AMRC
ADVANCED MANUFACTURING RESEARCH CENTRE
The University Of Sheffield.

Project RAID
Smart Fixturing Demonstrator

Abstract

In this paper it is shown how a closed loop double verification system, incorporated into a reconfigurable fixture, can be utilised to provide an intelligent quality improvement solution.

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INTRODUCTION

A major issue within manufacturing quality control is error induced by operators. In these cases, the incorrect set up and fit of parts within a fixture, can cost companies significant amounts of time and money in rectification work and scrap. A verification system within this process would be advantageous in ensuring all the correct processes have been followed from start to finish with no steps missed.

Another key aspect of expenditure in manufacturing is fixtures often requiring a large area. Therefore it would be beneficial for the fixtures to be reconfigurable to accommodate product variation and different processes. Using these methods it is thought that the footprint required could be greatly reduced.

Overview

The proposed solution for these issues was to: incorporate a verification system into the fixture capable of differentiating both the fixture configurations, and the components that have been loaded into it. However, in order for this to be truly "smart", the system must have dual modular redundancy (DMR) confirming the actions that have been completed with gates preventing its misuse. One method of creating this loop is through the use of low cost sensors connected to a PLC to generate an OK/NOK output. A Cognex vision system is the secondary form of verification as it can provide a visual check of the components and fixture configuration. Feeding this information back into the system to provide an OK/NOK output for both verification loops, created the necessary DMR. To provide this solution the Caterham car from project RAID (Reconfigurable Assembly Integrated Demonstrator) was selected as the test bed, with wide and narrow track wishbone product variations available.

System showcase at MACH 2018 exhibition.

Manufacturing Execution System

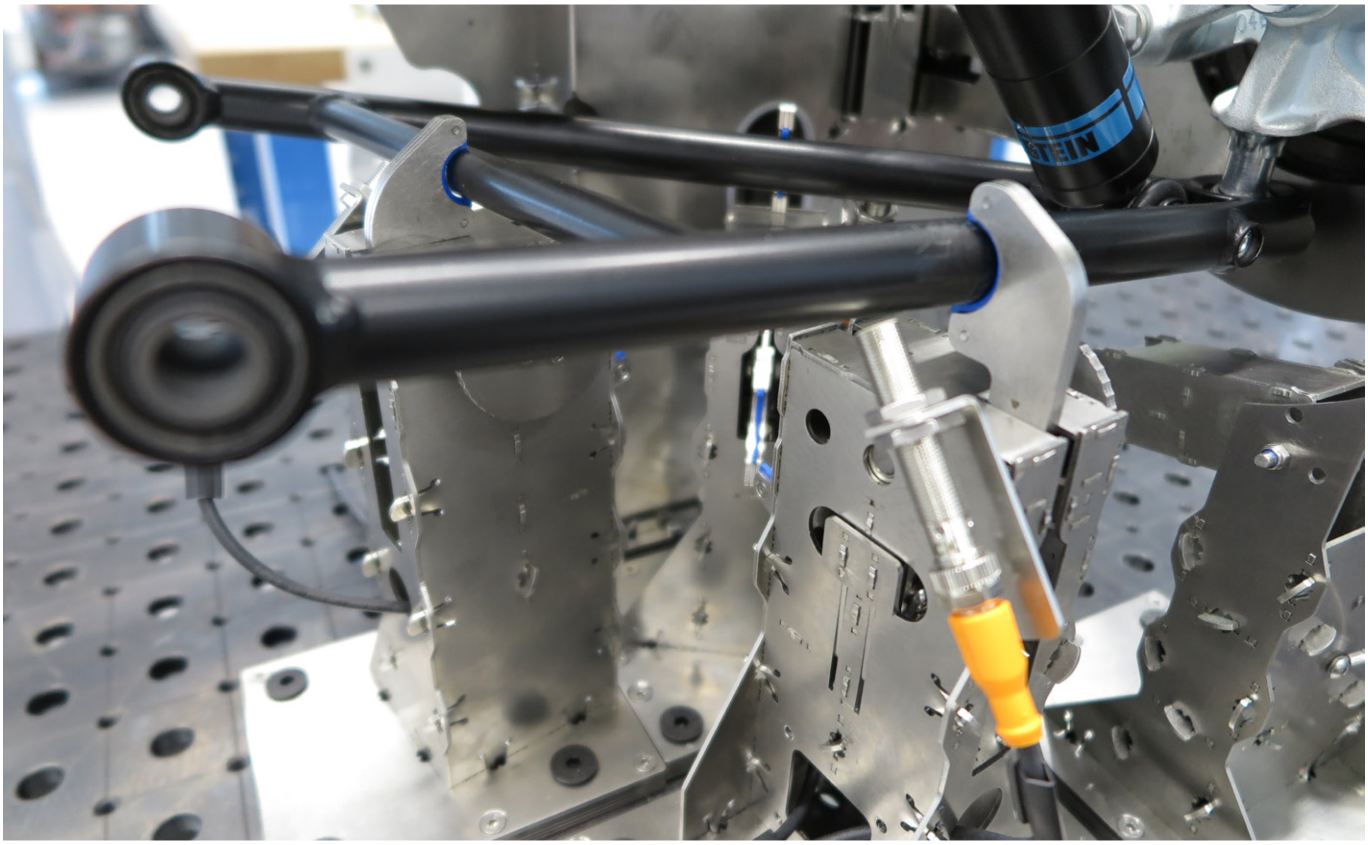
By using the manufacturing execution system (MES), the smart fixture was easily integrated into the system allowing the operator to have an easy to use dashboard on which work instructions were displayed in a controlled manner. Set up using Delmia Apriso, all of the integrated components (the display PC, sensors' PLC, Cognex camera and LAP laser projector) were able to interact with each other. The C# code written then provided the necessary logic for producing the desired outputs to the operator, enabling the correct build to happen each time.

