

INTERNATIONAL INSTITUTION FOR PRODUCTION ENGINEERING RESEARCH NEWSLETTER

edited by the Technical Secretary
M. SANTOCHI

Nr. 17 - October 2000

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from the Editor

Dear Colleagues,

I wish to inform you the next issue of the CIRP Newsletter is scheduled for

April 2001

All your contributions are welcome and will be considered for publication. For a fast and easy transmission of documents, you are invited to use the E-mail at the following address:

santochi@ing.unipi.it.

Please consider that the deadline for your contributions is:

March 15th 2001.

In addition I wish to remind you that CIRP has a web site on Internet at

A bibliographical research on CIRP Annals by authors, by title and by keyword is possible, reading the text of the CIRP newsletter is also possible and more practical than receiving the yellow pages. Links to WEB pages of CIRP's members labs are available and **links to your own page are welcome!**

Going to the WEB site you will discover that the **abstracts of the CIRP papers 2000** are available.

Very important notice

Please remember that the transmission of titles and abstracts of papers for the General Assembly 2001 will be allowed only through the new electronic system. For this reason if you wish to present a paper, go to the URL www.cirp.net, click on Publications, then click on Paper submission form.

In addition please remember that you will be asked to transmit your full paper in electronic version by January 7th, 2001. For this reason start on preparing a proper software on your computer to format your paper in the PDF format.

The Technical Secretary

Prof. Marco Santochi

Acknowledgement

The Editor wishes to thank Mrs. **A. Caponero**, Dept. of mechanical , nuclear and production engineering of the University of Pisa for her valuable help in preparing the Newsletter.

awards

We have the pleasure to inform you that our Colleague **Klaus J. Weinmann** received a Distinguished Alumnus Award from the Department of Mechanical and industrial Engineering, University of Illinois at Urbana-Champaign. He is one of three alumni who were honoured at the Spring 2000 M&IE Alumni Board Meeting on April 14.

Professor Weinmann is a Professor in the Department of Mechanical Engineering-Engineering Mechanics at Michigan Technological University. He received a bachelor of science degree, master of science degree, and PhD degree from the Department of Mechanical and Industrial Engineering, University of Illinois at Urbana-Champaign. He is a Fellow of the American Society of Mechanical Engineers. Within CIRP he serves as Chairman of the Scientific Technical Committee-Dictionary.

The Department of mechanical and Industrial Engineering at the University of Illinois established the Distinguished Alumnus Award in 1968 to honour outstanding achievements by its more than 12.000 alumni.

We have the pleasure to inform you that the Faculty of Mechanical Engineering and Process Engineering of the TU Chemnitz conferred on our Colleague Prof. Dr. Ing. Dr. h.c. **Manfred Geiger**, who holds the Chair of Manufacturing Technology (at the University of Erlangen-Nuremberg), the honorary doctor. Since the political turning-point in Germany Prof Geiger has been giving a great deal of assistance to the production engineering department at the TU Chemnitz. He supported the University on restructuring the Faculty of Mechanical Engineering and Process Engineering and on the fields of Instruction and research. He also is a member of the advisory council at the Centre Micro Manufacturing Engineer Sachsen.

A second honorary doctor degree was conferred on Prof. Geiger by the University of Dortmund. The Faculty of Mechanical Engineering acknowledges Prof. Geiger as an international leading scientist of the shaping and laser-technology and as a very engaged attorney of the interests of the engineering science at senate and main committee of the DFG (German Research Foundation).

Moreover Prof. Geiger was awarded the gold medal "PRO UNIVERSITATE LABACENSI" from the University of Ljubljana on the occasion of its 85th birthday in the beginning of December 1999.

We have the pleasure to inform you that in November 1999 our Colleague Professor Dr.-Ing. **Reiner Kopp** received the Doctor Honoris Causa from the Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil (UFRGS). Professor Kopp, director of the Institute of Metal Forming of the RWTH Aachen, was honoured for his outstanding achievements in science and technology, especially in the field of metal forming. He was recommended for the award particularly in recognition of his assistance in setting up the UFRGS's new material data laboratory.

