AdM-ERA Report Summary

Project ID: 295016
Funded under: FP7-INCO
Country: Egypt

Final Report Summary - ADM-ERA (Reinforcing Additive Manufacturing research cooperation between the Central Metallurgical Research and Development Institute and the European Research Area)

Executive Summary:
The AdM-ERA "Reinforcing Additive Manufacturing Research cooperation between CMRDI and the European Research Area" project aimed to integrate the Central Metallurgical Research and Development Institute (CMRDI) into the European Research Area (ERA). This was possible thanks to the cooperation with European partners Loughborough University (LbU - UK), Technical University of Cluj-Napoca (TUCN - Romania), and Intelligentsia Consultants Sàrl (Luxembourg). The cooperation between CMRDI and its European counterparts focused on its 2 strongest research topics:

A. Additive Manufacturing of Ti and CoCr alloys based prostheses,
B. Additive Manufacturing of biocompatible ceramic materials: HA, PEEK and TCP.

In spite of the political instability in Egypt during the project (October 2011 - March 2014), CMRDI achieved all the project objectives and obtained good results for its research on additive manufacturing. By the end of the project the following has been achieved:

• CMRDI sent 8 experts in Europe and 5 European experts came to Egypt to exchange knowledge and set up joint experiments with LbU and TUCN. CMRDI published 2 scientific papers based on the research work done within the AdM-ERA project:
  - "A novel design of a Additive manufacturing generated splint for vertical repositioning of the maxilla after Le Fort I osteotomy"; Shehab, M. F., Barakat, A. A., Abd Elghany, K., Baur, D.; Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics 115 No. 2; February 2014

• 6 Training modules have been developed for CMRDI's staff on research topics A and B as well as on European research funding programmes.
• Evaluation of CMRDI research excellence and development of a strategy plan over the next 5 years.
• A whole lot of promotional materials have been prepared and disseminated during the course of the project (e.g. Promotion Guide about CMRDI, leaflet, project website, etc.).
• CMRDI organised five (5) workshops on research topics A and B (4 workshops were planed during the course of the project).
• CMRDI organised an international conference in collaboration with TUCN.
• CMRDI and LbU prepared a proposal under the FP7-NMP work programme: NMP.2013.4.0-5 "Deployment of societally beneficial nano- and/or materials technologies in ICP countries". Intelligentsia initiates a proposal gathering research organisations from Europe and MPC countries (Algeria, Jordan and Egypt), the DeNaMM proposal, "Deployment of Nano- and Materials Technologies in Mediterranean Countries", was submitted the 04/12/2012.

Project Context and Objectives:
The overall aim of the AdM-ERA project was to integrate the Central Metallurgical Research and Development Institute (CMRDI) into the European Research Area (ERA), by developing cooperation with European research and innovation
organisations in its two strongest material research topics: A) Additive Manufacturing of Ti and CoCr alloys based prostheses, and B) Additive Manufacturing of biocompatible ceramic materials: HA, PEEK and TCP. These are also research topics highly relevant to the FP7 NMP and FP7 PPP-FoF work programmes.

CMRDI is a leading Egyptian research institute in the field of material sciences. Its researchers regularly publish international papers and present at international conferences in these research topics. CMRDI is a major research centre with a high potential for integration into ERA as demonstrated by its participation in many national and international projects. The AdM-ERA project involved expanding CMRDI's capacities and scientific expertise through strategic collaboration with the following four excellent European research and innovation organisations: Loughborough University (LbU), Technical University of Cluj-Napoca (TUCN) and Intelligentsia Consultants (Intelligentsia). By making a major contribution towards research cooperation in Research Topic A and Research Topic B, the AdM-ERA project enabled CMRDI to participate and contribute to several FP7 thematic priorities.

AdM-ERA lasted 24 months and was implemented by a dedicated team of experienced CMRDI researchers. It was overseen by a steering committee involving the consortium partners plus members of the Ministry of Higher Education and Scientific Research, the British University in Egypt and Cairo University.

