
Fig. 1/Source: Adobe Stock

Quality Assurance – man vs. machine

The monitoring of manufacturing processes, manufactured components and manufacturing plants themselves is an essential part of every modern production chain. In addition to visual inspection by humans, there is also quality inspection by automated testing procedures.

Due to the use in safety-relevant areas and the increasing complexity of components, non-destructive testing methods play an increasingly important role. Test methods that test the quality of the component without destroying it can be used at different points in the manufacturing process, depending on the technology used.

An important tool in this chain is the human visual inspection. The human brain is able to capture complex conditions and compare them with stored information from known types of defects. By using all the senses, the person used for this purpose can flexibly carry out the assessment directly by eye or by touch, or with the aid of assistance systems such as cameras or microscopes. The smooth alternation between detailed and less detailed tests is an advantage that only humans can achieve.

Numerous studies have shown that human performance is limited despite all the flexibility. Human testing by visual inspection is strongly influenced by the following factors:

- Temporary performance
- Fluctuating ability to concentrate
- Different individual performance levels
- Influence of working speed on accuracy
- Influence of the working environment
- Selection and training of the employee

In many current production lines, testing tasks are performed either by special testing personnel or by a trained machine operator as part of his operating and assembly activities. It has been assumed so far that it has no influence on the result whether an employee concentrates exclusively on one task during his work, or whether he performs a simple inspection activity as an additional task, almost incidentally. Studies by the aircraft industry have now shown that this is not reliably the case, especially in the field of quality monitoring.

The search for and evaluation of defects are the two most error-prone and cost-sensitive steps in quality assessment. The time used to inspect a component usually has a direct influence on the cycle time of the production line.

The shorter the test time, the lower the loss of time, the lower the cost of the test.

Abb. 2 Smart Factory/Source: Adobe Stock

The test personnel must decide independently how exactly the test is to be carried out. If no fault is found, the personnel must decide independently when the inspection is to be terminated. Therefore the specification of a concrete inspection time is difficult. Based on studies carried out it is assumed that there is a direct correlation between the testing time used and the detection of defects. The less time spent searching, the fewer deficiencies are discovered. Diagram 1 shows this correlation using a magnetic particle test.

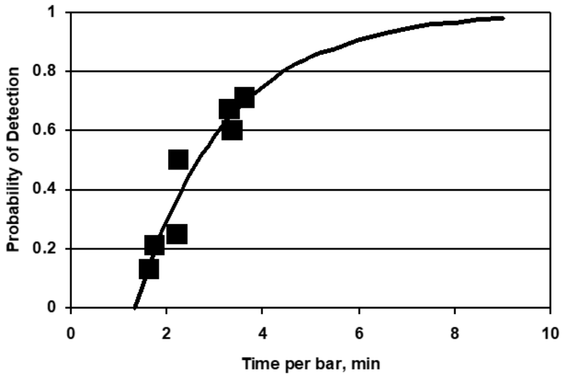

Diagram 1: Speed vs. Accuracy/Magnetic particle testing of steel beams/source: [1]

The longer the test, the higher the probability of finding all defects. However, this contradicts the intended shortening of the inspection time.

The performance of a human being is limited. Since 1948, hundreds of studies have been conducted on time-dependent performance and vigilance in quality monitoring activities.

The studies show unanimously that the vigilance of the test persons has drastically decreased after approx. 30 minutes. In some cases, only about 50% of the defects were detected. After one hour the value is now only 30%. An example is shown in diagram 2.

According to the study, the decrease in sensitivity can be further increased by various factors: Do defects occur very rarely? Are there several types of defects that need to be distinguished? Are they experienced test personnel or are there secondary activities that need to be performed? In addition to the general working conditions, such as general well-being at the workplace, the volume during the activity or the accessibility of auxiliary tools, human factors such as demotivation, private problems as well as the current state of health also play a decisive role.

