



MEMORANDUM OF UNDERSTANDING

FOR

ACADEMIC COLLABORATION

Between

THE UNIVERSITY OF JOHANNESBURG

(A juristic entity established in terms of the Higher Education Act 101 of 1997 (as amended from time to time) and represented by Prof Daniel J Mashao in his capacity as Executive Dean of the Faculty of Engineering & Built Environment and duly authorised thereto)

(Hereinafter "UJ")

and

ST. JOSEPH'S COLLEGE OF ENGINEERING AND TECHNOLOGY (SJCET), PALAI

(An entity established and managed by Catholic Diocese of Palai, India approved by All India Council of Technical Education and affiliated to APJ Abdul Kalam Technological University, India, represented by Dr. V.P. Devassia in his capacity as Principal and duly authorised thereto)

(Hereinafter "SJCET")

DJM

1. PREAMBLE

In the pursuit of excellence in scholarship and dissemination of knowledge to generate reciprocal benefit within a framework of openness, fairness, and equity that will serve both the collaborators, The University of Johannesburg (UJ), South Africa, and SJCET, Palai hereby sign a Memorandum of Understanding ("MoU") for Academic Collaboration.

UJ and the SJCET are collectively referred to herein as the "**Parties**" and individually as the "**Party**".

The two Parties have mutually agreed to the following:

2. AIM OF MOU

The aim of this MoU is to provide for co-operation on academic activities of the two Parties that will strengthen mutual understanding, foster friendly co-operation and promote sustainable and productive academic collaboration and exchange between faculty, researchers and students of both the Parties.

3. SCOPE OF MOU

For the duration of the Agreement, areas of joint activity may include (but are not necessarily limited to) the following:

- 3.1 Exchange of academic employees;
- 3.2 Student exchange;
- 3.3 Explore the establishment and promotion of joint research in the fields of Manufacturing, Rapid Prototyping, Sustainable Engineering and Green Manufacturing. This may include conducting collaborative research projects and the exchange of academic information and materials; and
- 3.4 Other such activities as may be mutually agreed upon in writing.

4. COMMENCEMENT, DURATION AND TERMINATION

- 4.1 This MoU will commence on the date of last signature and shall remain in force for an initial period of 3 (three) years.
- 4.2 Any amendment of and/or modification to the MoU will require the written approval from both Parties.
- 4.3 This Agreement may be terminated at any time by either of the Parties upon a notice period of 3 (three) months to the other Party. The Parties acknowledge that no reasons for termination shall have to be provided by the terminating Party.
- 4.4 Termination shall, however, not affect the implementation of the projects or programmes established under this Agreement prior to such termination and the Parties shall comply with their obligations as if the Agreement has not terminated until the completion of such projects or programmes.

- 4.5 Any student who has commenced studies at either institution before the date of termination may complete his or her study programme and the Parties shall comply with their obligations herein, as if this Agreement had not been terminated.

5. ACTIVITIES ENVISAGED

In pursuit of the aim of the MoU, the Parties hereby agree to undertake to promote, within the framework of the provisions of the respective government regulations, applying in each of the institutions, and subject to the availability of resources, the following activities:

5.1 ACADEMIC COLLABORATION

- 5.1.1 Research collaboration, including joint research projects in areas of mutual interest.
- 5.1.2 In so far as research can be promoted by a period of residence at the partner university, both Parties agree to appropriately support members of the partner university. Each will ensure that visiting academics are integrated well into existing research teams and, shall insofar as it may reasonably be possible provide working space and access to relevant resources to them.
- 5.1.3 Any future Inter-faculty agreements that results from this Agreement, (the project or programme specific agreements) will be included as binding addendums to this Agreement. In the event of any dispute between the terms and conditions of this Agreement and the project or programme specific agreements, the terms and conditions of the project or programme specific agreements, shall prevail.

5.2 EXCHANGE OF EMPLOYEES

- 5.2.1 The number, timing and duration of exchanges may vary according to the needs of the particular programme.
- 5.2.2 Sharing of library resources such as research papers, indices, books and magazines on relevant subjects where possible and appropriate, this will have to comply with both Parties' policies on copyright and intellectual property rights.
- 5.2.3 Sponsoring and conducting joint conferences, seminars, colloquia, training programmes, workshops and other academic meetings on matters of mutual interest.
- 5.2.4 Extending invitations for attending scholarly and technical meetings and assisting in making arrangements for attending national and international conferences.
- 5.2.5 Each Party will be responsible for all travel and accommodation arrangements for its own employees.