Project Results:

Twinning with LbU (UK):
Two Egyptian experts from CMRDI visited LbU from the 12/03/2012 to the 23/03/2012, namely, Ahmed Abdelsalam Taha and Haytham Abdelrafea Algaszar. During their travel they participated to the Additive Manufacturing Research Group and the Design School’s activities and had the chance to attend a workshop on additive manufacturing at Bath University (UK). The following twinning activities have been performed:

- Both experts received an in-depth training on the MIMICS (made by Materialise, Belgium) software using the digital format ‘DICOM folder’ for patient CT-scan images. The software is available at CMRDI but not used at the same level. The knowledge gained was then transferred to other CMRDI’s staff.
- The CMRDI researchers extended their knowledge by working with the experienced LbU researchers and learnt advanced features for (i) modelling of bones with high deformity due to injury or natural abnormality, (ii) modelling of compound bones like the zeugma bones and (iii) modelling of soft tissues and ligaments that are very difficult to be recognized and separated within the software.
- CMRDI researchers have worked in LbU labs for the preparation of Hydroxyapatite (HA) and Tri-Calcium-Phosphates (TCP) powders which are the essential bone substitutes based on Calcium and natural elements. They worked together with the LbU researchers and learned the different chemical formulas for both materials. They also learnt how to build prostheses from biocompatible ceramics by one of the following methods: (i) Mixing them with other low melting point materials like Ti6Al4V, (ii) Using AM to develop a metallic or ceramic mould and then casting the bioceramics paste after mixing with liquids, and (iii) Using a 400W laser power based AdM tools for the direct melting and joining of bio-ceramic powders.

Two Egyptian experts from CMRDI visited LbU from the 15/06/2013 to the 30/06/2013, namely, Dr Ahman Hamada Abdelhady and Dr Hassan Abdelsabour Abdallah. During their travel they participated to the Additive Manufacturing Research Group and the Design School’s activities related to: i) the design of prostheses based on medical computer tomography images; and ii) Evaluation of mechanical and metallurgical properties of TCP, HA and PEEK alloys based using additive manufacturing techniques. The following twinning activities have been performed:

- Follow up the state of the art in the field of AM research and equipment;
- Participation in project at the Additive Manufacturing Group, sharing knowledge and ideas in order to reflect the discourse within the scientific community;
- Review of successful research project models in order to develop the methodology and procedure of additive manufacturing research projects in Egypt;
- Prospects for future cooperation projects in the field of additive manufacturing in order to establishing and intensifying international research networks;
Twinning with TUCN (Romania):
Two researchers from CMRDI have travelled to TUCN from the 14/05/2012 to the 24/05/2012, namely, Ayman Hamada Abd Elhady and Hassan Abd Elsabour Abdallah. The coordinator of the project, Dr. Khalid Abd Elghany, joined them from the 18/05/2012 to the 26/05/2012. The following twinning activities have been performed:
• CMRDI's team worked on new equipment based on selective melting of metal powders by a 200W laser. This system is mainly used for the manufacturing of titanium alloys prostheses and CMRDI's team learnt how to use the machine, change the parameters and how to evaluate the final results.
• They also received knowledge on other AdM machines such as: the plastic Selective Laser Sintering, the Additive Layer Manufacturing and vacuum casting tools. They also learnt four new procedures for the manufacturing of prostheses using AdM technologies:
  • The direct manufacturing of Ti based prostheses based on the computer design,
  • Controlling the density and manufacturing of light weight prostheses using the concept of lattice core, which generates lighter structures rather than the solid core
  • The indirect process through the manufacturing of core parts using the plastic AdM machines. Then transfer to silicone or ceramic molds for casting the prostheses from Ti alloys or bio-compatible ceramics HA or TCP. This procedure is used if the prostheses geometry or materials have limitations for the direct SLM process.
  • Measure the deflection of the thin prostheses under different temperatures and working loads. This work was done through the joint experimental work with the researchers in TUCN and is important to predict the change in shape and performance of the prostheses used in countries where temperature change very rapidly like the cold weather in Romania or the hot weather in Egypt.

Two Egyptian experts from CMRDI visited LbU from the 15/06/2013 to the 30/06/2013, namely Haytham Elgazzar (Ph. D., Eng) and Mohamed Abdellatif (M. Sc., Eng). During their travel they learnt about: i) Reverse Engineering facilities in TUCN; ii) Non-traditional Machining facilities in TUCN; and iii) Finite Element Analysis methods and software. The following twinning activities have been performed:
• Sharing ideas and knowledge on AdM and RP research;
• Using new software for the design and the analysis of industrial products;
• Various idea was discussed through this visit can be used as new research projects;
• Enhancement of rapid prototyping lab facilities by adding new 3D scanning machine.
• CMRDI staff used TUCN's facilities for additive manufacturing:
  o Computer aided design and manufacturing software: CATIA V4, Pro/Engineer, Pro/Desktop, Mechanical Desktop, Solid Works, Solid Edge.
  o AdM equipments: SLS Sinterstation 2000 from 3D system; DTM Sinterstation 2000; Helisys LOM 1015 Rapid Prototyping Laminated Object: Stratasys Inc. FDM 1650; Selective laser melting MCP SLM Realiser-250; Creaform VIUscan™ 3D Color Scanner; Abrasive water jet (OMAX 2626 Jet Machining Center)

