

# Human machine interface for filament extruder

<sup>1</sup> Peter HRABOVSKÝ, <sup>2</sup> Ján MOLNÁR

<sup>1,2</sup> Department of Theoretical and Industrial Electrical Engineering, FEI TU of Košice, Slovak Republic

<sup>1</sup> peter.hrabovsky@tuke.sk, <sup>2</sup> jan.molnar@tuke.sk

**Abstract** — The goal of this paper is to describe the design and implementation of an HMI (Human machine interface) for filament extruder. The HMI is briefly explained in the introduction. The main screen and its dividing is described in the next part of this paper. Finally, the principle of program functionality in the HMI is described. The HMI source code will not be published in this post. Only the graphic part of the filament extruder machine is described in the paper. A control program for the PLC serving the control of the extruder filament has been described in the previous publication.

**Keywords** — filament extruder, Human machine interface , PLC

## I. INTRODUCTION

The Human Machine Interface (HMI) interface transmits information from machine to person. Using HMI, we can display and animate data dynamics, send process commands, modify process parameters for production, and showing process error messages (alarms). When creating the HMI environment, it is necessary to emphasis on the ergonomic environment, reliable and safe process operation and, last but not least, the easy and efficient exchange of information between the operator and the managed system. HMIs are usually deployed on Windows-based machines, communicating with programmable logic controllers (PLC) and other industrial controllers. HMI is a device designed to provide a person with insight into the technological process and inform it of process parameters in real time. Furthermore, it should allow a person to change process parameters conveniently. On Fig. 1 we can see some HMI displays from SIEMENS. Programs such as Simatic WinCC (TIA Portal), FactoryTalk View Machine Edition, EcoStructure Operator Terminal Expert and others are used to create HMI interfaces. [1] [2]



Fig. 1 HMI displays from SIEMENS [3]

## II. DESIGN OF HUMAN MACHINE INTERFACE

We used SIMATIC WinCC software from SIEMENS to design the HMI interface.

### A. Start screen of HMI

In the Fig. 2 you can see the start screen that appears when you run WinCC-Runtime. The screen has 5 buttons. For input or mode selection, it is necessary to authenticate with the button called *PRIHLASIT*. After pressing the button, the user is prompted to enter the login name (*Operator*) and password (*123456*), and press the *OK* button to confirm. After logging in, the operator gains access to the choice of two modes, namely, filament production or casting. After pressing one of the modes, the mode is activated and its mode is displayed. The start screen also includes the *ODHLASIT* button and the *UKONCIT* button. The button *ODLHASIT* logs off the operator from the system and then another user could log in. Use the *END* button to deactivate the entire WinCC-Runtime and close the window.