On December 24th, 1999, Professor Dr.-Ing. Dr. h.c. Reiner Kopp celebrated his 60th birthday. Also in 1999 he completed his 25th year as the director of the Institute of Metal Forming of the RWTH Aachen. In September 1999 the State Administration of Foreign Experts Affairs of the People's Republic of China presented its 'Friendship Award' to Professor Reiner Kopp of the Institute of Metal Forming, RWTH Aachen.

We are very glad to announce that our Colleague prof. **Serope Kalpakjian** has received the Albert Easton White Distinguished Teacher Award for 2000 from the American Society for Metals International.

We have the pleasure to inform you that our Colleague Professor **Yoram Koren** has been honored by the American Society of Mechanical Engineers (ASME) with its top award in manufacturing, the 1999 William T. Ennor Manufacturing Technology Award.

The new General Nicolau Award

The CIRP Senate of Past Presidents, meeting in Montreux, Switzerland on August 25, 1999, requested that the incoming President (Professor DeVries) draft a proposal for a new CIRP award. The intention of the Senate was that the award would be given initially at the 2001 General Assembly in Nancy, France on the occasion of the 50th anniversary of CIRP. The proposed new award would have to be approved by the General Assembly at its meeting in Sydney, Australia in order to meet the 2001 date. A draft proposal was presented for critical review by the CIRP Board and Council during their meetings in January, 2000 in Paris, France. Following their inputs and discussion, the following proposal has been presented for consideration at the General Assembly in Sydney, Australia, and has been agreed by the full majority:

The following is proposed as **Article 22** of the Internal Regulations:

1. The name of the award shall be the General Pierre Nicolau Award. The award honors General Nicolau, world renown authority in the field of production engineering, and it commemorates his contributions to the founding of CIRP.
2. The Award shall be conferred in recognition of a significant and

distinguished scientific contribution to a specific area within the field of production engineering encompassed by the interests of CIRP as defined in Appendix 5 of the Internal Regulations.

3. Recipients of the Award may be any member or non-member of CIRP; generally, they should be under the age of 45.
4. The Award shall consist of an appropriately prepared certificate and an honorarium of 5,000 Euro.
5. The Award shall be presented by the President to the recipient(s) during the Opening Ceremony of the General Assembly.
6. The Award will not be awarded posthumously except if a nominee's death occurs after the nomination has been received at CIRP Headquarters.
7. The Award shall be decided annually by a General Nicolau Award Committee consisting of the three most recent Past Presidents not serving on the Council.
8. In the case of a vacancy on the Committee, the President, upon the advice of the Board, will appoint an Active, Honorary or Emeritus Member to serve on the Committee for that particular year.
9. Nominations for the Award for a given year must be received by the CIRP Headquarters by April 1 of that year. The nominations will be valid only for the year that they have been submitted for consideration. Unsuccessful nominations may be revised, updated and resubmitted for consideration in subsequent years.
10. Only Active, Honorary or Emeritus Members may submit or support a nomination for the Award.
11. The nomination shall consist of a written (typed) proposal, not to exceed 1000 words, along with an appropriate cover letter from the member making the nomination. Each nomination is to be supported by letters from at least two additional members from a country or countries other than that of the person(s) nominated. The nomination proposal shall be well prepared and thorough, clearly justifying why the candidate is eminently worthy of

the Award. The nomination shall include a clear precise narrative appraising the accomplishments of the candidate in the area for which the candidate is being recommended for the Award. The curriculum vitae of the nominee(s) shall accompany a nomination.