During the project, CMRDI upgraded its current SLM system (model 2003) and with a new 200W laser system. In addition of collaborating with European partners, CMRDI discussed closely with Egyptian dental and bone surgeon to develop prosthesis to be implemented on patient. This cross communication with AdM experts and surgery doctors allowed CMRDI to develop new kind of implants for the Egyptian market and local needs.

The AdM-ERA scientific and technical works performed allowed CMRDI's staff to publish two (2) papers to renown journals:
• "Clinical and radiographic evaluation of a computer-generated guiding device in bilateral sagittal split osteotomies"; Ahmed Abdel-Moniem Barakat, Adel Abou-ElFetouh, Maha Mohammed Hakam, Hesham El-Hawary, Khaled Mahmoud Abdel-Ghany; Journal of Cranio-Maxillo-Facial Surgery 41/6; page 14; September 2013
• "A novel design of a Additive manufacturing generated splint for vertical repositioning of the maxilla after Le Fort I osteotomy"; Shehab, M. F., Barakat, A. A., Abd Elghany, K., Baur, D.; Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics 115 No. 2; February 2014
Potential Impact:
The AdM-ERA project succeeded in strengthening research links between the CMRDI and the European Research Area (ERA). The project’s final results demonstrated that durable research cooperation had been established between CMRDI and its European partners.

The dissemination activities consisted in raising the awareness of the ERA about Egypt, additive manufacturing and CMRDI through the AdM-ERA project, and on promoting the results obtained by CMRDI in the framework of the project. CMRDI intensified its participation to international events to promote their skills and excellence highlighting the findings and results achieved within the project.

CMRDI with the support of Intelligentsia frequently updated the website with news articles and produced newsletters to inform the public about the project advancement. All promotional materials (including the leaflet, poster and Promotion Guide about CMRDI) were disseminated when attending EC info-days, workshops and international scientific conference.

Initially, CMRDI planned to organise an international conference in Egypt on Additive Manufacturing research topics aiming to raise awareness of the international scientific community about their R&D activities, as well as promote Egyptian research organisations in Additive Manufacturing. However the unstable situation in Egypt was an issue to attract International experts. Therefore the conference was held in Cluj Napoca (Romania) in connection with the 11th MTeM – Modern Technologies in Manufacturing - international conference in collaboration with the partner TUCN. The event took place the 17-19 October 2013, gathering 76 international participants from 8 countries (Egypt, Greece, Hungary, Luxembourg, Slovakia, Slovenia, Poland, UK).

CMRDI organised five (5) AdM-ERA workshops while only four (4) were needed. This might prove the dedication of CMRDI to achieve the project objectives and raise the awareness of AdM and medical scientific community on CMRDI’s activities and project goals.

Additive Manufacturing is a modern and attractive field of science with many advantages and applications. One of the most promising field of application is the medical sector for maxilofacial and bones/joints surgery. During the project CMRDI did its best to promote this technique along material scientists, medical surgeon and the wider public. During the course of the project, CMRDI closely worked with the October 6 University, Cairo University and many other organisations in Egypt to bridge the gap between the AdM experts and the medical sector. Egypt has a clear interest in such manufacturing process for medical prosthesis and CMRDI contributed to raise the awareness of the concerned persons and developed in collaboration with the European partners, implants for Egyptian patients.

The AdM-ERA project had undeniably a socio-economic impact on the Egyptian population but also contribute to raise the European state-of-the-art on additive manufacturing of medical implants. CMRDI will continue to promote AdM S&T in Egypt and will strengthen its cooperation with TUCN and LbU.

List of Websites:
http://fp7-admera.org/

**Related information**

| Result In Brief | Bolstering EU-Egypt science research |

**Reported by**

Central Metallurgical Research and Development Institute
Egypt

See on map

**Subjects**

Regional Development

**Last updated on** 2015-02-19