5.3 EXCHANGE OF STUDENTS

- 5.3.1 Separate collaboration agreements shall govern the supervision of students studying abroad.

- 5.3.2 The Party (Host Party) where the students are enrolled at, will screen student applications and recommend students to the other Party for an invitation; these students will be screened in line with both Parties' academic regulations.
- 5.3.3 Transcripts of proposed exchange students' results will be provided to the Host Party by the Party where the student is registered, soon after the completion of the exchange after the necessary consent has been obtained from the student.
- 5.3.5 Each student will register and pay tuition and required fees at the Party where the students are enrolled. The Host Party may waive tuition if the student follows the agreed upon academic programme, which may include limited choices made at the institution hosting that student, even after commencement of the exchange, as negotiated with the representatives of the Parties.
- 5.3.6 Students enrolled at the Host Party will be subject to the same rules and regulations as local students. Students will be eligible for all the services and rights normally provided to locally enrolled students.
- 5.3.7 Each student will be responsible for arranging the necessary relevant immigration requirements (e.g. a study permit and any other travel documents). Parties agree to reasonably assist where necessary with the application of visas.
- 5.3.8 Students are responsible for costs of accommodation, international and local travel in host country, books, equipment, health insurance and other expenses arising out of the exchange.
- 5.3.9 The partner institution may refer an exchange student for language assessment if necessary/applicable.

6. INDEMNITY

- 6.2 6.1 Each Party (the "Indemnifying Party") shall indemnify and hold harmless the other Party from all losses, claims, suits and expenses which the other Party may suffer as a result of or in connection with a breach by the Indemnifying Party of any of the provisions of this Agreement. Subject to clause 6.3 below, neither Party shall be liable to the other Party for losses, claims and/or damages which constitute indirect, special and/or consequential damages.
- 6.3 Notwithstanding anything to the contrary in this Agreement, neither Party excludes or limits its liability to the other Party for death or personal injury caused by its proven negligence or that of its employees or for fraud or theft by it or its employees.
- 6.4 Nothing in this clause will be taken as in any way reducing or affecting a general duty to mitigate loss suffered by a Party.

7. PROGRAMME SPECIFIC AGREEMENTS

- 7.1 This MoU is designed to facilitate development of mutually beneficial exchanges/programmes and to promote research and educational relationships.
- 7.2 Before any of the activities referenced above may be implemented, both Parties shall negotiate details and resolve the issues involved therewith and enter into an agreement pertaining to that activity ("Programme Specific Agreement").
- 7.3 The term of such Programme Specific Agreements shall not extend beyond three 3 years in length unless specifically agreed upon and in the event of a period longer than 3 years needs to comply with all relevant policies and procedures.

8. FUNDING

- 8.1 The Parties agree that each activity undertaken pursuant to this MoU shall be dependent on the availability of funds, and financial arrangements for each activity shall be negotiated prior to entering into a Programme Specific Agreement related thereto.
- 8.2 The Parties agree that they shall use reasonable efforts to find adequate financial resources for the activities and exchanges/programmes undertaken pursuant to this MoU.

9. CONFIDENTIALITY

- 9.1 Each Party agrees that the Confidential Information of the other Party will be held in confidence to the same extent and the same manner as each Party protects its own Confidential Information, but each Party agrees that in no event will less than reasonable care be used.
- 9.2 Each Party shall, however, be permitted to disclose relevant aspects of such confidential information to its officers, employees and consultants on a need-to-know basis, provided that they have undertaken to protect the Confidential Information to the same extent as required under this Agreement.
- 9.3 Each Party agrees to use all reasonable steps to ensure that the other Party's Confidential Information received under this Agreement is not disclosed in violation of this paragraph.
- 9.4 Confidential Information shall not include information that:
- 9.4.1 is or becomes generally known or available to the public at large through no negligent act or omission of either Party:
 - 9.4.2 can be demonstrated to have been available lawfully to either Party prior to the disclosure or had thereafter been furnished to either Party without restrictions to disclosure or use or
 - 9.4.3 can be demonstrated to be independently developed by the recipient of Confidential Information without use of such Confidential Information and such independent development is proven on the basis of either Party's records related to such development.

