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The effect of Ambient Conditions on the Functional and Locational Precision of a Single Job Robotic Arm

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ABSTRACT

In the recent era, automation is leading the manufacturing industry. Most of the physical movement operations are getting automated to meet larger precision and less errors. Several automation processes are using the programmed robots to achieve the same. On the other hand, the robots employed are also getting upgraded in all perspectives like programming, hardware, structural design and structural materials. Recent invention in manufacturing merely depends on additive manufacturing of metals and polymers. For a simple load application, the polymers/polymer composites are largely recommended. This study focuses on the performance of such additively manufactured robotic segments and their structural response as a candidate for robotic arm to do pick and place operations. The service ambience is simulated physically to bring 10°C service condition and reference is taken as room temperature (24°C). The robot is programmed to reach a specific target location and is repeated for 100 trials. Performance is measured and analysed for consistency.

Keywords: Ambience effect, positional accuracy, robotic

INTRODUCTION

The effect of service temperature and ambience conditions are the most promising factors deciding the performance of a robot in operation (Yin et al., 2014). Most of the present manufacturing industries use robots in high fatigue operations where larger human error is anticipated (Ibaraki et al., 2021; Weck et al., 1995). Nevertheless, the robot does an optimum performance in the repeated operations than the human, there are several factors affecting the performance of the robots (Ibaraki et al., 2021). The position/locational accuracy is mainly influenced by several factors (Ibaraki & Kawano, 2023). Similar to the thermal expansion characteristics of the virgin as casted polymeric materials,

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the additively manufactured polymers also responded significantly against the service temperature (Sevinchan et al., 2018). Most of the structural designs made for the polymeric materials are now considering the thermal expansion coefficient as a major factor when concerning the product performance (Santolaria et al., 2009). In recent years, researchers focused on the thermal significance of the performance of the robots in service (Wang et al., 2022). In line with this, an experiment is designed to investigate the significance of service temperature on the locational accuracy and consistency of the additive manufactured robotic segments and presented here for the interest.

METHODOLOGY

Manufacturing of Robotic Segments

Segments for this research of climate characteristics of robotic arms are made through additive manufacturing (AM), especially the fusion deposition molding (FDM). Environmentally degradable Polylactic Acid is preferred as filling filament for the FDM process. Melt coils for the FDM process are supplied by GreenCoils India, Pune. The Snapmaker 3D Indian is used in additive manufacturing of the robotic segments. Initially, the robotic arm segments are designed though a modeling package and transferred to the Snapmaker platform for slicing and rendering. Figure 1 shows the robotic arm design and the same is fed into the AM unit.



Figure 1. Segmental plan of the robotic arm

All the AM segments are assembled to connect electronically through an Arduino uno controller. Upon the connections a DC source is given for the activation of the arm to move the precise location.

Ambient Study

The locational accuracy of the robotic arm reaching as per program under the room temperature and low temperature are studied for 100 trials. The room temperature experiments are done at simple open laboratory places. Exclusive low temperature cabins with temperature control are prepared to conduct a low temperature study on the locational accuracy of the fabricated robotic arm. Set temperature to study the locational accuracy of the AM produced robots are 24°C for room temperature and 10°C for the low temperature study. Before the initiation of both the experiments, the robot arm is left aside in the ambience for 5 hr to avoid uncertainty. Programming is done to reach the robotic arm from

(0,0,0) to (0,40,0) spatial location every time of the hundred iterations. The variation in the reach of the target coordinate in each trial is measured through a laser measuring system and recorded for further analysis. With the available result data, positional accuracy and energy consumption are studied as the response of the variation in operational ambience condition.

