

Ćurčić, S. , Milovančević, M. , Šarenac, S.

## APPLICATION OF MECHATRONIC STRUCTURES FOR THE PURPOSE OF ENVIRONMENTAL PROTECTION

**Abstract:** The paper analyzes the issues related to harmful emissions of plastic into the atmosphere, i.e. describes plastic used for the formation of containers and bins. In addition, the harmfulness of producing the container itself in tools (molds) on robots based on the noise produced by the individual molds where they create a problem for the operators in the production is also described. Certain analyses are presented in which it is attached how these problems occur and then analyze how these problems are solved with various aids. These aids in our case are sensors, visual control and some other mechatronic structures that are the topic of this paper. Experimental analysis is done by changes in PLC applications where sensors give us certain signals for the action of our protection and thus with the help of these analyzes it is concluded how these problems are solved. Through calculations and certain measurements, which are based on previous experiences, these problems are solved using software that are destined for it, where changes in the sequence of obtaining bins are added to certain sub programs or structures for the purpose of solving this problem. The results of the analysis, give us information on how all these problems can be stopped and of course if they come to them and solve these problems.

**Key words:** harmful emissions, plastic containers, noise pollution, mechatronic solutions, experimental analysis

### 1. INTRODUCTION

Plastic is a material derived from oil. After use, plastic products decompose in the country for a long time, over 100 years. Therefore, it should be known that plastic waste, in essence, does not have to be waste, but a group of new resources, that is, raw materials that can be reused. Plastic waste in landfills accounts for 9% of the total weight of waste, but by volume it occupies 32%. Recycling waste plastics contributes to reducing electricity consumption and thus reducing greenhouse gas emissions. In Serbia, about 10% of plastic waste is recycled. Plastic recycling is the separation and sorting of plastic materials from waste and its reuse. Plastic waste is a very complex substance, because its chemical composition varies depending on the type of plastic. Therefore, it is very important to first separate the plastic by type. There are seven types of plastic, which are most often recycled. Each of them has its own recycling marks, for ease of separation. It is best if there are opportunities to separate plastic waste at the place of its formation. Many plastic materials can be reused if they are properly sorted. In addition to the labels, plastic for recycling can be successfully classified by the ignition process. Different types of plastic when up there have a different smell and color of flame. Such a sorted plastic goes for further treatment, which consists in washing and cleaning sorted plastic. Washing and cleaning is carried out for more efficient use in further production. The next stage of plastic recycling is shredding in special mills for grinding this material. The larger pieces are cut into smaller pieces, for easy placement in the mill. Such ground plastic, known in jargon as "grinding", can be various granulations, which depends on the sieve on the mill. The resulting granulate can be used immediately in the process of manufacturing plastic items, and can also go through another stage, i.e. the reconstruction. This

stage of re-grinding is carried out with regranulators. The resulting plastic regranulate is used directly in the process of manufacturing plastic items.

The physical properties of the plastic are: light weight, easy processing, properties can be modified, low permeability, chemical resistance.

Recycling: Plastic can be recycled using different methods. Plastic recycling is the process of reusing scrap and waste plastic and reprocessing materials into useful products, sometimes in completely different forms from the initial state. Since plastics are not usually biodegradable, recycling is part of a global effort to reduce the share of plastics in waste. This helps to reduce the high proportions of plastic in the accumulation of waste [1].

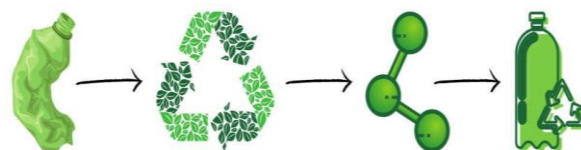


Fig. 1. Molecular plastic recycling [1]

### 2. ANALYSIS AND MEASUREMENTS

Analyses and measurements are described problems that arise in the company Inmold Group Požega.

Analyses are carried out on certain problems in the plant and along with the analysis and type of problem, the solution of that problem belongs to the given topic is also stated. Analyses of the problem will be presented, in order, in their entirety.

#### 2.1 Solving the high temperature problem created by plastic injection molding machine

For the analysis, the measurement of air humidity and temperature in the working area for the production

