Testing the functionality of the safety belts of road vehicles in the production process phase

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Abstract. The safety belt is an essential element of the concept of passive safety of road vehicles (passenger transport). The functionality of seat belts is an imperative requirement for road vehicle manufacturers, requiring analyses and tests from the design stage. The present paper proposes a review of the retractor-shutter assembly during the production process phase in order to increase the quality and eliminate the manufacturing defects.

1. Production process in automotive industry - product testing and validation

As a result of the development of the automotive industry, increased competition among producers, and the increasing demands of consumers, the quality of products is of great importance.

Complex production processes in the automotive industry are based on a number of functional and dimensional parameters.

Under the conditions of increasing competition, the market has necessitated the development of systems that produce on the principle of production in flux, but in the conditions of serial production, ie of integrated systems of production organization. They meet under different names, such as [1]:

- linear programming;
- PERT method;
- CPM method (Critical Path Method);
- "Just in Time" method (J.I.T.).

Work productivity combined with increasing product quality is possible by automating assembly lines and implementing additional test and verification station. Automated testing and verification systems, being very complex, have combined mechatronic elements, enabling manufacturers to implement and adopt quality systems imposed by the beneficiaries.

Quality is an essential part of a products and services. According to the standard ISO 8402 of 1995, quality is defined as follows: "Quality is the set of features an entity that gives it the aptitude to meet expressed and implied needs".

In the latest edition of this SR EN standard ISO 9000/2008 quality is defined and more concise "The extent to which a set of characteristics intrinsic meets the requirements "(where intrinsic, as opposed to the term assigned signifies the presence permanently a feature in an entity, and the requirement is a need or expectation that is declared, generally implied or mandatory; "into the general default "means that it represents a internal practice or habit for organization, and the "declared requirement" means its presence in a document) [2].

Therefore the quality of a product or service is determined not only by characteristics and properties it has the extent to which it meets the expressed needs by the user or beneficiary as well as

others requisites that are not stipulated but need met. Thus, the definition of quality incorporates either sides or aspects of quality.

By the quality feature it is understood any function or property of a product or service that is indispensable to meet the client's needs or giving them the ability to be useful.

The Quality Management System is supports standards that describe the organization and operation within quality. These standards for the enterprise include:

- quality manual;
- rules, procedures and instructions;
- forms required for records (scheduling, operating and maintenance documents) effective control of processes.

The Quality Manual (MQ) formalizes organization and operation of the quality of the enterprise and serves:

- as a good practice standard in terms of quality management in everyday life;
- as a target to be touched;
- certification audit support company.

As a general conclusion through the Quality Management is being targeted EXCELLENCE.

The control systems implemented in the automotive industry operate in compliance with continuous requirements updated on the quality of the products, which they controls. In the construction of cars, as in others industrial fields, product quality control it is organized in four forms:

- before processing;
- after processing (passive);
- during processing (active);
- integrated.

The responsibility for the quality of the products belongs to the executors, who must produce products according to the required specifications, and the assessment of their conformity rests with the quality inspectors. Into the mainly the notion of quality is ensured by final control of the parts, respectively of the products, with the aim of identifying the non-compliant ones and eliminating them.

2. Passive safety - safety belt

The first patent for a seat belt was filed in the 19th century by English engineer Geroge Cayley. Later, there were a number of Americans who also received patents for the invention, but Nils Bohlin, a Swedish engineer is the one who received the title of inventor of the three-point seat belt.

Until 1959, cars had only two-point seat belts (Figure 1), but Nils Bohlin was able to revolutionize car safety. Thus, the first vehicles that received such a passive safety system were those produced by Volvo.

Another interesting thing is that Volvo offered the patent for the seat belt and the other manufacturers in the industry free of charge. As usual, the seat belt has evolved, but its basis will always be that of Nils Bohlin.

