In-process Monitoring and Quality Control of Hot Forging Processes towards Industry 4.0

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The importance of quality control in any manufacturing process has always been recognised. However, now more than ever before, it is a key requirement in order for manufacturing companies to remain competitive in the digital age. Because of the complexities and globalization of the manufacturing supply chain, real-time product quality analysis has become an important issue in the global manufacturing industry. However, in the metal forging industry, the attainment of efficient real-time quality control within forging processes has been faced with many technological challenges. These challenges are associated with the need for more sophisticated process modelling and simulation tools, cost-effective self-tuning sensors and a lack of robust and efficient in-process monitoring and quality control technologies for the forging industry [1]. Therefore, there needs a pressing research programme that aims to meet the needs of effective in-process monitoring and quality control in a hot metal forging process by developing efficient real-time data-driven techniques for monitoring and improving the quality of hot forged parts. This will eventually help revolutionise the metal forging industry towards its embracing Industry 4.0.

However, some of the challenges in achieving this long-term ambition include: the difficulty in directly accessing product attributes during hot forging, the absence of linear relationships between process parameters and product parameters [2], the variation in input parameters of individual products in different hot forging operations and the high dimensionality of process data [3]. On the other hand, it is believed that answering the following research questions would be the appropriate starting point in tackling these challenges and meeting the research needs. They include;

- What are the most significant process parameters in a hot forging process with regard to the desired product parameters, how are they determined and how can they be captured and analysed in real-time?
- What existing statistical and data analytical techniques are suitable for identifying the underlying relationships between forging process parameters and quality outcomes. Moreover, are these data analytical techniques best used alone or combined with traditional process monitoring and quality control techniques like SPC to improve the overall monitoring performance?
- What is the effectiveness of using data mining approaches in tackling the process monitoring and quality control problems in an industrial hot forging process?

Recent research works have shown that the robustness of data mining techniques like artificial neural networks (ANN), decision trees (DT) and cluster analysis make them attractive for the high complexity and high dimensionality in manufacturing setups like the hot forging process. As such, these techniques can be a major consideration in the proposed research.

It is expected that such an online monitoring system would help identify some underlying relationships between process parameters in a forging process that affects certain predetermined quality characteristics of the forged part, as well as contribute to achieving the reduced reworks, fewer material wastes and fewer scraps in the hot forging processes. A successful implementation of these techniques would also mitigate the costs associated with defective parts, lead to downtime reduction and improve the overall system performance.

References

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