of plastic packaging and products used in food industry was carried out. The measurement was carried out in the working area, the plant, where there are machines for the production and processing of plastic products. In the room there are large temperature variations during the production process that affect the quality of production of the product itself and the atmosphere in the plant itself where workers perform work in the production and maintenance of the machine. The machine that is the main cause of the temperature variation in operation is the plastic injection molding machine. There are other machines in operation, but they don't have too much influence. The plastic injection molding machine operates at high temperatures of over 120°C, which is necessary for melting plastic and injection molding. The main problem arises in the summer when the outside temperatures are over 30-35 °C, then the cooling and ventilation systems have to work continuously because otherwise due to excessive temperature, the product is deformed because the tool has a fixed cooling mode and due to excessive temperature inside the plant there is inadequate cooling in the tool so that there is inconsistent products in production as well as a more difficult working conditions for workers who serve the machine and work in the plant. Due to the high temperature in the plant, it becomes barely tolerable for workers because then the problem is not only heat but also toxic gases that are released due to the process of making from plastic that can be harmful in the long term. Specifically for the manufacture of the aforementioned plastic packaging, toxic gases are at a minimum because for the production of containers made of plastic used in the food industry, PS (polystyrene) is used, which is not as harmful as PVC plastic because polyvinyl chlorides release a large amount of toxic gases that are far more dangerous than polystyrene [6].

### **Troubleshooting devices**

To solve the defined problem, the following components will be used:

- The RH520 is a portable temperature measuring device that is fixed in nature. It can be placed on a wall or a flat base. The device has power supply via AC adapter and can be inserted 3 AA-type batteries that serve as support in case of voltage drop or if the measurement is carried out in the field [5],
- Temperature sensor,
- Visual control camera with PLC PLC Schneider Modicon M241.

### **The principle of problem solving**

The solution of the problem is based on the following:

- The sensor detects high temperatures,
- The type of nature of the problem (hardware or software) is revealed,
- The IML robot borrows visual inspection cameras, where you can see a higher percentage of scrap, which tells us that the problem is related in the insufficiently solid state of the vessel (the vessel does not have enough time to harden because the temperature of the mold is higher than the set),
- RH520 provides temperature and humidity values

(along with the percentage of harmful ness of plastic in the air), i.e. data and reacts to the machine and robot to stop immediately,

- The workforce from this part is isolated for a while
- The problem is solved (analysis and the whole process of solving it below).

One of the main causes of this problem is that these high temperatures, which lead to air damage and intolerability, come from the mold of the machine in which the molten plastic is injected as well as the injector itself. The analysis leads to the conclusion that every time this problem occurs, it was in the 3rd shift or in the late hours in summer temperatures when the machine works non-stop for a large number of hours or at 3h, 4h when the temperatures in the summer are therefore huge.

The temperature of molten plastic becomes significantly high, where the molds become very hot and therefore do not get the given shape of the container. For some initial detection, a visual control on the robot is used, which immediately detects scrap with a given program. Confirmation of the problem comes from temperature sensors and later workers complain about the heat in the area. Then the alarm goes off that something is wrong.

### **Visual inspection of IML robots**

The system performs a 360-degree inspection for all types of IML decorations – wrapping decorations as well as basic labels regardless of the orientation of the labels. Even unadorned surfaces can be inspected for a flawless look. IMLWatcher® is applicable in all areas of IML manufacturing design. It is usually used to control bowls, cups and lids. Depending on the requirements, the system can be equipped with multiple cameras and special lighting that are capable of detecting all typical IML defects such as the control of the edges of the bowl and whether the ethics are beautifulblind or melted (to us important because it is the main cause of temperature), blow-bis, offset etiquette and angular rotation. IMLWatcher® provides comprehensive quality control for the mold marking process. The advantage is obvious: the system can be integrated directly into automation robots and therefore especially saves space and efficient. It fits into the existing landscape without any difficulty and supports very fast cycle times.

In Fig. 2, you can see the camera scanning the vessels and looking at certain edges, thus detecting whether the vessel is good or not. On the right side you can see the scales where certain aspects are checked whether they meet the conditions that are given and that the bowl is classified as a non-compliant product or not.

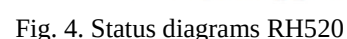
These aspects are: the edges of the bowl, the position of the label (vertical, horizontal and label rotation), blow-encore, bubbles and folds that occur due to high temperature, contamination, errors in printing on the label and defect on the edge of the label.

In Fig. 3, we can see a classic example of error detection and that is poorly glued label and edges are not good. For both, the causative agent is high temperature. Later, this container is placed on a strip of bad pieces and we in the PLC program can see how this number grows,

request is more important than all of these because he is the main alarm that tells us that something is wrong. Then the RH520 instrument enters and the measurement is carried out. By measuring (attached graphic) you can see the temperature, humidity and harmful emission of plastic into the atmosphere. The measurement was carried out at the plant for the production of packaging and plastic products of polystyrene type (PS). In operation, the machine worked occasionally (you can see the graphics after the temperature jump). The average outdoor temperature is 16 °C.



The first diagram is a diagram of the temperature in which see the jumps and falls that are described in the text above. The second diagram gives an increase in the value of plastic damage in that room at the moment of high temperatures. It can be seen that the damage has not reached great values, so in this case overhaul and cooling was carried out.