10. CANCELLATION

- 10.1 Should any of the Parties fail to comply with any of their obligations in terms of this Agreement, the other Party may cancel the Agreement without prejudice to any rights it may have in terms of the Agreement, by giving two (2) months written notice.
- 10.2 Any student who may have commenced at either institution before the date of termination may complete his or her study programme as if this Agreement had not been terminated and the Parties warrant that they will continue to comply with their obligations under this Agreement and the programme specific agreement until completion of the study programme.

11. INTELLECTUAL PROPERTY

- 11.1 For purposes of this Agreement, "**Intellectual Property**" means any creation of the mind that is capable of being protected by law from use by any other person, whether in terms of South African law or foreign intellectual property law, and includes any rights in such creation, but excludes copyrighted works such as a thesis, dissertation, article, handbook or any other publication which, in the ordinary course of business, is associated with conventional academic work.
- 11.2 Each Party shall remain the sole owner of all pre-existing industrial or intellectual property rights, technical data, know-how, designs, specifications and the like generated or acquired before the signature or outside the scope of this Agreement ("**Background Intellectual Property**") and the other Party will not have a claim against such Background Intellectual Property, which may include, but are not limited to thoughts patents, patent applications, inventions, discoveries and improvements, copyright in documents, computer software, drawings, designs, operational analysis, technology, course material and know-how and written material, including course material of whatever nature compiled for the purposes of this research.
- 11.3 Neither Party shall acquire any rights, title or interest of any kind in any Intellectual Property owned by another Party ("the owner Party"). All Intellectual Property owned by the owner Party and all modifications made by it to that Intellectual Property, shall at all times remain the sole property of the owner Party. Unless specifically authorised in this Agreement or in writing by the owner Party (and then only to the extent so authorised), any other Party shall have no right to use the owner Party's Intellectual Property in any manner
- 11.4 In terms of this Agreement, "**Foreground Intellectual Property**" means Intellectual Property that is, or has been created, exemplified or developed (whether in whole or in part) in terms of this Agreement.
- 11.5 It is the intention of the Parties that all research derived from the collaborative efforts of the Parties will be the joint property of both Parties, proportionate to the Parties' respective

contributions, unless otherwise specified in a particular programme specific agreement, and/or the specific institutional policies on intellectual property and/or applicable legislation.

- 11.6 In the event that the Parties determine that the Foreground Intellectual Property is jointly owned by the Parties, the Parties shall enter into a separate written agreement to set out (without limitation) the sharing of costs and benefits.
- 11.7 Further to clause 11.6, when either one of the Parties wanting to use the jointly owned research for any further purpose i.e. delivering of papers and publishing of academic articles, the other Party's written consent will be obtained.
- 11.8 If the Parties, respectively each grant to the other, a fully paid-up, non-exclusive and non-transferable license to use its Background Intellectual Property, (excluding the right to grant sub-licenses), such rights of use shall be for non-commercial purposes, and to the extent that such license is strictly required by the other Party to perform any obligation it may have in relation to any activity that forms part of the collaboration in terms of this Agreement.
- 11.9 No transfer, assignment or license in regard thereto shall be of any force and/or effect, unless specifically recorded in writing and signed by the Parties.
- 11.10 No Party will claim any Intellectual Property rights to any trademarks or brands of the other Party, nor will one party use any trademarks or brands of the other Party without the written consent of that Party.
- 11.11 The Parties acknowledge that with regards to publications, the Parties shall prior to any publication, meet and agree the authorship and rights of each Party to review the other's draft publications.
- 11.12 For the avoidance of doubt the Parties acknowledge that they shall each comply with the applicable laws of their respective countries. In instances where there is a conflict between the applicable laws of the two countries, specifically in respect of Intellectual Property, the Laws of England and Wales, shall prevail.

