Visual Inspection of Details in the Automotive Industry

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Abstract. Every company strives for efficient and high-quality production, therefore systems for visual control and process monitoring have been implemented in all industries. The continuous growth of automated production and the tendency to reduce human capital in the manufacturing industries, necessitates the development of highly intelligent software solutions for machine vision and product quality in the process of creation and processing. Leading companies such as: COGNEX, KEYENCE, OMRON, SICK, IFM, BALLUFF and many others are in a constant race to develop products and software systems for automated machine vision. The current development looks at automated inspections in automotive manufacturing. A composition of a station for the implementation of an automatic check for the correct assembly of an electro-switching element (rubber) is proposed. A test process has been created and will be presented to the client.

Keywords: Machine vision, industrial automation, automated visual inspection.

1. INTRODUCTION

Automated inspections provide modern solutions to problems in automotive manufacturing. In the past, product inspections in many manufacturing sectors were carried out by operators. The human factor is a root cause of errors and the impossibility of a stable process. The need for highly qualified personnel in any production is related to financial resources and long-term personnel training. In specific cases of production processes, visual inspection by a human is almost impossible. Computer vision can completely replace the human factor, even in critical situations – aggressive environment and life-threatening processes [1]. The serial production of each product includes a visual inspection. In this operation, the process requires an operator to inspect the component for visual defects and discrepancies in externals characteristics such as: color, shape, mechanical defect, etc. [2]. In the work environment, the operator performs the assigned task continuously for a long period of time, which leads to fatigue of the optic nerve. It is extremely difficult for the worker to remain concentrated in such cases.

Software products with AI can replace the human factor completely in cases of visual monitoring. In order to construct adequate hardware systems, it is necessary: the right combination of cameras, optics and lighting, so that the captured images show all inconsistencies. All these components show why the automation and visual inspection processes is an interesting topic that is yet to develop and gain popularity as an important part of all aspects of industries.

Fig.1 Station for automatic inspection of final product after assembly.

2. DESIGN OF PRODUCTION LINE

Automated assembly lines are a set of multiple stations (machines) that have a specific purpose. The time to produce one item or to perform is determined by the time of the slowest operation in the assembly process. The quality of the final product is determined by the quality of the production process and the checks that are implemented in the workstations, as well as the analysis that is made in the design process of the project production line.

2. 1. The FMEA Method

The FMEA method (analysis of possible defects and their effects) is based on the assessment of the risk of occurrence of defects. The FMEA method is a tool for ensuring maximum efficiency of processes and systems. Due to its nature, it is suitable for assessing risks to the health and safety of workers. With the use of the method, experts in the relevant field establish the possible causes of errors in the process. On the base of the information and the analisys relevant actions are determined to minimize the influence of the factors.

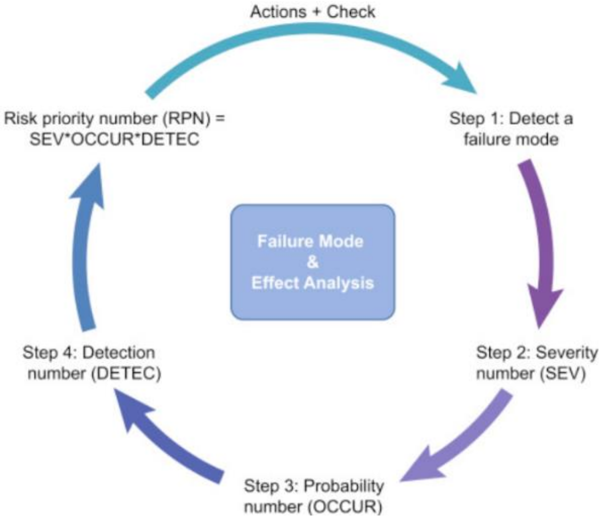

Fig.2 FMEA diagram. [3].

The process analysis helps designers to add checks at precisely defined positions (stations) in the production line that will save time and financial resources for subsequent changes in the construction process. The implementation of automated inspections with the use of cameras, sensors and measuring devices saves time and guarantees repeatability and a stable work process.