12. Detailed instructions on the preparation of the nomination is available from the CIRP Secretariat

meetings seminars conferences

The 7 th

CIRP International Seminar on Computer Aided Tolerancing

Main theme:

Integration of Functionality - Specification and Verification

C A C H A N

April 24- April 25 2001

ENS de Cachan, France

Topics

Tolerance and functionality

Tolerance specification

Tolerance analysis

Tolerance synthesis

Tolerancing for Flexible parts

Tolerance representation

Statistical tolerancing

Education of tolerancing

Computational metrology, verification

Geometric quality control

Tolerancing standard

Industrial applications and CAT systems

Important Dates

15 November 2000 : Abstract Due

15 December 2000 : Abstract Acceptance Notification

15 January 2001 : Final Program Announcement

15 March 2001 : Camera-Ready Papers Due

For further information:

The Laboratoire Universitaire de Recherche en Production Automatisée
of the Ecole Normale Supérieure de Cachan F94235

Tel : 33 1 47 40 22 66

E-mail: CIRPtolerancing2001@lurpa.ens-cachan.fr

Seminar Web Site: <http://www.lurpa.ens-cachan.fr/CIRPtolerancing2001>

PRIME 2001

1st International Seminar on

Progress in Innovative Manufacturing Engineering

20-22 June 2001, Sestri Levante (GENOA), Italy

TOPICS

Topics of the seminar include, among others:

- Materials: composite materials, ceramics, diamond, CBN, smart materials

- Tools: for high speed cutting, for nanometric cutting, for nanometric cutting
- Manufacturing processes: high speed machining cutting of advanced materials, electro-physycal & chemical processes (EDM, ECM, Laser manufacturing,...)
- Innovative processes in metal forming
- Optimisation in manufacturing processes Rapid prototyping systems, rapid tooling
- Measuring systems and metrology in manufacturing
- Surfaces metrology, parameters and characterisation, surface quality
- Transducers, smart sensor
- Clean-safe machining.

IMPORTANT DATES

10 November 2000 Submission of abstracts

30 November 2000 Provisional acceptance

10 March 2001 Submission of full paper

10 April 2001 Notification of acceptance

For more information, please visit the Seminar website at:

<http://www.dip.unige.it/prime/>

CIRP 1st-International Conference on

Agile, Reconfigurable Manufacturing

May 21-22, 2001 (Just before NAMRC)

University of Michigan

Ann Arbor, Michigan, USA

Sponsored by:

The University of Michigan

NSF ERC for Reconfigurable Machining Systems

and several industrial firms

Theme: Reconfiguration is a fast growing research field in manufacturing that spans from system-level design issues, to modular machines, reconfigurable control and rapid ramp-up methods after reconfiguration. A recent report of the National Research Council mentioned that Adaptive, Reconfigurable Manufacturing is priority #1 for future systems (*Visionary 2020*). Because of the high interest of industry in this area we have been asked to organize a conference, in which we can all learn more about this subject.

Papers are solicited in all areas of Reconfigurable Manufacturing. Application and research papers will be accepted. The papers will be reviewed and published in the conference proceedings (CD-ROM). Topical areas may include:

Reconfigurability and Agility in Semi-Conductor Fabrication

Reconfigurable Assembly

Reconfigurable and Agile Machining Systems

System-Level Process Planning and feature-based methods

System Configurations – Generation and Impact

System Scalability for Adaptive Capacity

Simulation of Modular and Reconfigurable Systems

Line Balancing in Modular Systems

Flexible Scheduling

Factory-Based Agile Applications

Modular Machines

Reconfigurable Machine Tools and Robots

Discrete-Event Control, Petri-Net Control, Control Flow-Charts

Open-Architecture Control Systems

Sensors for Diagnostics and Rapid Ramp-Up

Multi-Axis Motion Control

Virtual Reality and Human interfaces

Reconfigurable Tooling and Parallel Tools

Reconfiguration Cost and Life-Cycle Economic Modeling

Conference Coordinator: Ms. Roz Harden

Engineering Research Center

University of Michigan

2300 Hayward Street

Ann Arbor, MI 48109-2136, USA

Phone: +001-734-763-9999

FAX: +001-734-763-5700

Email: rmharden@engin.umich.edu

Paper Submissions Schedule:

October 3, 2000: Submit 1-2 pages abstract

December 1, 2000: Authors notified of acceptance

MARCH 1, 2001: FULL PAPER SUBMISSION

May 21-22, 2001: Conference

AC'01
VI International Conference on
Monitoring and Automatic Supervision in
Manufacturing

Topics

- Abrasive Processes
- cutting chaired
- Micro Machining
- Computer communication
- Unconventional Maching (EDM/ECM)

Conference Secretariat

AC'01 Organizing Committee

Warsaw University of Technology

Narbutta 86,

02-524 Warsaw, POLAND

Tel: (+48 22) 8499 390, (+ 48 22) 660 8473

fax: (+48 22) 8490 285

E-mail: ac01@wip.pw.edu.pl

**XII Workshop on Supervising
and
Diagnostics of Machining Systems
Karpacz 18th - 23rd March 2001**

**VIRTUAL
MANUFACTURING**

TOPICS

- Virtual design systems
- Virtual environment and data basis for design and manufacturing
- Advanced concepts of global and open design and manufacturing
- Modelling of virtual processes
- Virtual engineering
- Agent systems application to virtual manufacturing
- Planning and scheduling of virtual manufacturing
- Quality management in virtual manufacturing systems
- Integrated managing of virtual manufacturing
- Human problems in manufacturing
- Innovative machines tools and machining modules
- Tooling systems for virtual manufacturing
- advanced diagnostics and supervision of virtual processes
- High speed and high precision cutting

- Human intelligent interfaces for machine tools and process control
- Advance open control systems
- Information flow in virtual manufacturing
- Intelligent machines and systems for virtual manufacturing
- Live cycle in virtual machining systems
- Complexity management in manufacturing

Further information:

tel: +4871 3202703

fax +4871 3202703

E-mail: jedrzej@itma.pwr.wroc.pl

**3rd International Workshop on
Emergent Synthesis**

IWES'01

March 12th - 13 th 2001

Bled, Slovenia

TOPICS

- Concepts for emergence toward engineering synthesis
- Emergent synthesis methods for the designing systems of artifacts
- Emergent synthesis methods for the manufacturing systems of artifacts
- Emergent computation for utilizing artifactual systems
- Synthesis of relational emergence in artifactual environment

Modeling and simulation of emergent systems applications to technical and economical systems

For more information, please contact:

IWES' 01 Secretariat

Department of Control and Manufacturing Systems Faculty of Mechanical Engineering

University of Ljubljana

Askerceva 6

SI-1000Ljubljana

Slovenia

Phone: +386 1 252 32 24

Fax : + 386 1 218 567

E-mail: lakos@fs.uni-lj.si

<http://www.fs.uni-lj.si/lakos/events/iwes01>

International CIRP Seminar

Design in the New Economy

June 6 - 8, 2001 in STOCKHOLM, SWEDEN

TOPICS

- Design theory and principles
- Design methodology from concept to detailing
- Design process modelling
- Methods for evaluating design concepts
- Design for outsourcing, insourcing and doing right sourcing
- Analysis and simulation in the design process
- Product modelling, virtual prototyping, digital mockups
- Feature and constraint modelling
- Product structuring and product information management, PDM, EDM
- Product life-cycle modeling, optimization and simulation

- Integrated product and manufacturing design
 - Process and production planning
 - Process design, modelling and simulation
 - Manufacturing system design and simulation, the digital plant
 - Distributed system for design and manufacturing
 - Artificial intelligence methods in design and process planning
 - Teamwork, leadership, learning organisation, competence management
- Information and knowledge integration throughout the product life cycle

CONFERENCE SECRETARIAT

Brigitta Johansson

Royal Institute of Technology

Dep. of Manufacturing Systems

Computer systems for Design and Manufacturing

Brinellvägen 66

S-100 44 STOCKHOLM, Sweden

Tel: +46 8 790 63 78

Fax +46 8 790 90 75

E-mail: bj@cadcam.kth.se

<http://www.psm.kth.se/conferences/cirp2001>

ASK 2001

March 23rd and 24th 2001

The Institute of Metal Forming (IBF), RWTH Aachen, is going to host the 16th 'Aachener Stahlkolloquium' under the motto "Innovative Semi Finished Products - Basis for High-duty Products". Under the chairmanship of Prof. Dr. Ing. Dr. h.c. Reiner Kopp, the main topics will be:

Latest developments in forming processes, lightweight construction, process chain analysis, simulation and virtual reality. Some 25 papers will be presented.