12. DATA PROTECTION

- 12.1 Each Party to this Agreement agrees to comply with all the applicable data protection legislation when collecting, processing, storing or sharing personal information relating to any student or employee in terms of this Agreement.
- 12.2 As it may be applicable in South Africa, the Parties acknowledge that the Electronic Communications Transactions Act 25 of 2002; the Consumer Protection Act 68 of 2008 and the Protection of Personal Information Act 4 of 2013, will apply.
- 12.3 As it may be applicable in India, the Parties acknowledge that the Information Technology Act (2000) ; the Information Technology (Amendment) Act 2008 and the *Consumer Protection Act, 2019* will apply.
- 12.4 Each Party shall comply with all applicable privacy and data protection laws regarding the processing and storage of any Personal Data (as hereinafter defined) received from the other

Party, including the General Data Protection Regulation (GDPR) for any Personal Data originating from the European Union (EU). The term "Personal Data" shall mean any information relating to a living individual which could be used to directly or indirectly identify the individual. Personal Data is considered to be Confidential Information and should be treated as such based on the terms above.

- 12.5 Each party shall ensure that any person(s) authorized to process the Personal Data in accordance with this agreement have committed themselves to confidentiality or are under an appropriate statutory obligation of confidentiality.
- 12.6 Each party shall implement appropriate technical and organizational measures to ensure the security of the Personal Data obtained or processed for the purposes of this Agreement.
- 12.7 Both Parties acknowledge that it will not transfer any data processed or collected in terms of this Agreement to a third party without the consent of the Party to whom the personal information belong.

13. GENERAL CONSIDERATIONS

- 13.1 The terms of, and the necessary resources for, such joint activities and exchange programmes, shall be discussed and mutually agreed upon in writing by both Parties through the liaison officers specified by the Parties prior to the initiation of the particular activity or programme.
- 13.2 The activities under this Agreement will be undertaken by specific appointees from each institution.
- 13.3 For the sake of clarity, both Parties confirm that this will be a legally binding memorandum of Understanding.
- 13.4 Both Parties agree that they will follow all applicable laws and regulations in both countries as they exist today as well as in the future, including but not limited to any privacy legislation and data protection legislation.
- 13.5 Exchange of academic information and materials, publications, research databases, and courseware, will comply with both Parties' policy on access to information as well as all relevant legislation pertaining to access to information.
- 13.6 The Parties and each of its owners, affiliates, officers, directors, employees and agents acting under its instructions and/or influence and taking actions in furtherance of this Agreement, will comply with all applicable anti-corruption laws, including the Prevention and Combating of Corrupt Activities Act No. 12 of 2004 of the Republic of South Africa, the U.S. Foreign Corrupt Practices Act of 1977, the Australian Criminal Code Amendment (Bribery of Foreign Public Officials) Act of 1999 and the UK Bribery Act 2010 to the extent that they are applicable and the Parties also agrees to adhere to any other applicable anti-bribery and anti-corruption laws and regulations applicable in the Republic of South Africa (collectively, the "**Applicable Anti-**

Corruption Legislation). Any non-compliance with any applicable anti-corruption legislation might be an acceptable reason to terminate this agreement, provided that SJCT shall comply with the laws in this clause 13.6 only insofar as it is in accordance with international law.

- 13.7 In the unlikely event of any litigation, such litigation will take place in the country of the Aggrieved Party.
- 13.8 In the unlikely event of any dispute between the Parties, the Parties will use their best endeavors to resolve the dispute amicably. Should the dispute not be resolved within a reasonable time, and it is considered to be of a serious nature, the Aggrieved Party may inform the other Party of its intention of arbitration. Such arbitration will take place in the country of the Aggrieved Party, and that country's arbitration legislation will take precedence, provided that all documents related to such proceedings and the proceedings itself, shall be in English.
- 13.9 Indemnity and limitation of liability
- 13.9.1 Each Party shall defend, indemnify and hold harmless the other Party from all losses, claims, suits and expenses of any kind and description, including, without limiting the generality of the foregoing, losses, claims, suits and expenses arising out of or in connection with property damage, injuries or death sustained by any person or persons whatsoever which may result from or arise in connection from this Agreement.
- 13.9.2 Under no circumstances shall either Party be liable for any indirect or consequential damages arising out of or relating to its performance or failure to perform under this Agreement.
- 13.9.3 Neither party excludes or limits liability to the other party for death, personal injury caused by its proven negligence or that of its employees, for fraud or theft by it or its employees and for a breach of any of the provisions in this Agreement.
- 13.9.4 Nothing in this clause 13.9 will be taken as in any way reducing or affecting a general duty to mitigate loss suffered by a Party.
- 13.10 *Force Majeure*
- 13.10.1. If either Party is prevented, whether in whole or in part, from performing any of its duties, functions or obligations under this Agreement, whether timeously or at all, due to an act of God or acts of authorities (which for the purposes hereof shall mean any national and/or global epidemic, pandemic, war, political riots, student unrest, industry related strikes, civil commotions, insurrection, sabotage, legal prohibitions or restrictions), then such failure shall not constitute a breach under this document, and the obligation to perform shall be suspended to the extent and during the continuance of such prevention provided that the Party prevented from performing in terms of this Agreement shall use its best endeavours to minimise any delay occasioned thereby.
- 13.10.2 In order to qualify for the protection under the above clause, the party providing a service / or who is prevented from performing in terms of this contract, shall forthwith upon the happening or anticipation of the happening of such event notify the other party thereof and furnish that party with full particulars of the nature and cause of the prevention or expected prevention and