2. 2. Process map

An example map of a production process is depicted in Fig. 3. Manufacturing operations are numbered from 10-1000. Each operation is calculated with machine time and operator time. Any addition of automated or other checks increases the production time and makes the final product more expensive.

Due to customer complaints, manufacturers are required to integrate cameras, sensors and other automatic checks into already existing production lines.

The benefits of implementing machine vision are:

- Full or partial automation with a minimum of human errors and cost reduction;
- Increasing the production line efficiency;
- Increasing the manufactured product quality and reducing complaints;
- Reduction of human intervention in the production process and the possibility of digitalization;

2.3 Problems in the Integration of Automated Checks in Production

Integrating additional checks into already built production lines (machines) is a laborintensive process. Designers are limited by space, structural change of existing details, stopping the production process to integrate hardware and software components. In some cases, it is impossible to integrate the check into a specific operation. Machine vision is known for its speed, accuracy and repeatability. Machine vision constructed with the right camera optics can easily and with high reliability inspect small details of objects that are invisible to the human eye. Machine vision systems integrated into a production line can inspect many items per minute. They reliably and repeatedly exceed the human capabilities in process of quality checks.

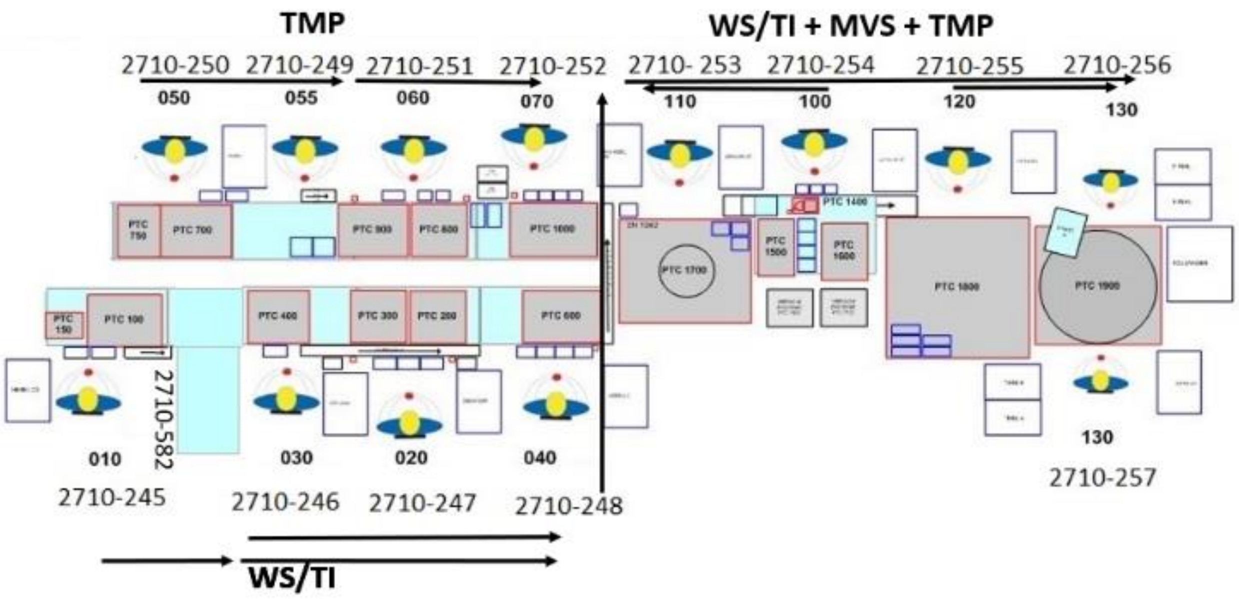

Fig. 3 Sample map of a production line.

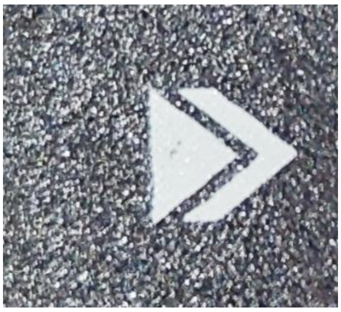

Fig. 4 Checking for the presence of scratching without camera.

Fig. 5 Checking for the presence of scratching with camera.