## Solution to the problem

The conditions in the production facility are tolerable in a measured period of time, but it is still necessary to better air condition the space in terms of cooling it when the machine is not working at the time of overhaul, servicing, maintenance, tool replacement, etc. Air

conditioning and ventilation systems are now developed according to automation systems. A slight cooling is always present. When the temperature in the summer reaches great values the sensor gives a signal and begins a higher cooling. This is also true for ventilation and that is how this problem is solved.

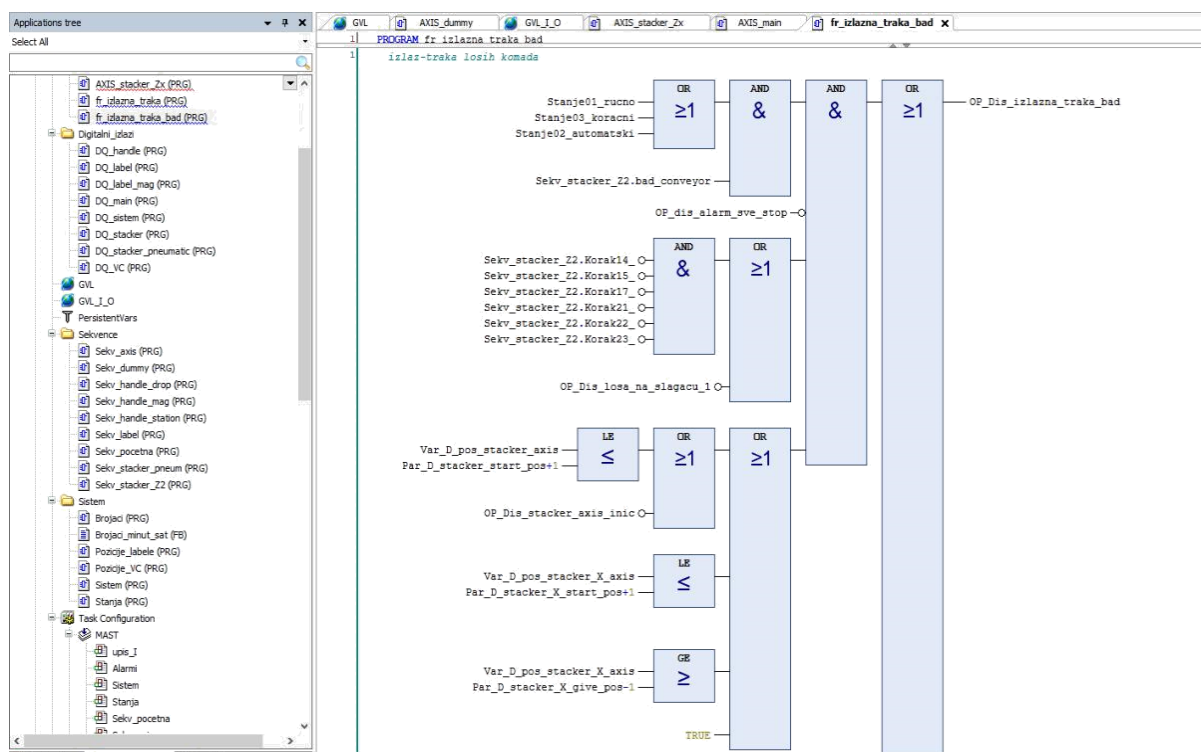


Fig. 5. PLC program related to counting non-compliant pieces

## 3. CONCLUSIONS

This paper initially describes specifically plastic and the great importance of recycling as well as some interesting facts about it. The introductory story is reduced to explaining the essential concepts related to plastic and injection into machines. This story is very important for this topic because it gives us some initial story about all the problems faced by companies engaged in the production of plastic products. It is described what kind of plastics are used, their characteristics and explanation of how plastic is inserted into the machine and the whole term is in some optimal way derived in this paper.

Next are given all the essential elements that help us solve the above problems. We have their characteristics and a detailed description of their application. The great importance of PLC and instruments that help us to conclude what kind of problems are present.

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### Authors:

**PhD Srećko Ćurčić**, University of Kragujevac, Faculty of Technical Sciences, Svetog Save 65, 6, 32000 Čačak, Serbia, Phone: +381 32 302 737.

E-mail: [srecko.curcic@ftn.kg.ac.rs](mailto:srecko.curcic@ftn.kg.ac.rs)

**PhD Miloš Milovančević**, University of Niš, Faculty Mechanical Engineering, Aleksandra Medvedeva 14, 14000 Niš, Serbia, Phone.: +381 64 1138300.

Email: [milos.milovancevic@gmail.com](mailto:milos.milovancevic@gmail.com)

**BSc Slobodan Šarenac**, INMOLD Plast d.o.o. Serbia, Phone: +381 60 0517940

E-mail: [slobodan.sarenac00@gmail.com](mailto:slobodan.sarenac00@gmail.com)