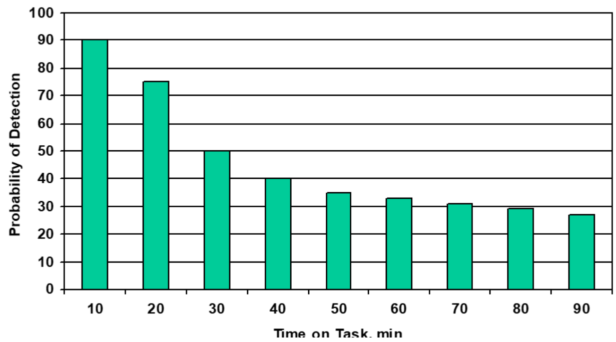

Diagram 2: Probability of defect detection as activity process/source: [1]

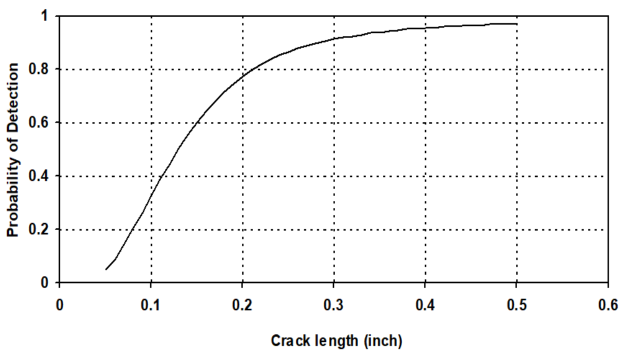

Diagram 3: Probability of detection as a function of crack length/Source: [1]

At the same time, the general suitability of the human being for the testing task must be considered. There are limits to the human eye. In studies, which were carried out both under laboratory and under real conditions, test persons were given samples with cracks in metal surfaces for visual inspection. Diagram 3 shows the results.

The smaller the crack, the lower the probability that it was found. Even large cracks were not reliably detected by the test persons. Moreover, there is no guarantee that every type of crack will be detected equally by every human being. Diagram 4 shows the result of another study.

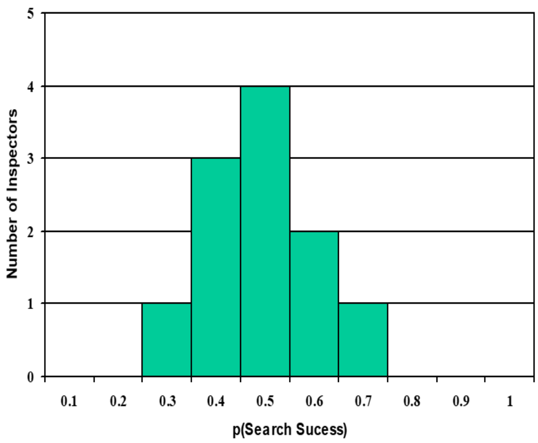

Diagram 4: Successful recognition depending on the respondent / Source: [1]

The majority of the test persons were only able to determine about 60% of the defects. One respondent even detected only 30% of the existing flaws. These studies underline the **biological limits** and **differences between individuals**. They illustrate that a uniform test result for quality control by humans, even under the same boundary conditions, cannot be reliably guaranteed.

In order to compensate for these deficits, automated process monitoring and inspection systems for quality assurance are increasingly being used in production plants. The technologies used are capable of detecting, evaluating, recording and reporting defects in fractions of a second. Depending on the task, these systems monitor the production process online during production or in a downstream inspection station.