For detailed information please contact:

ASK 2001

Institut für Bildsame Formgebung

Intzestraße 10

52056 Aachen

Tel: +49 241-80 5915

Fax: +49 241-8888 234

Email: schulz@ibf.rwth-aachen.de

<http://www.ibf.rwth-aachen.de/ask>

2nd Grinding Colloquium ² Grinding - a Competitive Technology²

Bremen, Germany

November 9 - 10, 2000

The conference takes place on November 9 and 10, 2000 organized by the Verein Deutscher Schleifmittelwerke e. V. (VDS) in co-operation with the Laboratory for Machine Tools and Production Engineering (WZL) of the Aachen University and the Department of Production Technology, University of Bremen.

Industrial experts and researchers from institutes will be presenting their solutions and concepts for competitive grinding production. The topics at the colloquium are focused on a wide field of production grinding:

For further information please contact:

Dr.-Ing. E. Minke

Production Technology/Manufacturing Processes

University of Bremen

Badgasteiner Str. 1

D - 28359 Bremen

Germany

phone: ++49-421-218-3530

fax: ++49-421-218-3272

e-mail: minke@iwt.uni-bremen.de

books and journals

Our colleague prof. **Serope Kalpakjian** announces that the 4th edition of his textbook "Manufacturing Engineering and Technology" has just been published by Prentice Hall.

from the labs

Joint Chinese-German research for flexible automation in forging industry - a new production concept for automation

In a joint research project IPH - Institute for Integrated Production Hanover, Germany and BRIMET - Beijing Research Institute for Mechanical & Electrical Technology, China are developing an advanced manufacturing system for forging parts (AMS.forging). Core of the development is a flexible automated forging system consisting of the forging and handling equipment. To work successfully this high end technology has to be combined with an environment covering an efficient control of both the manufacturing process and the production management.

The advanced manufacturing system for forging parts will help the mostly medium sized enterprises in the forging industry to meet the requirements of automobile manufacturers in the supply chain. The increasing variety of product types lead to smaller lot sizes of forging parts. In parallel higher precision of the parts is demanded which requires higher accuracy of the process. Though, both flexibility and automation have to be matched in one system.

Aim of the co-operation is the development and evaluation of a production concept in which the forging handling equipment will be connected by a bus based control system. This process and plant control communicates with the production management and the production data capturing system in order to optimise the whole process. This includes the order administration, the scheduling, the tool management as well as the material management and the tool shop.

AMS.forging is the latest project of a continuous line of projects between institutes from Hannover and Chinese institutes and companies since 1991. The research and development is based on working group meetings, direct informationflow using electronic mail and exchange of students and researchers. AMS.forging runs three years and is supported by the German Department of Education and Research (BMBF) and the Chinese Department for Science and Technology (MOST).

Contact:

IPH – Institut für Integrierte Produktion Hannover gemeinnützige GmbH
Dr.-Ing. Bernd C. Schmidt or Dipl.-Ing. Kirsten Tracht
Hollerithallee 6
30419 Hannover, Germany
Tel.: +49-511-27976-225
Fax: +49-511-27976-888
Mail to: ams@forging.de

Virtual Manufacturing at the IFW, Hannover

A new junior research group is installed at IFW by the ministry of culture and science. This research group starts working at the end of this year and is focussing on a modular simulation system in order to model the manufacturing process by its main components: machine tool, cutting tool, workpiece and the cutting process itself. The aim is to optimise the manufacturing process in a virtual reality before manufacturing. The group consists of 4 researchers and 1 programmer and will be funded for the next 5 years.

