An Intelligent Hybrid Manufacturing System for Surface Quality Monitoring with Industry 4.0

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Abstract

Additive manufacturing (AM) and machining in a single machine colloquially known as Hybrid manufacturing help to produce customized and complex products without assembling including greater design freedom and reduced material wastage. A CNC-based face milling mechanism is introduced in the same system to overcome those defects and enhance the quality. To increase productivity and improve product surface quality, evolving additive manufacturing demand and finishing subtractive processes must be combined on the same platform. For the additive manufacturing method, Fused Deposition Modeling (FDM) will be employed, and a face milling operation will be performed for surface finishing. A camera module is used to capture surface images for defect detection such as stringing, rashing, and surface cracking after the AM process. Convolutional Neural Network (CNN) is applied to the captured image for the defect detection process. If the CNN analysis reveals any surface defects, a face milling operation will be performed on the surface for better surface quality. The proposed architecture provides a platform to collect data from the image captured by the camera module for evaluating and identifying surface defects using CNN. CNN provides good accuracy and precision rates for the detection of surface defects which leads to CNC Milling operation for enhancing the surface of the product by smoothing the partially roughened surfaces. Therefore, this study demonstrates to improve the surface quality, reduce cycle time, set up time reduction & improve the product's sustainability. The proposed approach of a hybrid manufacturing system also provides a basic framework to increase efficiency, reduce downtime, increase efficiency, improve end part consistencies of the product as a consequence of post-processing & defect detection in the same system, and enable I4.0.

Keywords

Surface quality, Milling operation, Hybrid manufacturing, Convolutional neural network, Sustainability.

Biographies

Pervez Hossain is an undergraduate student of Industrial & Production Engineering (IPE) under the department of Mechanical and Production Engineering (MPE) at Ahsanullah University of Science and Technology (AUST). He has a great interest in the fields of Industry 4.0, Intelligent milling, Machining Parameter optimization, Sustainable Product Design, Lean Manufacturing, Six Sigma, Total Quality Management, and Supply Chain Management. He is proficient

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SM Rahaman is an undergraduate student of Industrial and Production Engineering (IPE) under the department of Mechanical and Production Engineering (MPE) at Ahsanullah University of Science and Technology. His major areas of research interest are Additive Manufacturing, Lean Manufacturing, Six Sigma, Green Manufacturing, Total Quality Management, Logistic, and Supply Chain Management. He has skills in Matlab, Microsoft Excel, and Microsoft Word, and knows the C programming Language. He has the desire to do research in the manufacturing and industrial sectors.

Md Shihab Shakur is pursuing his master's in Industrial and Production Engineering (IPE) from the Bangladesh University of Engineering and Technology (BUET). He received his B.Sc in Industrial and Production Engineering (IPE) under the Department of Mechanical and Production Engineering (MPE) at the Ahsanullah University of Science and Technology (AUST). He is currently a lecturer in the IPE program under the Industrial and Production Engineering department of the European University of Bangladesh. His research interest includes the area of Manufacturing process, Advanced manufacturing processing, Metal cutting, Industry 4.0, and Decision analysis. He has achieved prizes in different tech-based competitions in Bangladesh like Innoventure'19, IN +!, CODWARE'18, TECHNOCAD, etc. He has been the semifinalist in the national Television reality show "Esho Robot Banai". He has also achieved prizes in the international event named "Mindspark'20" and participated in Techkriti'19 at IIT, Kanpur, India. He has completed his internship program at Hatil Furniture under the research and development department. He has good command over Solidworks, keyshot, Mastercam, Abaqus, Matlab, Minitab, Cura and knows the C, C ++, and python programming languages. He is ambitious to do extensive research work in manufacturing process design, Industry 4.0, intelligent manufacturing, non-conventional manufacturing process etc. Shihab is a general member of IEOM AUST Chapter.

Dr. M. Azizur Rahman is an Assistant Professor in Industrial and Production Engineering (IPE) under the department of Mechanical and Production Engineering (MPE) at Ahsanullah University of Science and Technology (AUST), Dhaka, Bangladesh. He is a member of IEB (Bangladesh), OCIEBS (Singapore) and IMechE (UK). Dr. Azizur is a registered Chartered Engineer (CEng, UK). He earned B.Sc. in Mechanical Engineering from Bangladesh University of Engineering and Technology (BUET), Masters in Mechanical Engineering from National University of Singapore (NUS), Master of Science (Logistics) from Nanyang Technological University (NTU), Singapore and Ph.D. in Mechanical Engineering from National University of Singapore (NUS), Singapore. Dr. Azizur is currently serving as a Guest Editor for Special Issue "Intelligent Additive/Subtractive Manufacturing" in Journal Micromachines. He also serves in Editorial, Advisory, and Review Board of IJAMP (International Journal of Advanced Manufacturing Processes), JPSME (Journal of Production System and Manufacturing engineering), AOE (Annals of Engineering). Dr. Azizur has extensive working experience in various manufacturing industries in Singapore. His research interests include Additive manufacturing (3D printing), Metal cutting and Ultra-precision machining, Electrical discharge and Laser beam machining, Micro/nanofabrication, Logistics and Supply chain management, Intelligent manufacturing process for Industry 4.0.

Dr. Md Shahnewaz Bhuiyan is an Associate professor in Mechanical Engineering (ME) program under the Department of Mechanical and Production Engineering at Ahsanullah University of Science and Technology (AUST). He is a member of IMechE (UK). He is a registered Chartered Engineer (C Eng, UK). He received his D. Eng. and Masters in Mechanical Engineering from Nagaoka University of Technology (Japan), B.Sc. in Mechanical Engineering from Bangladesh University of Engineering and Technology (BUET). His research activities include the area of fatigue and fracture of light alloys, fracture of composite materials, microstructural studies of SME products in Bangladesh, environmental assisted cracking, additive manufacturing. He has published many journal papers and conference articles in these areas.