Fig. 5 clearly shows the difference in the resolution of the problem when zoomed in by the camera, which is not possible to check by an operator.

3. IMPLEMENTATION OF AUTOMATIC CHECK FOR CORRECT ASSEMBLY OF ELECTRICAL SWITCHING ELEMENT

A station was designed to test the correct placement of a part (tire) during assembly, Fig. 6. Test process has been created and will be presented to the client.

The following customer requirements must be met when building the layout:

- The layout of the installation must correspond to the software and hardware used and its capabilities for accurate and precise measurement.
- To have a simple construction and meet the standards of interchangeability and standardization of the parts used.
- To meet the specific requirements of the client.
- To meet the requirements for maintainability and easy adjustment.
- The operator should not be able to move to the next step when a NOK result is reported.
- To comply with labor safety requirements.
- To meet POKE YOKA requirements.

3. 1. 3D Design of the Installation

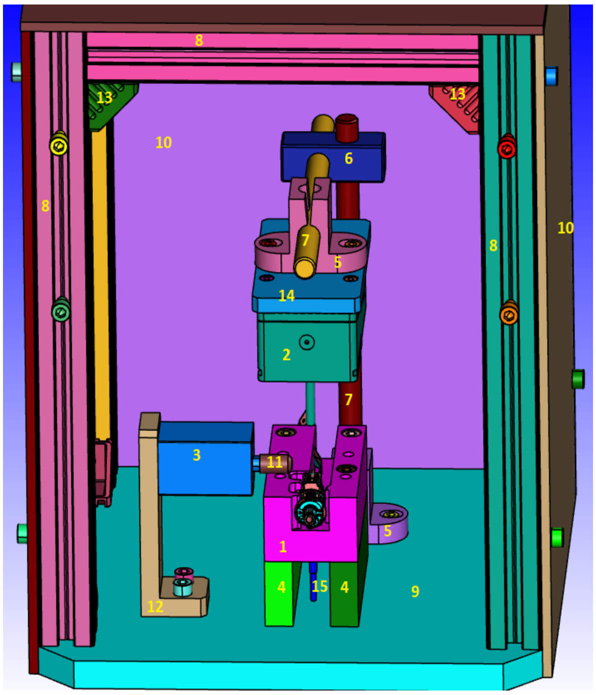

Fig. 6 3D design of the installation.

1. Working matrix; 2. Camera; 3. Locking cylinder; 4. Substrate; 5. Stand; 6. Stand model 2; 7. Rod stand; 8. Bosch profile; 9. Substrate; 10. Covers; 11. Locking head; 12. Cylinder stand; 13. Fasteners; 14. Camera stand; 15. Sensor.

3. 2. Automatic Inspection with 2D Camera SICK Inspector I40

SICK Inspector I40 camera was chosen, Fig. 7, which meets the technical and economic requirements for the intended inspection.

The technical parameters of the camera are:

Sensor resolution 640 px x 480 px

Scan/frame rate 40 fps 1) Number of inspections 32; Reference images 32 objects [4].

Fig. 7 SICK Inspector I40 camera [4].

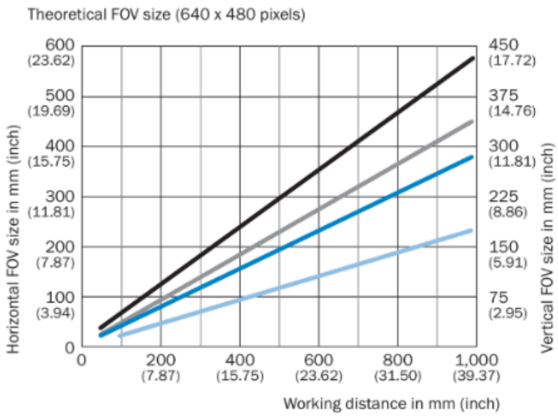

Fig. 8 The operating parameters of the camera [4].

3. 3. Verification Process for Correct Assembly of parts

The time required to check the correspondding part depends on the number of references that will be checked by the camera.

In the current installation, the number of checks is an object locator and an element (tire) contour check. The theoretical time to check the camera for one cycle or one part takes 1 second.