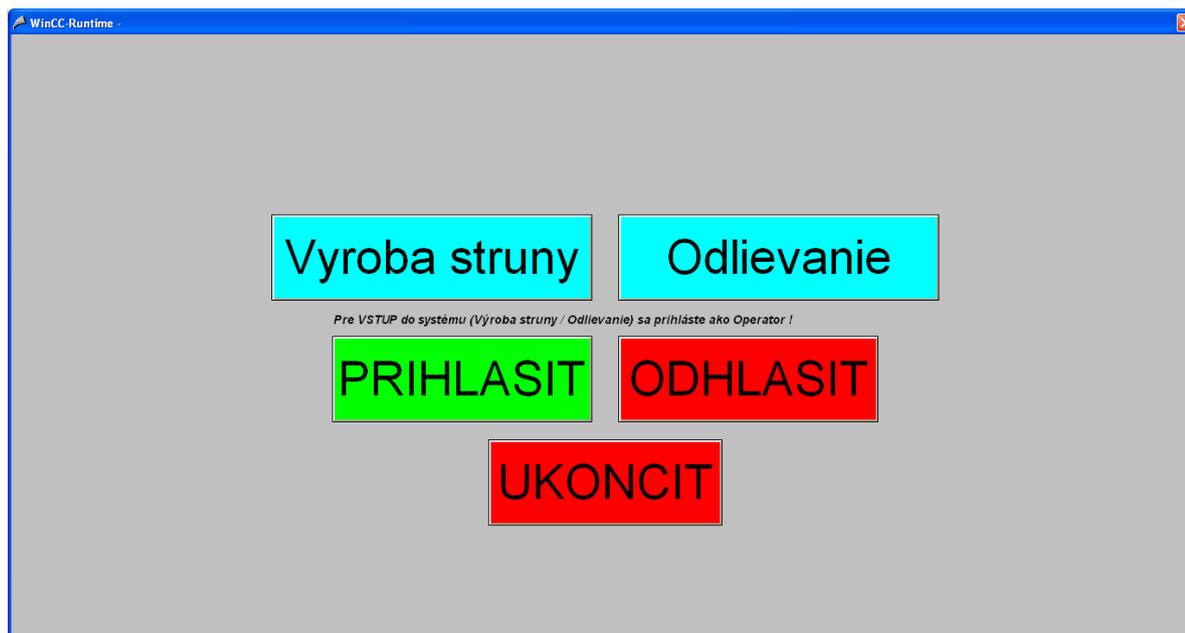


Fig. 2 Start screen of HMI

### B. Screen of production filament

After starting the production of filament mode, the screen that can be seen is shown in Fig. 3.

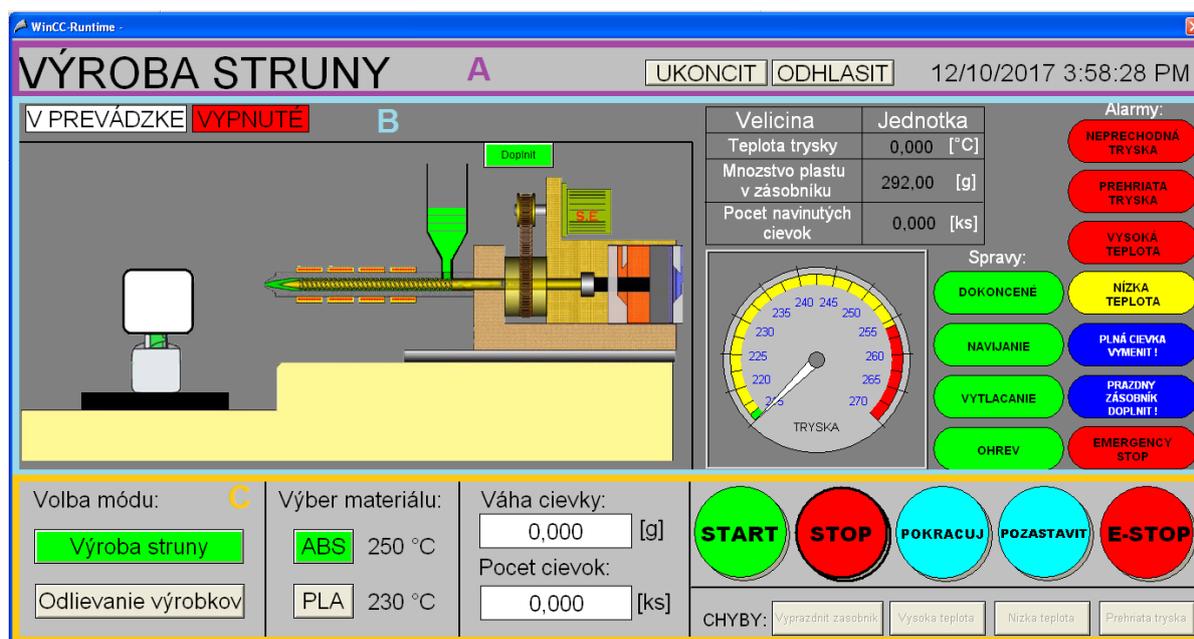


Fig. 3 Production of plastic filament for 3D printer

## The HMI screen is divided into the following main parts:

### A. Overview area

On the Fig. 4 we can see the overview area of HMI. The name of the production process is located in the left part of this area. Next there are buttons for ending the program *UKONCIT* and logging out *ODHLASIT* of the mode. The current time and date are on the right. If you press the button *UKONCIT* the entire program will be turned off. Both buttons can only be pressed if no production process is in progress, otherwise pressing them is systemically prohibited!