Currently, most cars enjoy this three-point clamping system (Figure 2). A peculiarity in this sense is represented by the motor sports cars in which 5 and even 6 points grip belts are used. They are designed from belts with grips on the shoulders, on the sides and between the legs, all joining the abdominal area.

The three-point retractable belt works when a pressure is exerted and has the role of blocking the retracting drum when it feels a tension. In new cars with the latest technology (Mercedes-Benz S-Class), Pre-Safe systems automatically tighten the belt and lock it when the vehicle slips.

Also for this type of vehicle, the seat belt has a sensor that activates the airbags, so if the belt is not installed, the airbag itself will not work.

This has been thought and tested by Mercedes-Benz engineers, because at a major impact where the driver is thrown to the front of the dashboard, the airbag can break its column.

Figure 1. Two point seat belt

Figure 2. Three points seat belt

Despite the fact that over the years this system and have been modifications and improvements, the main purpose of the safety belt remains the same. It consists of a belt made of a special resistance textile material, made of polypropylene material, which is meant to hold the body fixed in the seat to impact or other shocks [3].

3. Mechatronic buckle functionality testing system

FluidSim is a program for the design and simulation of pneumatic systems. This program can be used to perform experiments, produce simulations in real time and can be used as a modulator of control of the virtual system. The Pneutronic system must perform four basic operations, Figure 3 [4]:

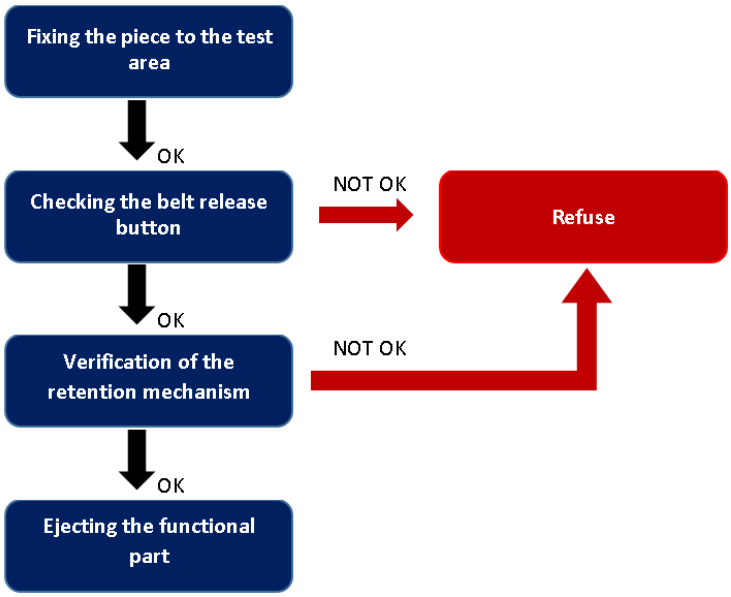

Figure 3. The operating algorithm of the mechatronic test system

In the first operation, the part is fixed on the test area, followed by the verification of the release button of the belt.

The button testing is done to verify its functionality, being the first step in testing the mechanism. If the button does not work, the test process stops and the piece must be removed and taken to refuse. If the button is functional, continue the testing process by testing the belt tension mechanism. In this test phase, double-check the belt retention. If the mechanism is not functional, then the piece is passed to

the waste, the piece remains in the test area and if the piece is functional, the process continues, this being the fourth operation, the piece is removed from the test area.

We used four valves, 5/2 ways, a 2/2 way valve, 3, pneumatic cylinders, a one-way rod (button, tongue and release) and 1 pneumatic cylinder with double and double barrel action, a grease filter, a air filter, two pressure gauges and a shank, Figure 4 [5], [6].