the anticipated extent and duration thereof and shall at all times keep that party informed as to the position prevailing from time to time, in order to enable that party to take all such steps as it may consider necessary to protect its interests and reduce any loss or inconvenience to itself or others including, but not limited to, the right to appoint any other service provider(s) to render the services or any aspect thereof.

13.10.3 Notwithstanding anything to the contrary contained or implied in this clause, should such delay endure for a period of 3 (three) months or more, then the aggrieved party shall be entitled, but not obliged, to cancel this agreement on written notice to the other party to such effect and that party shall not have any claim against the aggrieved party arising there from.

13.10.4 Cession: Neither Party is entitled without the prior written consent of the other Party to cede all or any part of its rights in terms of the Agreement to any person, assign all or any part of its obligations in terms of the Agreement to any person, or subcontract with any other person to perform all or any part of its obligations in terms of the Agreement.

13.10.5 Severability: All provisions and the various clauses of this Agreement are, notwithstanding the manner in which they have been grouped together or linked grammatically, severable from each other. Any provision or clause of this Agreement, which is or becomes unenforceable in any jurisdiction, whether due to voidness, invalidity, illegality, unlawfulness or for any other reason whatever, shall, in such jurisdiction only and only to the extent that it is so unenforceable, be treated as *pro non scripto* and the remaining provisions and clauses of this Agreement shall remain of full force and effect. The Parties declare that it is their intention that this Agreement would be executed without such unenforceable provision if they were aware of such unenforceability at the time of execution hereof.

13.11 Warranty of authority

Each Party warrants to the other Party that it has the power, authority and legal right to sign and perform this Agreement and that this Agreement has been duly authorised by all necessary actions of its management structure and constitutes valid and binding obligations on it in accordance with the terms of this Agreement.

14 DOMICILIA CITANDI et EXECUTANDI

14.1 The Parties choose as their *Domicilium Citandi et Executandi* for all purposes under the MoU, whether in respect of notices or other document communication of whatsoever, the following addresses:

14.1.1 University of Johannesburg

Physical Address

Faculty of Engineering & Built Environment
Auckland Park Kingsway Campus
Cnr Kingsway and University Road
Auckland Park

2092

Post address

PO Box 524

Auckland Park

2006

Contact Person: Dr. CE Anghel

Telephone: +27-11-5596111

E-mail: canghel@uj.ac.za

14.1.2 St. Joseph's College of Engineering and Technology, Palai

Physical address: Choondacherry P O, Kottayam, Kerala, India 686579

Contact person : Dr. Lijo Paul, Dean PG, SJCET, Palai

Email: lijo.paul@sjcetpalai.ac.in ; deanpg@sjcetpalai.ac.in

Telephone: +91 9846270462

- 14.2 All notices and any other communications by either Party in terms of this Agreement or relating to it shall be given in writing, and sent by registered post, or delivered by hand to the recipient Party at its relevant address.
- 14.3 Either Party may, by written notice to the other Party, change any of the addresses at which, (or the designated person for whose attention) those notices or other communications are to be given.
- 14.4 Any notice or other communication given by any Party to the other Party which:
- 14.4.1 is sent by registered post to the addressee at its specified address shall be deemed to have been received by the addressee on the 10th (tenth) Business Day after the date of posting; or
- 14.4.2 is delivered by hand during the normal business hours of the addressee at its specified address shall be deemed to have been received by the addressee at the time of delivery.
- 14.5 The provisions of this clause shall not invalidate any notice or other communication actually given otherwise than as described in these provisions.
- 14.6 The email addresses provided in terms of this Agreement will be used for general correspondence purposes.