In-built sensor verification

The sensors were connected via IO-Link to the PLC providing easy to read data. An IO-Link master system was used, allowing up to 16 sensors to be connected via a single Profinet port. Analogue signals were converted to digital signals before being converted back at the PLC, to give the desired readings. The sensors used included PNP inductive, photoelectric distance, vibration and temperature. The vibration and temperature sensors monitor environmental conditions, with any adverse measurements being logged and the operator notified so that the fixture can be checked for conformance. The PNP and distance sensors were used to determine the configuration of the fixture and the components that had been loaded. The sensors chosen were the most applicable however, strain gauges and infrared sensors were both considered should a lower cost solution have been required. However, the accuracy of the readings would have been lower, giving a less reliable quality control measure.

Operator guidance

To display the correct build steps to the operator, the dashboard provided visual and worded instructions. The LAP laser projector, projected information onto the workbench area for further visual guidance. Using these systems and the MES integration, the operator is accurately guided throughout the process to ensure that the fixture and parts are assembled correctly first time.



In-built system verification.

Vision system verification

The second verification system was provided through the use of a vision system, a Cognex 8000 series camera. This system was chosen as the in-built intelligence allows 2D visual programs to be written in which the logic is instated. The logic within the program is created by building the fixture perfectly, taking a snapshot of this and then using the pixels generated to give a gold standard. The verification compares the pixels of the gold standard images with the live build images to ensure they align. Should the live build images vary with those of the gold standard, the logic will produce an NOK output to be interpreted by the control system. By using the two methods described, verification of the system is able to prevent incorrect loading or positioning of any parts that enter the fixture. The main disadvantage associated with a vision system however, is the variance in natural light. This variance can cause irregularities in the pixels being compared thus requiring a constant light source to flood the parts, removing this source of error.

Business benefits

The key business benefits of a smart fixture and the technologies encompassed within it relate to the overall improvement of quality control. By utilising control measures such as those discussed, cost savings can be found through; the reduction of rectification work, a reduction in scrapped components, a digitised build data process meaning root cause analysis investigation time can be greatly improved and the earlier capture of defects meaning less downtime will be incurred through incorrect loading of components.

Conclusion

In summary the installation of a double verification system into a production environment would be of great benefit, especially where current quality control measures are either time consuming or do not meet company standards, such as Six Sigma. The main drawback with setting up such a system is associated with the installation expenditure, as geometric fixturing of bespoke parts can be expensive and capturing the required data with vision systems involves high value equipment and additional set up time. However, these disadvantages may be vastly outweighed once the system has been set up correctly as the quality control is greatly improved.

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