RESULTS AND DISCUSSION

Influence of Ambience on Positional Accuracy

The additively manufactured robotic arms are initially tested under the regular ambience condition. The room temperature maintained in the laboratory is 24°C. Conventional room pressure and relative humidities are recorded and maintained throughout the experimental trials. Through Arduino programming, the robotic arm is scheduled to reach the spatial coordinates of 0,40,0 from the specified 0,0,0 origin. Figure 2 illustrates the variation of reach coordinates (only as Y coordinate, since others are 0,0). Observations from experimental trials are classified into two clusters. The first cluster presents the results obtained from trials 1 to 50, the second cluster presents the results obtained from the trials

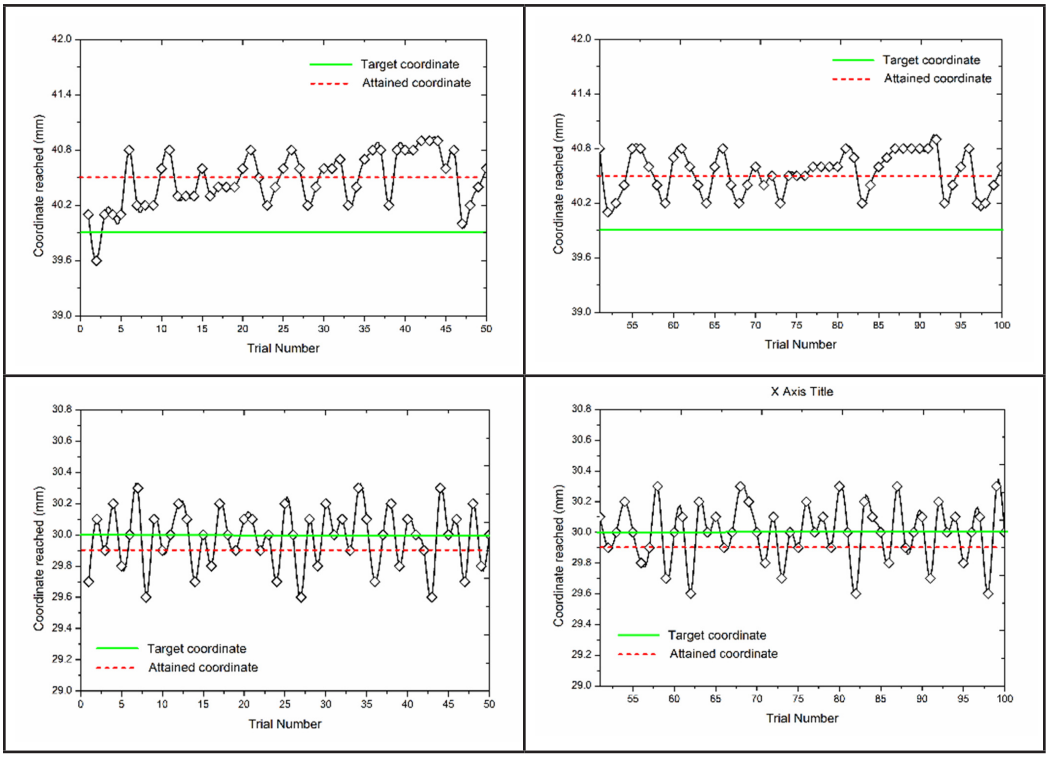

Figure 2. Variation of target reach as experimental iterations at room temperature condition

51 to 100 in both the room temperature (RT) and low temperature (LT) ambience conditions. The same are notated as RT1, RT2, LT1 and LT2 in the illustrations. Figure 2 shows the observations made on both clusters of room and low temperature. It is noted that, in both the clusters, the locational accuracy of the room temperature tested robots is mostly in the upper ranges of actual location (40 mm). The average reach of the manipulator point is 40.503 mm and has a standard deviation around 0.2607.

On the other hand, in both the clusters of low temperature tested robots, mostly the manipulator reached the exact location, and average reach is very close to the actual coordinate of the program. The average reach-out is 29.987 with the standard deviation around 0.1886 which attributes a closer reach of the manipulator to the target coordinate.

CONCLUSIONS

Comprehensive research on the positional accuracy of pick and place robots in two different ambiences are done on the robotic segments made using PLA. Results have shown that PLA based robotic segments have greater reliability under the deep temperature service environment and they have proved the suitability to be used in several cold weather applications.

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