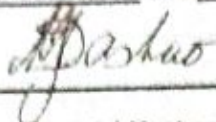
15 SIGNATORIES

This MoU is made in two equally authentic copies, one for each of the signing Parties.

Signature page to follow.

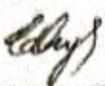
Signed on behalf of THE UNIVERSITY OF JOHANNESBURG (UJ)

SIGNED at Johannesburg this 27 day of March 2023

SIGNATURE: 

NAME IN PRINT: Prof. Daniel J Mashao

In his capacity as Executive Dean of FEBE duly authorised hereto.

WITNESSES SIGNATURE: 

WITNESSES NAME: Dr. CE Anghel

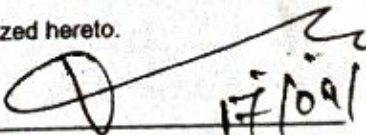
Signed on behalf of ST. JOSEPH'S COLLEGE OF ENGINEERING AND TECHNOLOGY, PALAI

SIGNED at Palai this 17 day of April 2023.

SIGNATURE: 

NAME IN PRINT: Dr. V.P. Devassia

In their capacity as Principal, duly authorized hereto.

WITNESSES SIGNATURE:  17/04/2023.

WITNESSES NAME: Mr. Suresh George, Finance Officer, SJCET, Palai

Submitted

Subject: MOU with Johannesburg University Reg:

Respected Sir,


An academic MOU with Johannesburg University has been processed. The details of the academic MOU have been attached for your reference. The MOU includes partnership with university in academic level in organising international conferences, writing journal papers, book chapters, applying for patents based on joint research and faculty exchange programmes. There is no financial burden for the college and any such items will be raised from external sources on mutual understanding. I request you to sanction the MOU on behalf of the college and make the same effective at the earliest.

Yours faithfully

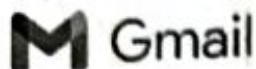


Lijo Paul

may be permitted.
No clauses in the MOU
are against the interest
of SJCEET


16/4/23





Lijo Paul <lijo.paul@gmail.com>

Final MoU document

Anghel, Cristina <cpopa@uj.ac.za>
To: Lijo Paul <lijo.paul@gmail.com>

Tue, Mar 28, 2023 at 1:03 PM

Dear Dr Paul,

I am glad to finally send you the signed document, please see attached.

Please see below instructions from our office regarding the signing of the document.

"Should the signatory decide to proceed with Agreement please arrange that the authorized University signatory signs and executes the Agreement by initialing every page, signing in the designated space and dating their signature".

Kind regards,

Dr. Cristina Anghel

Lecturer

Department of Mechanical and Industrial Engineering Technology,

Faculty of Engineering & the Built Environment

University of Johannesburg

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About the book


Description

Sustainable Manufacturing examines the overall sustainability of a wide range of manufacturing processes and industrial systems. With chapters addressing machining, casting, additive and gear manufacturing processes; and hot topics such as remanufacturing, life cycle engineering, and recycling, this book is the most complete guide to this topic available. Drawing on experts in both academia and industry, coverage addresses theoretical developments and practical

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Provides basic to advanced level information on various aspects of sustainable manufacturing
Presents the strategies and techniques to achieve sustainability in numerous areas of manufacturing and industrial engineering such as environmentally benign machining, sustainable additive manufacturing, remanufacturing and recycling, sustainable supply chain, and life cycle engineering

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Materials Forming, Machining and Tribology

Kapil Gupta *Editor*

Materials Forming, Machining and Post Processing

 Springer

Materials Forming, Machining and Tribology

Series Editor

**J. Paulo Davim, Department of Mechanical Engineering, University of Aveiro,
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This series fosters information exchange and discussion on all aspects of materials forming, machining and tribology. This series focuses on materials forming and machining processes, namely, metal casting, rolling, forging, extrusion, drawing, sheet metal forming, microforming, hydroforming, thermoforming, incremental forming, joining, powder metallurgy and ceramics processing, shaping processes for plastics/composites, traditional machining (turning, drilling, milling, broaching, etc.), non-traditional machining (EDM, ECM, USM, LAM, etc.), grinding and others abrasive processes, hard part machining, high speed machining, high efficiency machining, micro and nanomachining, among others. The formability and machinability of all materials will be considered, including metals, polymers, ceramics, composites, biomaterials, nanomaterials, special materials, etc. The series covers the full range of tribological aspects such as surface integrity, friction and wear, lubrication and multiscale tribology including biomedical systems and manufacturing processes. It also covers modelling and optimization techniques applied in materials forming, machining and tribology. Contributions to this book series are welcome on all subjects of "green" materials forming, machining and tribology. To submit a proposal or request further information, please contact Dr. Mayra Castro, Publishing Editor Applied Sciences, via mayra.castro@springer.com or Professor J. Paulo Davim, Book Series Editor, via pdavim@ua.pt