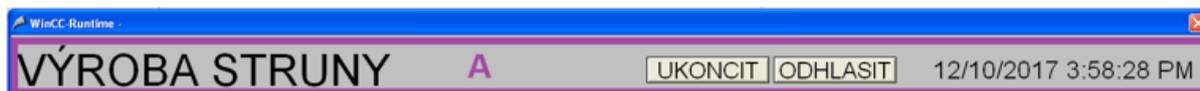


Fig. 4 Overview area

### B. Working area

On the Fig. 5 we can see the working area of HMI. The technological process of production is shown in the left part of this area. Four pictures that show us the individual states of the production of filament are gradually switched over. In the figures, it is possible to see a machine for producing a filament and a coil with a motor on which the produced filament is wound. In the machine, there is a hopper on which we can see the current state of the contained amount of plastic. If the tray is empty, the red button *Doplňit* flashes. Pressing the *Doplňit* button once adds 100 grams of plastic and the button stops blinking and turns color to green. The hopper can be fill to a maximum weight of 500 grams of plastic pellets.

On the right of the technological process, there is a table that shows the individual quantities and their units as the temperature of the nozzle, the amount of plastic in the container, the number of coils wound. An analog nozzle temperature display called *TRYSKA* is also located below the table. It displays the temperature according to the values given in the control program for a given type of material, namely ABS or PLA. On the right, there are popups *Spravy* and *Alarmy*. Individual pop-ups *Spravy* and *Alarmy* show us the states in which the production process of filament is located. The green message *OHREV* signals the heating of the nozzle to the desired temperature. The green message *VYTLACANIE* indicates when a filament will flow out from the nozzle. The filament winding process is shown in green message by *NAVJIANIE*. This process is completed after one coil is winding the filament. When the specified number of coils has been wound up, the status *DOKONCENE* is displayed. Alarm state the *PREHRIATA TRYSKA* is displayed together with the *EMERGENCY STOP* status and the machine is switched off to prevent damage. The red message *VYSOKA TEPLOTA* shows us a critical exceedance of normal temperature. The yellow message *NÍZKA TEPLOTA* it shows us when the nozzle temperature drops below the normal temperature, since it is yellow in color, no intervention is required since the machine automatically calibrates the temperature to normal.

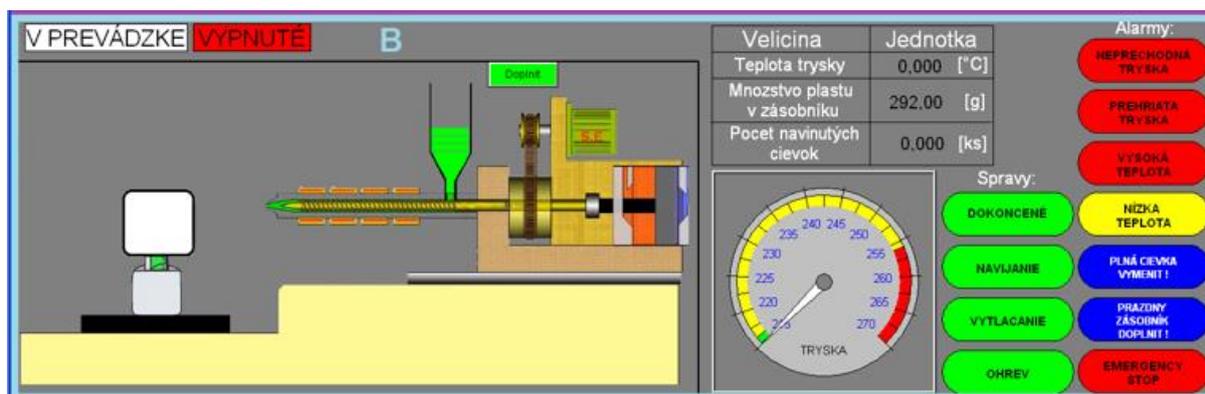


Fig. 5 Working area

### C. Input area

On the Fig. 4 we can see the working area of HMI. In this section, it is possible to switch between modes (*Výroba struny / Odlievanie výrobkov* - not yet implemented), choose the material (*ABS / PLA*) from which the filament will be produced and the weight of the produced spool (*Vaha cievky*) and the final number of spools (*Pocet cievok*). There are control buttons in the right part of this area. The green *START* button turns on the string production process. Press the red *STOP* button to stop the production