Table 1 shows the possible checks by the SICK I40 camera and the corresponding time for the check used.

TABLE 1. Theoretical time to perform the camera checks [5].

Reference object configuration	Typical time for real selection
Only locator	0,5s
Locator plus four pixels counter inspections.	1s
Locator plus four edge pixel counter inspections.	1s
Locator plus four contour inspections.	2s
Locator plus four pattern inspections.	1s
Locator plus 32 pixel counter inspections.	3,5s
Locator plus 32 contour inspections.	20s

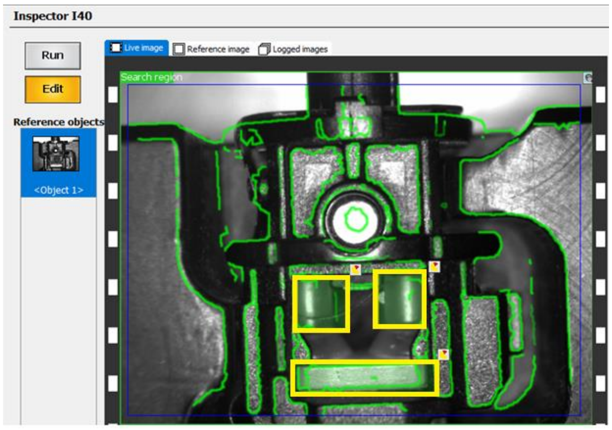

Fig. 9 shows positive result of the test that verifies the correct placement of the part (contact rubber) of the assembled unit.

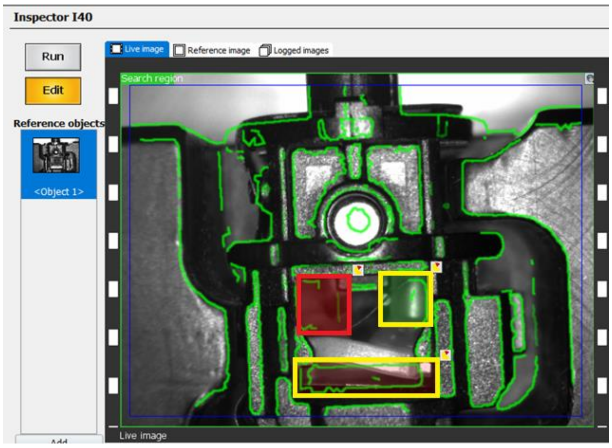

Fig.10 shows a negative result of the test that verifies the correct placement of the part (contact rubber) of the assembled unit. The elements (the base and one pin of the rubber) that are in the correct position are marked in yellow. The position error is marked in red on the second pin of the rubber, which is outside the camera position area.

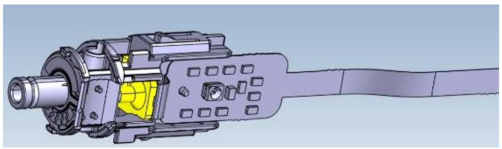

Fig. 11 3D model of the assembled workpiece.

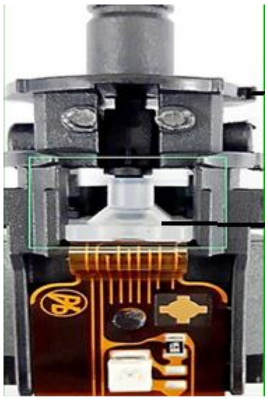

Fig. 12 shows a picture of the final product (work-piece) after the automatic check and OK result.

4. COMMENTS AND CONCLUSIONS

The proposed layout of an automatic inspection station for correct assembly showed the following results:

1. Detection of minor defects meeting the quality requirements set by customers.

2. Greater precision, reliability and speed is achieved compared to operator visual assessment.

3. Successfully completed inspections under variable conditions such as changing illumination and poor contrast.

4. Adaptation to the speed of the production line.

5. Meets high safety standards.

6. Achieved verification of measurement parameters without interrupting production and within a preset time.

7. Space saving and easy integration in small spaces.

8. A test process has been created and will be presented to the client.

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[5] Operating instructions I40, Select Reference Object page 36.