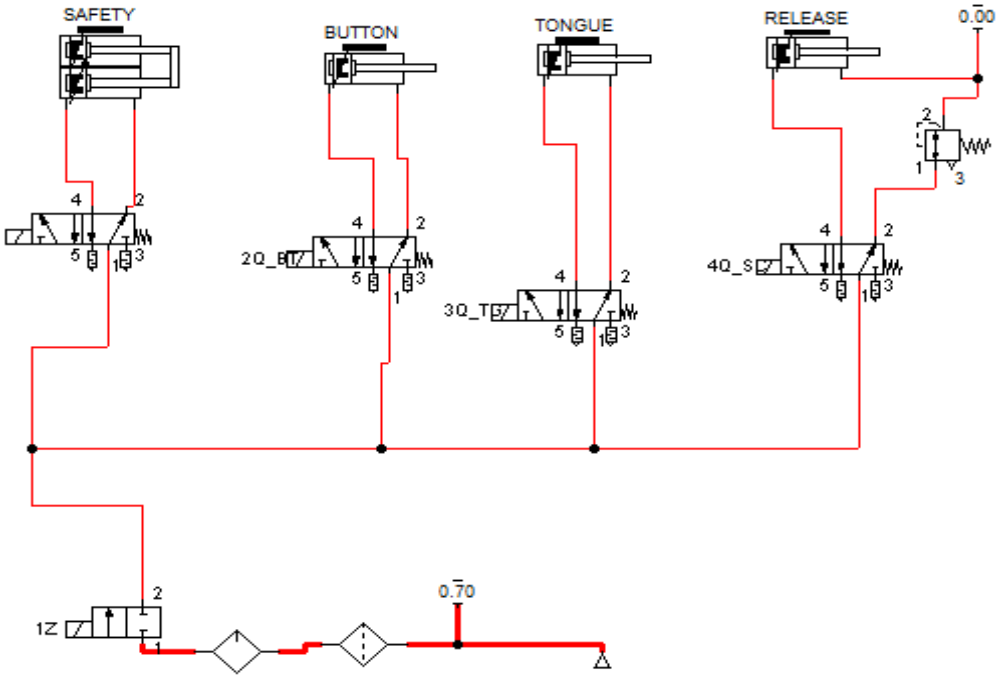

Figure 4. Pneumatic test bench system

4. Programming of S7-1200 SIMATIC PLC

The range of Simatic S7 modular programmable controllers offers powerful automation capabilities at affordable costs. Due to the ease of installation and programming, they can be used from simple to most complex applications.

The real-time analysis performance of the process and the powerful communication options are exceptional qualities of this equipment. The large-scale integration, space saving and increased power of the equipment make it suitable for its implementation in multiple applications.

Figure 5. SIMATIC S7-1200

SIMATIC IPC (Industrial PC) equipment offers maximum performance using state-of-the-art technologies, pre-installed Windows operating systems, as well as integrated communication interfaces.

The SITOP Compact family, LOGO! Power, SITOP lite, SITOP smart, SITOP modulated, DC UPS, SITOP PSU8600, Power Supply System and custom power supplies - are flexible configurable power supplies that help optimize energy management, save space and have an intuitive interface

The programming of this PLC is realized with the help of the TIA Portal V14 program. The new version of the TIA Portal (Totally Integrated Automation) engineering platform shortens the time required for production and increases productivity. Siemens upgrades engineering with the new V14 version, which brings a variety of new features to Industry 4.0 and digital enterprise requirements.

The TIA Portal combines the assignment of parameters and the programming of the automation components - from the controller and the HMI operator panel to the actuators - with functionalities such as security and safety. A harmonized package, consisting of the Simatic Advanced Controller and the Sinamics servo system, has already been integrated into the motion control applications in the TIA Portal.