Seminars at IWF Hannover

Seminar on natural stone and construction material in Bad Oeynhausen.

Following the success of the IFW - Steinkolloquium in the late 70s and the beginning of the 80s which attracted participants from several countries, the 4th IFW - Steinkolloquium has taken place in Bad Oeynhausen, Germany, 4 - 6 of September 2000. Approximately 100 persons from 8 nations were participating the 4th IFW-Steinkolloquium. During the conference different aspects in the field of processing natural stone and construction materials from industrial applications, research and development were discussed. In the two days of presentations 18 different companies and research institutes have shown new trends and innovations in machining stone material. The next Steinkolloquium will be held in 2004

From our Colleague Professor **Brinksmeier** we receive and report the following abstracts of Ph.D. theses

"Methods for Investigation and Optimization of Cooling Lubrication in Grinding"

Author: Dr.-Ing. **Carsten Heinzl**

Published as: „Methoden zur Untersuchung und Optimierung der Kühlschmierung beim Schleifen“, Forschungsberichte aus der Stiftung Institut für Werkstofftechnik Bremen, Band 2, Shaker Verlag, Aachen, 1999. (ISBN 3-8265-6763-3, 204 pages, 105 figures, price: 50,10 €).

The machining process "grinding" is generally critically assessed concerning the amounts of heat produced during the process operation. Relatively high friction effects in abrasive machining cause heat production which can lead to thermal damage in the surface layer of machined parts. Furthermore an inefficient cooling and lubrication system can result in higher tool wear and surface roughness. Therefore the application of cooling lubricants is of utmost importance in the field of grinding. Usually the optimization of the coolant supply system including the selection of the

coolant itself is based upon empirical know-how or short practical trial-and-error-tests. Causal dependencies which would widen the understanding of cooling and lubricating effects on the grinding process itself as well as the work results were only rarely studied in the past. According to this situation, systematic approaches using broader preliminary experimental investigations and thus resulting optimized grinding parameters or using fluid mechanical investigations in the coolant supply nozzle or in the grinding gap are not or only rarely applied. This Ph.D. Thesis deals with three methods for investigation and optimization of cooling lubrication in grinding of the ballbearing steel 100 Cr 6:

- The method for experimental data based modelling and process optimization makes use of experimental results in external cylindrical plunge grinding of 100 Cr 6 with a vitrified CBN grinding wheel. During these investigations not only the material removal rate, but also parameters of the coolant supply system incl. coolant type were varied (for instance nozzle design and supplied flow rates). Artificial neural nets were used for modelling purposes in order to map the varied parameters on process quantities (such as forces) and the work results (e.g. roughness, residual stress). The established models were finally applied for the purpose of carrying out a computer aided selection of optimized parameter combinations respecting quality, ecological and economical requirements.
- The method for flow visualization aims at the optimization of the coolant supply towards the contact zone by realizing the most efficient nozzle design. Eddies and backflows in the nozzle can be made observable and consequently avoided by adapting the nozzle's form.
- The third method which makes use of pressure measurements in the contact zone offers the possibility to get more detailed information about grinding force components which can be used to assess lubrication properties resulting from additives in cooling lubricants. Furthermore this method has the potential to estimate the flow rate of the grinding fluid passing through the grinding zone which is an important parameter for the cooling effectiveness in the machining process.

Environmental friendly conceptualization of machining processes

Author: Dr.-Ing. **J. Eckebrecht**

Published as: "Umweltverträgliche Gestaltung von spanenden Fertigungsprozessen - Forschungsansätze und Wissenstransfer -", Forschungsberichte aus der Stiftung Institut für Werkstofftechnik Bremen, Band 3, Shaker Verlag, Aachen 2000. (ISBN: 3-8265-7661-6, 181 pages, 78 figures, price: 48,00 €)

Machining processes like turning and grinding are state of the art in metalworking industry and therefore widely in use. The flexibility of these operations which enables the profitable machining of smallest batches up to the production of large series of products at high accuracy and productivity are the base of the outstanding importance of these machining processes. For the metalworking industry highly developed machining processes are the precondition to face the competition at the market.