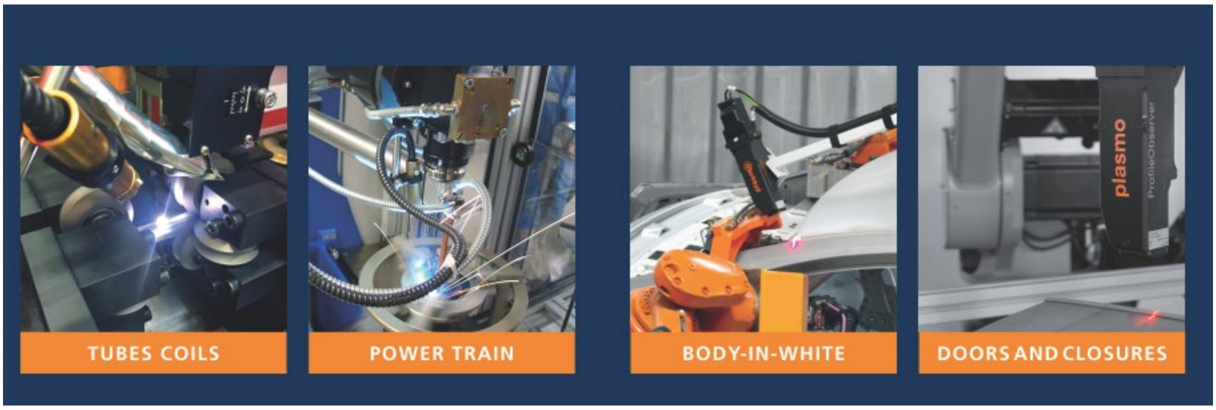

Fig. 3 Quality assurance industry/Source: plasmo

Online monitoring offers the possibility of monitoring the manufacturing process in "real-time" and thus drawing direct conclusions about the achieved quality of the component. This means that additional inspection times and cycle times are not affected.

In the course of electrification in the automotive industry, automated monitoring is increasingly becoming the focus of companies, especially in battery production. In addition to the different types of batteries, material combinations and partially charged processing, manufacturers are also faced with the challenge of a very high number of welds. A typical battery pack for a passenger car consists of approx. 7,000 lithium-ion batteries of type 18650. Even when changing to the next larger type 2170, approx. 2,000 batteries are required to operate an electric vehicle. Each of these individual batteries has a welded contact. Depending on the car model, these batteries are connected in different ways in series and parallel to each other. This is necessary in order to achieve the current and voltage values necessary for the operation of an electric vehicle. To guarantee the full functionality of the battery, each of these contacts must be tested by the manufacturer. With a test time of only approx. 2s per weld, even an experienced tester quickly reaches his limits with 2,000 contacts to be tested per battery pack. If several production systems are now in use, possibly in shift operation, the strain on the inspecting employees increases considerably.

Just like human controllers, automated monitoring systems must also be trained. Simple installation is not enough. The tolerances of the systems must be set in such a way that the detection of all critical faults is guaranteed at the lowest possible pseudo fault rate. Nevertheless, even these systems do not work perfectly! Compared to their human counterparts, they still have significantly higher detection rates, a consistently high performance, can be used 24 hours a day / 7 days a week, are fatigue-free and have no private problems that could distract them.

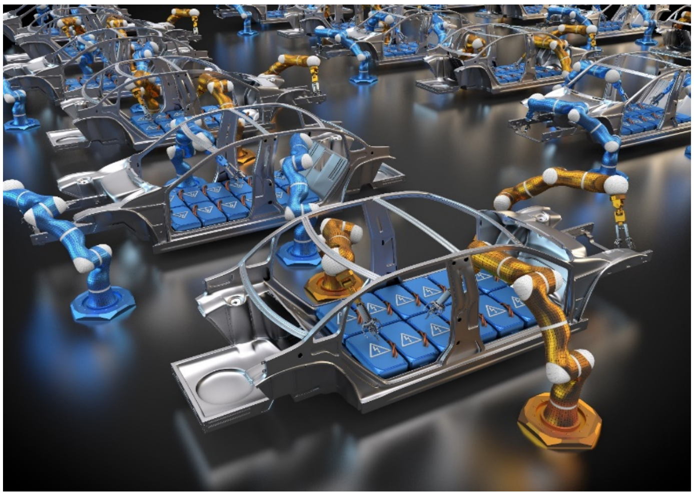

Fig. 4 Battery welding/Source: Adobe Stock

The purchase of automated quality monitoring systems seems expensive at first glance. Compared to the recurring costs of training current and new employees and the costs that can arise from the sources of human defect mentioned above, the cost of purchasing quality assurance systems is a one-off investment for a company that can be used for a very long time.

Human visual inspection is a flexible method of monitoring the quality of manufactured components. However, today's production volumes, the increasing complexity of components and manufacturing processes in the field of fine and micro machining, are clearly exceeding human performance. Automated process monitoring systems are indispensable in modern production chains in order to be able to guarantee a consistently high quality of manufactured parts and components.

Source:
1. Colin G. Drury and Jean Watson, “Good practices in visual inspection,” FAA/Human Factors in Aviation Maintenance (2002);

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