process. The production process can be paused by pressing the cyan *POZASTAVIT* button and then pressing the cyan *POKRACUJ* button to continue the production process. The *E-STOP* button is used to completely shut down the production process in the event of an unexpected error. Below this button are buttons that can simulate certain fault conditions during program run. Pressing the *Vyprazdnit zásobník* button clears the hopper contents and stops the production process and pauses until the hopper is manually filled. Pressing the *Vysoka teplota* button will cause the normal nozzle temperature to be exceeded. The *Nizka teplota* button will manually set the temperature below normal and the program will automatic to adjust the right nozzle temperature. If you press the *Prehriata tryska* button, the production process stops and switches to *EMERGENCY STOP* mode.

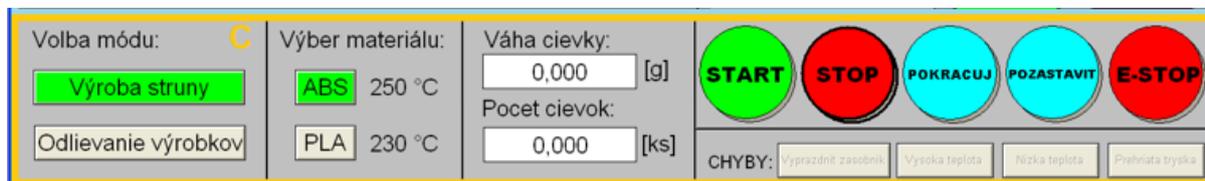


Fig. 6 Input area

### III. DESCRIPTION OF PROGRAM FUNCTION IN HMI

After successfully logging in and selecting the mode, it is necessary to set individual parameters for production. In the overview area (see Fig. 7), we will display the selected mode, for example, *VÝROBA STRUNY* together with the date and time, and the *UKONCIT* and *ODHLASIT* buttons.



Fig. 7 Overview area

In the working area, it is possible to see the initial state of the manufacturing process where a string making machine is shown together with an engine that is used to wind the manufactured coil with a plastic filament (see Fig. 8).