Beside of the demands on the efficiency and economy of cutting processes the question of their environmental friendliness grow to a task of rising interest. Responsible for this development are

the enhanced environmental aims of industry and rising costs for production-wastes respectively for end-of-pipe technologies.

Deciding over the introduction of new technologies normally the user faces the problem that different technologies are available, which have to be compared and must be adapted by more or less extensive adjustment work to the specific conditions of the respective production enterprise.

Especially for small and medium (sme) enterprises this is problematic since the personnel resources for such often very complex and multilayered decisions are not available. Time for extensive test runs and adjustment work is missing as well. Concerning environmental related information of new machining technologies usually less data exist which can support the decision process.

Concerning this background the main target of the recently finished Ph.D. Thesis of J. Eckebrecht is to contribute to the introduction of more environmentally friendly machining processes. To achieve this goal an analysis is carried out on the obstacles for the enterprises concerning the introduction of new technologies and the assessment of their effects on the environment. In a second step, possibilities for the environmental friendly design of machining processes are presented on the base of three areas: the application of coolants (minimum quantity lubrication), the recycling wastes from grinding (reuse of grinding swarf) and the energy consumption of machining processes (grind-hardening). Furthermore the introduced processes and procedures are compared and assessed by various assessment methods.

The analysis of the barriers of sme's for the introduction of environmental friendly machining processes show that the scope for the design of such processes often is too limited so that environmental aspects are suppressed. Additionally failures in organization of operational procedures and missing qualification of the engaged staff are to recognize. Therefore the transfer of knowledge is of prime importance. Suggestions for the conceptualization of the knowledge-transfer from research institutes into industry and principles of corresponding educational offers concludes the Ph.D. Thesis of Mr. J. Eckebrecht.

miscellaneous

UK CIRP Members Initiatives

Using a modest residue of funds from the 1993 General Assembly held in Edinburgh the UK members formed a Charitable Trust. The funds available from within this Trust are being used to support potential CIRP UK members to attend CIRP Conferences. In this way we hope to strengthen the UK CIRP membership by attracting individuals who are expected to develop a good standing in international manufacturing research.

Traditionally each year in May the UK CIRP members have met in closed session to review their activities; a necessary event, but not one, which has had a technical aspect to it. We have now sought to change this with a new format that we think will better serve to co-ordinate UK technical activities and engender interest in CIRP.

We invite potential CIRP Corresponding and Associate members to a meeting where they are able to make formal presentations about their research and development work in manufacture. Wives, partners are included and a modest social programme is arranged. This has been very successful and we hope that the organic growth of this event will occur thus enhancing the profile of CIRP in the UK.

At the meeting held on 12 May 2000 at Cranfield University presentations were made as follows:-

Professor A A Torrance

Trinity College Dublin Modelling of Grinding

Professor A J Medland

University of Bath Human Modelling (interactions with machines)

Dr A De Silva

Glasgow Caledonian University Precision Electro-Chemical Machining

Mr D Aspinwall

University of Birmingham Electrical Discharge Texturing

Professor D K Harrison

Glasgow Caledonian University Creation of a Rapid Prototyping Centre

Professor D J Stephenson

Cranfield University Materials Processing Research at Cranfield

Professor N N Gindy

University of Nottingham Responsive Manufacturing

Dr N Slater

Dynacast Ltd Advances in Tool Making Processes

Dr J M Sharp People/Process Interface in Modern

University of Salford Manufacture

Professor P G Moropoulos

University of Durham Manufacturing Planning for Competitiveness

This was followed by a short tour of the Precision Engineering Laboratory at Cranfield, and in the evening a most enjoyable dinner was held with our partners and other UK members, in all about 30 people attended.