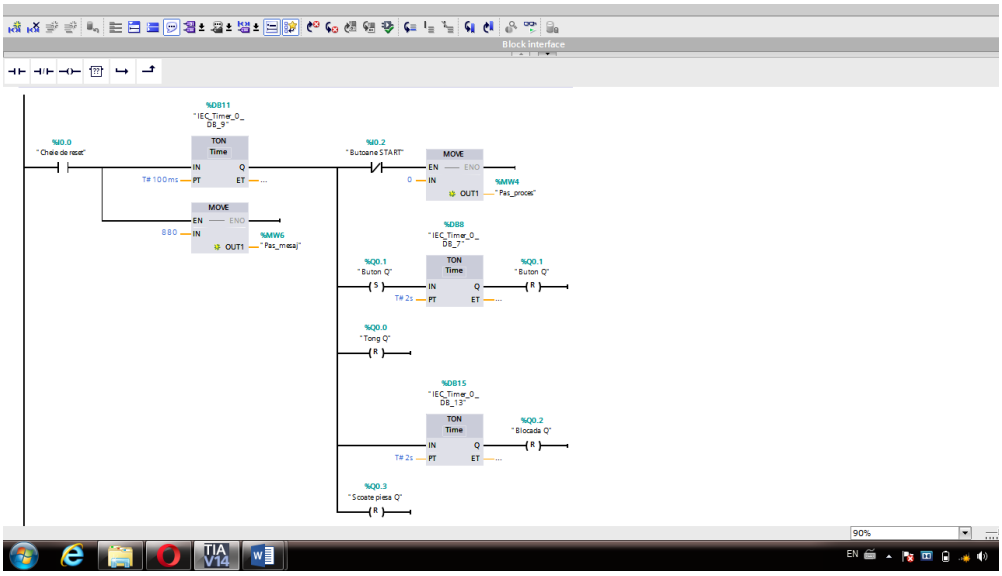

Figure 6. TIA Portal V14 program interface

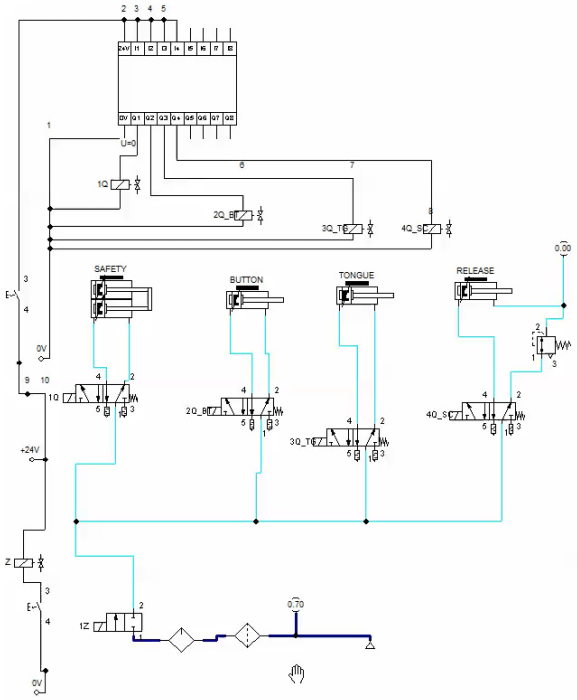

Figure 7. Mechatronic schematic of the stand for checking and testing the buckle

The new S7-1200 programmable automatic, designed primarily for advanced motion control, has all the functions necessary for process control. It can quickly and accurately manage multi-axis dynamic systems, aided by the new Sinamics V90 drive. This package now allows Simatic users to solve advanced movement control tasks in a familiar environment.TIA Portal provides access to the entire digitized automation, integrated engineering and transparent operation. Together with PLM (Product Lifecycle Management) and MES (Manufacturing Execution Systems) in the Digital Enterprise Software Suite, TIA Portal complements the holistic range of software programs offered by Siemens to companies on the way to Industry 4.0.

5. Conclusion

The simulation and design of the mechatronic system with the dedicated FluidSim software presents a number of advantages, such as:

- lower time and costs for simulation and design;
- real-time visualization of the order and action of the elements of the mechatronic system (Figure 7);
- the possibility to change the energetic and temporary parameters of the proposed mechatronic system;
- increasing labor productivity and product quality by eliminating the human factor.

The implementation of the testing systems on the assembly manufacturing line leads to a reduction of the production time, but also of the defects, thus increasing the productivity but also the quality of the products.

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