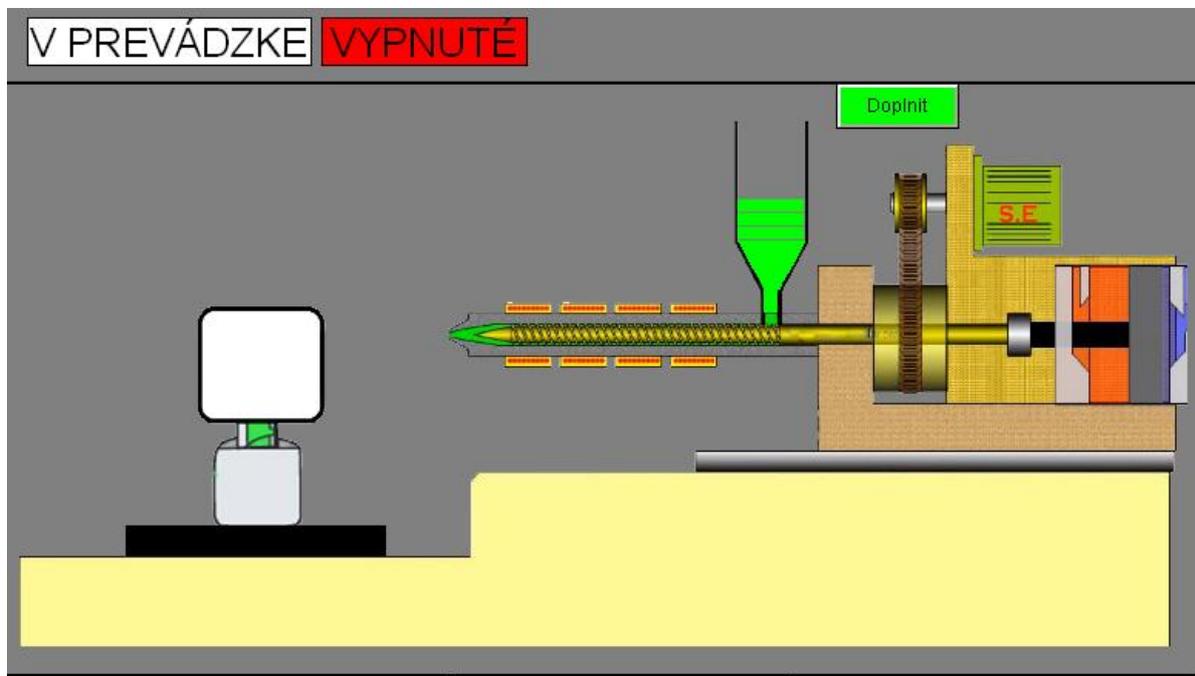


Fig. 8 Working area - device status and technology process

In the input area, it is necessary to select the correct mode by starting the production process, select the type of plastic material from which the filament will be produced (see Fig. 9).

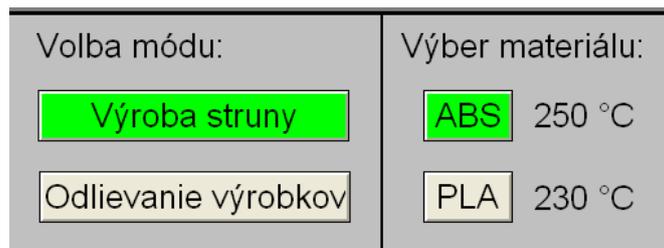


Fig. 9 Input area - selecting mode and material

Then we need to enter the weight of one coil in grams and the number of coils that we require to produce in pieces. These parameters can no longer be changed when the button is pressed (see Fig. 10).

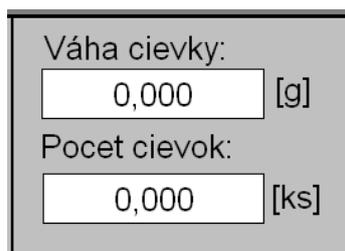


Fig. 10 Input Area - Spool weight and number of spools

It is important to check the condition of the plastic pellets in the hopper as production cannot be started with the empty hopper. If the tray is empty, it is signaled by a blue color alarm in the work area on the right and a red blink of the *Doplňit* button itself. It is necessary to add the required amount of plastic using the *Doplňit* button next to the hopper (see Fig. 11) (one press of the button adds 100 grams of plastic to the hopper, maximum 500 grams can be added). When the tray is empty, the machine is paused. After adding plastic pellets to the hopper it is necessary to press the *POKRACUJ* button. Then the machine will continue to manufacture plastic filaments.

