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Designing a robotic welding cell for bus body frame using a sustainable way

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Abstract

The implementation of automatic systems to execute tasks on the automotive industry brings many advantages when compared to humans. The quality, reliability and safety emerge as important advantages in the use of automatic systems. Vehicles such as buses, ambulances and garbage trucks, among others, are produced by smaller companies that are specialised in a certain genre of vehicles. The small quantities of the production series and the high rate of customization per client make it impossible to use fully automated production lines. This study aimed to determine the advantages of using a robotic welding cell to produce bus body structures and to follow its implementation in the production process. In order to make a reliable data comparison, it was chosen a part from the bus's luggage to execute all necessary tests which will be welded using an out of service robot already owned by the company.

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1. Introduction

1.1. Production systems and flexible automation

Production systems are a huge part of a factory. The quantity produced annually affects the chosen layout for a certain plant. Factories can be classified into three different types depending on the quantity produced: low, medium or high production [1]. The boundaries that separate these types are a bit fuzzy and depend on each author, but it can be assumed that a low production factory produces a maximum of 100 vehicles per year, a medium production is between 100 and 10,000 units per year and a high production factory produces up to 10,000 units per year [2]. The Portuguese bus manufacturer Caetanobus produces up to 100 units per year and therefore its factory is classified as medium production. These types of factories adopt one of the following manufacturing philosophies: batch or cell manufacturing. Cell manufacturing consists of design different workstations, composed of human workers and one or more machines, which are specialised in producing a limited group of parts. These parts must be carefully selected to ensure there are not significant differences between them and they can be manufactured with the same equipment. The short variety allowed by cell manufacturing is the greater downside of this philosophy [3].

Product variety refers to the different products manufactured in a single factory. In the case of Caetanobus, product variety goes up to another level since it produces four types of buses: minibus, coach, urban and airport. For that reason, it can be assumed that there are four different production systems, each one with its own product variety. Product variety can be classified in hard or soft depending on the number of differences between products. A pair of products with huge differences, that share no common parts, is classified into hard variety [2]. However, buses of the same production system are put into soft product variety category due to the customization required by each customer. Buses designed for urban environments or coaches designed for long distance travelling must be opened to a certain level of customization. Today's customers have individual specifications and manufacturers must fulfil them to gather their satisfaction [4]. To successfully deal with product customization, batches are produced following a cell manufacturing philosophy due to the high number of common parts [5]. In any factory, there are tasks like processing, handling, assembly and inspection which tend to be automated with the objective of achieving a high productivity system while the worker's fatigue is reduced [6]. In the past, automation systems tended to be organised in two categories: automation of manufacturing systems and computerization of manufacturing supporting systems. Nowadays, modern automated systems are implemented by industrial computers connected to a central system responsible for managing information from the whole factory. Consequently, the two categories are bonded together [7]. These modern automation systems are often organised in three different types instead of the previous two: fixed automation, programmable automation and flexible automation [8]. Flexible automation is used by cell manufacturing philosophy and consists of systems capable of producing a restricted group of similar parts with minimum time lost while programming or changing the physical setup [7]. The perfect match between flexible automation systems and soft variety products turns these systems into powerful solutions for the bus industry.

1.2. Bus manufacture

A bus is divided into two main components: chassis and bodywork. The chassis is the component responsible for carrying all mechanical parts required to move and for supporting all loads applied to the vehicle. The bodywork is the component that includes the internal and external special equipment of the vehicle [9]. There are also integral buses where the chassis and the bodywork are part of the same structure and there is no visible difference between them. A key component of the bodywork is the superstructure that defines the general shape. It represents a skeleton in which all equipment are applied, such as seats, interior and exterior panels and glasses [10]. Nowadays, there are two methods to assemble the superstructure. The first method was developed in the industry's early days and it consists in the construction around the chassis. Under the orientation of technical drawings, the production line starts to build the skeleton by welding one element at the time. They start with the chassis and body frame connections and end with the roof assembly. The second method, which is the one used at Caetanobus, consists on welding the superstructure separated from the chassis. This structure, called cage, is divided into six parts: floor, roof, right side panel, left side panel, front and rear. The six different parts are built separately and are then assembled to form the