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Kapil Gupta
Editor

Materials Forming, Machining and Post Processing

 Springer

Preface

Materials forming, machining and post-processing techniques are fundamental manufacturing techniques that are required individually or simultaneously to manufacture near-net-shape engineered parts. Their working principles, process mechanisms, salient features and latest developments are of prime importance. Modelling and optimization of the aforementioned techniques to improve quality, productivity and sustainability are also a major requirement. This book provides insights into some of the important forming, machining and post-processing techniques being used commercially.

There are a total of 11 chapters in this book. Chapter "Fundamentals in Sheet and Tube Forming: Material Characterization, Conventional and Novel Processes and Involved Mechanics" sheds light on fundamentals and advances in sheet metal and tube forming processes. Analysis and optimization of the metal injection moulding process for near-net-shape manufacturing of engineered parts are discussed in Chapter "Analysis and Optimization of Metal Injection Moulding Process". With the help of a case study, the feasibility and suitability of friction stir welding for 3D printed thermoplastic parts is discussed in Chapter "On Friction-Stir Welding of 3D Printed Thermoplastics". Chapter "4D Printing" provides insights into the latest technology 4D printing. Comprehensive information on non-conventional micro-machining processes is given in Chapter "Non-conventional Micro-machining Processes". Formation of a desirable surface integrity on super-alloys by wire spark erosion machining is discussed in Chapter "Investigation on Spark Erosion Machining Induced Surface Integrity of Super-Alloys". Environmentally friendly lubricants and lubrication/cooling techniques are comprehensively discussed in Chapter "Role of Eco-Friendly Cutting Fluids and Cooling Techniques in Machining". Chapter "Titanium Machining Using Indigenously Developed Sustainable Cryogenic Machining Facility" also reports on green machining of titanium alloys where an indigenously developed cryogenic machining setup has been used for experimental research. Laser-based advanced post-processing and surface treatment techniques are detailed in Chapter "Advanced Laser Based Surface Treatment Techniques to Improve the Quality of the Products". Chapter "LASER Cladding—A Post Processing Technique for Coating, Repair and

Re-manufacturing” reports in detail the fundamentals of laser cladding technique. An experimental study on the effects of the laser beam and electron beam welding on different material grades is reported in Chapter “Electrochemical Behaviour and Surface Studies on Austenitic Stainless Steel and Nickel-based Superalloy Dissimilar Weld Joints”.

I sincerely acknowledge Springer for this opportunity and their professional support. Finally, I would like to thank all the chapter contributors for their availability and valuable contributions.

Johannesburg, South Africa
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Kapil Gupta

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Non-conventional Micro-machining Processes



Lijo Paul, J. Babu and J. Paulo Davim

Abstract Nonconventional micromachining processes are developed to meet the manufacturing requirements of new materials and products where usual processes are found inadequate. Based on the type of energy used for material removal, the different micromachining processes are classified into thermal, mechanical, chemical and hybrid processes. Hybrid processes combine two or more machining processes to achieve the desired machining. Descriptions of the important micromachining processes, their material removal mechanism and salient application fields are dealt with in this chapter.

