CHAPTER

10

INTEGRATING FUZZY-BASED INTELLIGENCE FOR ADDITIVE MANUFACTURING REPAIR DECISIONS

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10.1 INTRODUCTION

Component repair and restoration are critical processes in remanufacturing since components have to be returned to their original specification and performance before entering their new life cycle. As one of the tenets of the circular economy, remanufacturing is gaining significance as a strategy for achieving environmental sustainability by reducing industrial waste from end-life vehicles. Remanufacturing can be defined as a systematic process aimed at returning used products to their original condition based on specification, quality and warranty. Processes involved in remanufacturing are disassembly, cleaning, restoration and quality testing (Hatcher et al., 2013). Typically, reparation processes in remanufacturing are performed manually using conventional methods such as welding. Highly skilled and experienced workers must carry out these processes (Zhang et al., 2015). According

to Buşu et al. (2015), the reparation process is complex and critical when it involves many different tools or machines. Several researchers have reported other limitations of the manual process, including the labour-intensive nature of the process and the lack of automation systems (Gao et al., 2007; Kurilova-Palisaitiene et al., 2018).

To date, additive manufacturing (AM) technology has evolved from part fabrication to part repair and restoration (Matsumoto et al., 2016; Yin et al., 2018). AM technologies such as direct energy deposition (DED) and powder bed fusion (PBF) have the potential to be applied in the component reparation process (Saboori et al., 2019). Yin et al. (2018) reported on using cold spray technology to repair aeroplane corroded gearbox transmissions.

The deployment of enabling technologies of IR4.0 will certainly bring automation to a higher level. Automation can further enhance the sharing of data and information for process efficiency. In the case of AM-based repair, the process can be improved through AI-based intelligence that can complement human decision-making during repair and restoration. Knowledge-based techniques such as fuzzy logic, neural networks, and optimisation methods should capture design and process knowledge for machine learning. This chapter presented and discussed the development of a fuzzy-based decision-making model in AM repair during automotive component remanufacturing. Fuzzy logic can capture uncertainties and vagueness in decision-making during component repair and restoration.

10.2 APPROACH

This section outlines the comprehensive approach to data collection and analysis, focusing on case studies, in-depth interviews, and hands-on training, to develop a fuzzy-based model for effective component repair in automotive services.

10.2.1 Data Collection

To obtain data and information for the development of the fuzzy-based model, case studies and in-depth interviews were conducted at two automotive service centres and a turbocharger remanufacturing company. Information on the capability of PBF technology for repair was acquired through hands-on training and in-depth interviews with the technology experts at Kolej Kemahiran Tinggi MARA (KKTM) in Kuantan, Pahang.

10.2.1.1 Case Study at Automotive Service Centre

The aim of the case study, which involved in-depth interviews and observations, was to obtain information on the different types of damages to end-of-life components and how those components are repaired. The study includes components such as a pulley for the alternator, a piston for the engine block and a turbine blade for the turbocharger.

For this chapter, the piston of an engine block was chosen as the case study. The piston is an automotive component commonly remanufactured by the industry (Golinska & Kawa, 2011; Kim et al., 2009).

10.2.1.2 Case Study at a Remanufacturing Company

An industrial visit to a turbocharger remanufacturing company in Shah Alam, Selangor, was carried out. The company provides service for reparation and remanufacturing of damaged turbocharger parts. Based on an interview with the company owner and a technician, damages to components, difficulties in component disassembly, conventional methods and processes used for reparation and their limitations were identified.