Incremental Sheet Forming for manufacturing customized UHMWPE cranial implants

Isabel Bagudanch, PhD, University of Girona, Spain
Ines Ferrer, PhD, University of Girona, Spain
Maria Luisa Garcia-Romeu, PhD, University of Girona, Spain

Abstract

Statement of the Problem: Commonly, head injuries are produced by a punctual dynamic force. When fractures are produced, they are followed by tensile loads that generate more fractures on other cranium areas. Prostheses have the objective to patch a damaged area and heal the injury. Nowadays, research is focused on customized prostheses and there is no interest to develop a standard product to produce in mass series [1-5]. Incremental Sheet Forming (ISF) is a technology useful to manufacture small batch or one-of-a-kind sheet products. This paper presents the use of ISF with the aim of manufacturing cranial prostheses in biocompatible polymeric sheet. **Methodology:** The cranial implant is designed based on computerized tomographies (CT) of the patient, converting them into a 3D model using the software InVesalius. To generate the toolpath for the forming operation Computer Aided Manufacturing (CAM) software is employed. Once the cranial implant is manufactured in a Kondia CNC 3 axis milling machine, a 3D scanning system is used to determine the geometric deviation between the real part and the initial design. **Findings:** The spindle speed is one of the most important parameters that affect the results of the final part. It has been shown that using 2000 rpm spindle speed and a negative die it is possible to achieve an appropriate geometric accuracy of the prosthesis (with discrepancies below 1.5 mm) (Fig. 1) fulfilling the standardized mechanical requirements. **Conclusions:** The use of polymeric implants in cranioplasty is advantageously because of their lightweight, low heat conductivity and mechanical properties similar to bone. The results demonstrated the huge potential of manufacturing polymeric cranial prostheses by ISF, as far as these processes provide high formability with appropriate geometric accuracy. Furthermore, the cost of the implant has been calculated revealing that it is a cheap process with a low lead-time.

Image

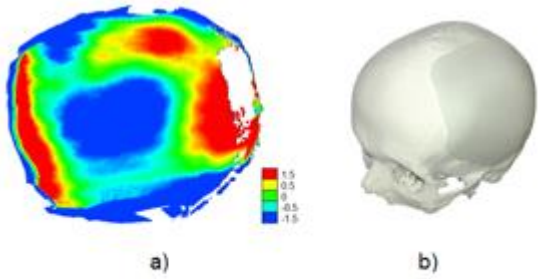


Figure 1. *a) Cranial implant geometric deviation. b) adjustment of the implant to the biomodel.*

Recent Publications

1. Saldarriaga, J.F.I., Vélez, S.C., Posada, M.D.A., Henao, I.E.B.B., Torres Valencia, M.E.C.A. (2011) Design and manufacturing of a custom skull implant. American journal of engineering and applied sciences, vol. 4, issue 1, pp. 169-174.
2. Bagudanch, I., Garcia-Romeu, M.L., Ferrer, I., Ciurana, J. (2018) Customized cranial implant manufactured by Incremental Sheet Forming using a biocompatible polymer. Rapid Prototyping Journal 24.
3. Castelan, J., Schaeffer, L., Daleffe, A., Fritzen, D., Salvaro, V., Da Silva, F.P. (2014) Manufacture of custom-made cranial implants from DICOM images using 3D printing, CAD/CAM technology and incremental sheet forming. Revista Brasileira de Engenharia Biomedica 30, 265–273.
4. Duflou, J.R., Behera, A.K., Vanhove, H., Bertol, L.S. (2013) Manufacture of Accurate Titanium Cranio-Facial Implants with High Forming Angle Using Single Point Incremental Forming. Key Engineering Materials 549, 223–230.
5. Fiorentino, A, Marenda, G.P., Marzi, R., Ceretti, E., Kemmoku, D.T., Silva, J.V.L. (2012) Rapid prototyping techniques for individualized medical prosthesis manufacturing. Innovative Developments in Virtual and Physical Prototyping 1, 589–594.



Biography

Isabel Bagudanch is a Researcher at the Product, Process and Production Engineering Research Group (GREP), University of Girona, Spain. Her research focuses on advanced manufacturing processes such as incremental sheet forming and additive manufacturing.

Email: isabel.bagudanch@udg.edu