Keywords Micro machining · USM · AJM · EDM · ECM · ECDM · AWJM · LBM · ECDG

Notation

AEDMM	Abrasive electro-discharge micro-machining
AJM	Abrasive jet machining
AWJM	Abrasive water jet machining
CAD	Computer aided design
CAM	Computer aided manufacturing
CD	Chemical dissolution
CHM	Chemical milling
CMM	Coordinate measuring machine
CNC	Computer numerical control
DC	Direct current

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ECD	Electrochemical dissolution
ECDG	Electrochemical discharge grinding
ECDM	Electrochemical discharge machining
ECG	Electrochemical grinding
ECM	Electrochemical machining
EDM	Electro discharge machining
G	Grinding
HAZ	Heat-affected zone
IBMM	Ion beam micro-machining
IEG	Inter-electrode gap
LBM	Laser beam machining
MRR	Material removal rate
PMMA	Polymethyl methacrylate
PZT	Piezoelectric transducer
UHP	Ultra high power
USM	Ultrasonic machining
USMEC	Ultrasonic-assisted electrochemical machining
VAM	Vibration assisted machining
WJ	Waterjet
WJM	Water jet machining

1 Introduction

Many new high performance engineering materials are being developed to meet the stringent requirements of modern industry in terms of size and accuracy of the products. Companies worldwide are vying with each other to meet these customer requirements efficiently and effectively in the stipulated period of time. Some examples of the newer engineering materials are nitroalloy, hastalloy, nimonics, carbides, heat resistant steel, wasp-alloy, etc. These materials find wide applications in aerospace, nuclear engineering and other industries owing to their:

- high strength to weight ratio
- high hardness and
- high heat resisting quality.

However, machining of those materials is difficult and, in many cases, even impossible with conventional machining processes. The advanced machine tools such as Numerical Control/Computer Numerical Control/Direct Numerical Control/Machine Centres etc. are also found wanting in these cases as the machining processes would involve:

Chapter 3

High speed machining of composite materials

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1 Introduction

In early 1930s, it was observed that, during machining of nonferrous materials, temperatures surprisingly decreased with increase in cutting speeds after exceeding a critical cutting speed. This was the precursor to a new division of machining called high speed machining (HSM). The decrease in temperature at higher cutting speeds widens HSM's industrial applications due to its productivity benefits. Major benefits of the high speed machining include reduction in cycle time and waste, and increase in equipment utilization and production rate. High speed machining also reduces the tool wear and surface roughness of the workpiece, because of the reduced cutting temperatures.

It is difficult to give global process parameters to suit a definition of HSM for different work materials and cutting tools. Categorization of low, medium, and high speed machining can be done for a particular group of materials and

machining process. Based on extensive research work at the Aerospace Manufacturing Technology Centre of the National Research Council Canada, Attia et al. [1] gave the criteria to define HSM of composite materials based on the DN number; it is high speed machining when $DN \geq 5 \times 10^5$ where D = nominal diameter of the hole (mm) and N = spindle speed (rpm). Other factors that influence HSM are as follows:

1. Tool geometry and overhang length of the tool that affect the dynamic stability of machining process;
2. Glass transition temperature;
3. Hole quality, delamination, and thermal damage; and
4. Tool life.

Speed ranges for classifying spindle speeds for HSM of composites with small drilling/end milling tools are as follows: for low speed machining 100–10,000 rpm, for high speed machining 10,000–15,000 rpm, and for very high speed machining 15,000–50,000 rpm. The transition range from low to high speed machining was given as 8,000–12,000 rpm, and that from high to very high speed machining was given as 12,000–20,000 rpm.

2 Need for high speed machining of composite materials and challenges

Although products with composite materials are made to near net shape, they sometimes need further machining to meet dimensional and assembly needs. Drilling of holes is very often required for assembling parts made of composite materials. There are several techniques and methods developed by researchers for defect-free drilling, which include conventional drilling, grinding drilling, high speed drilling, and some nonconventional machining processes such as ultrasonic machining, ultrasonic vibration-assisted machining, laser machining, electric discharge machining, electrical chemical spark machining, and water-jet machining. Among these processes, high speed drilling gives better productivity.

High speed drilling (HSD) increases the productivity of drilling process. High speed drilling can be achieved by high rotational speeds and high axial feeds of the tool. For a fixed axial feed increase in rotational speed reduces feed per tooth. This will minimize the induced forces (thrust force) within particular range of spindle speeds and feed rates [1]. Reduction of these forces minimizes the drilling-induced damage of delamination and improves the hole quality. It should be noted that high rotational speed might cause tool vibration that leads to increase in friction-induced temperature. This will cause the tool wear and thermal material damage on drilling of subsequent holes. It is also worthy to note that reducing the feed/tooth to very low values causes increase in drilling-induced forces due to high cutting pressures based on workpiece and tool combination. In order to utilize the benefits of HSD, it is necessary to use