisation.

1978 **Professor D E Bowns CEng MIMechE**, for his contributions to the development of education in the field of fluid power engineering.

1976 **P M M Price BSc ACGI CEng FIMechE**, for his elastohydrodynamic slipper pad which has improved the volumetric efficiency of an axial piston pump currently in production.

1975 **J G Keenan BSc CEng FIMechE FRAeS**, for outstanding achievements in the study of hydraulic mechanisms including hydraulic power transmission components and controls.

1974 **C M Edgehill BSc**, for his contributions to developments within the fluid power industry.

1973 **Professor W M J Schlosser**, for work in the field of analogue models for comparative testing and evaluation of all forms of power transmissions.

1972 **R H Y Hancock CEng MIMechE**, for his contribution in the field of hydrostatic drives

1971 K Foster MA PhD CEng MIMechE, for his distinguished contributions to research in the fluid power industry.

1970 **G P Copping**, "Automatic Letter Facing" and "Stacking and Destacking Letters"

1968 **B Lengyel PhD DipIng CEng MIMechE** and **Professor J M Alexander BSc PhD DSc CEng FIMechE**, "Design of a Production Machine for Semi-continuous Hydrostatic Extrusion"

The ASME Robert E. Koski medal

The Robert E. Koski Medal, established in 2007, recognizes individuals who have advanced the art and practice of fluid power motion and control through education and/or innovation. The Medal was established by ASME's Fluid Power Systems and Technology Division to honour Robert E. Koski's contributions to the field of dynamics, control and design engineering. It is presented annually at the Bath/ASME symposium, at which the recipient is invited to give the keynote Koski Lecture.

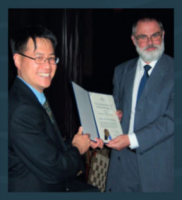
Medal Recipients

2018	Luca Zarotti	2012	Siegfried Helduser
2017	Werner Dieter	2011	Richard T. Burton
2016	Kim A Stelson	2010	Yongxiang Lu
2015	Monika Ivantysynova	2009	Jan-Ove Palmberg
2014	Hubertus Murrenhoff	2008	Clifford R. Burrows
2013	Wayne J. Book	2007	Wolfgang Backé

2015 recipient Professor Monika Ivantysynova with Beverly and Chris Koski, and previous recipients of the Koski Medal, at FPMC 2015 in Chicago

Professors Kim Stelson and Hubertus Murrenhoff

Professors Wayne Book and Siegfried Helduser



Professors Richard Burton, Yongxiang Lu and Jan-Ove Palmberg

Professors Cliff Burrows and Wolfgang Backé