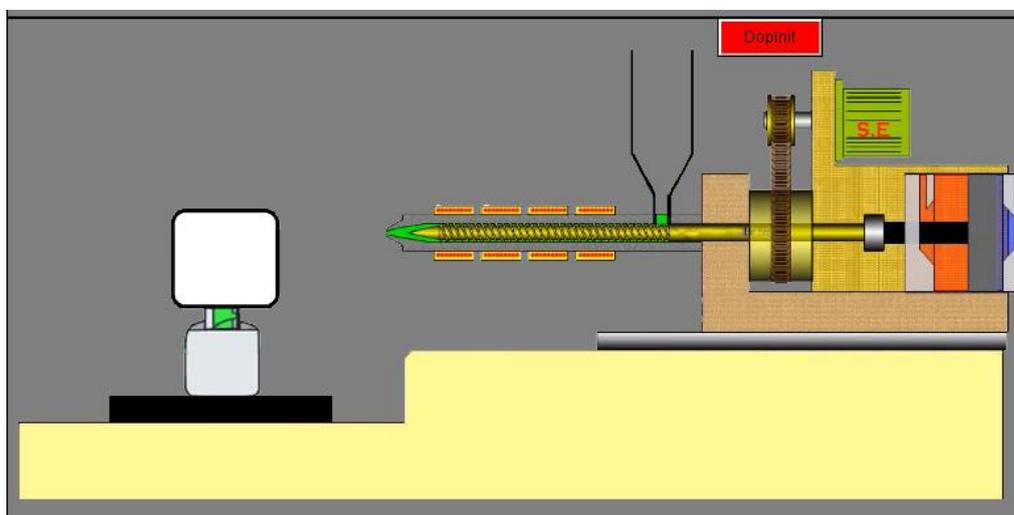


Fig. 11 Empty hopper with red flashing button

Then we can press the *START* button to start the filament production process. In the working area (see Fig. 12) we can notice the change of state from *VYPNUTÉ* (red color) to the state *V PREVÁDZKE* (green color).



Fig. 12 Change status from VYPNUTÉ to V PREVÁDZKE

The nozzle temperature gradually starts to rise, which can be seen on the analog display called *TRYSKA* (see Fig. 13). The individual temperature readings are explained in the controlling program (in previous publications) for PLA and ABS. As the temperature increases, we can observe the display of the *OHREV* message indicating the heating of the nozzle to the desired temperature (see Fig. 13).

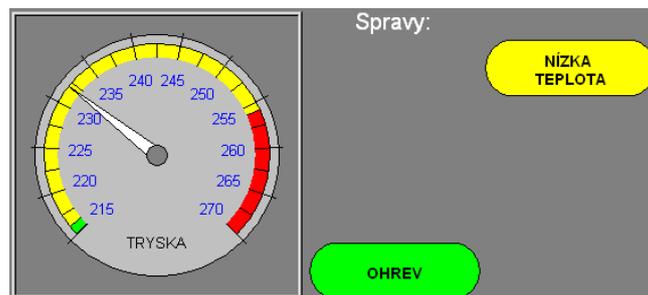


Fig. 13 Displaying the analog temperature *TRYSKA* and messages *OHREV* and *NÍZKA TEPLOTA*

When the desired temperature is reached, the *VYTLACANIE* message will be displayed to indicate that the filament extrusion process has started and we can also see it at the same time changing the image to the left. After two seconds of the extrusion process starts the winding process, which is indicated by the *NAVIJANIE* message together with the image change, where we can notice that a certain amount of material has already been wound on the spool (see Fig. 14).

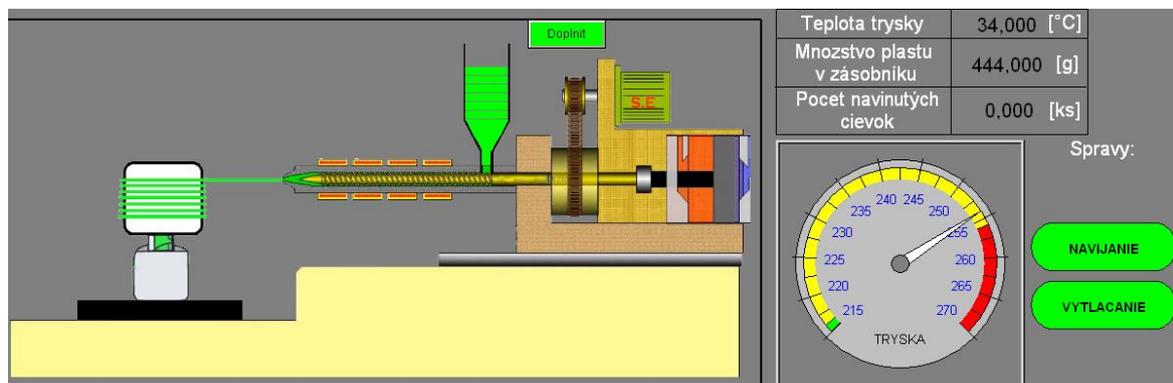


Fig. 14 Messages called *VYTLACANIE*, *NAVIJANIE*

Individual messages are displayed cyclically until the required number of entered spools has been produced. When the specified amount of spools is reached, the message *DOKONCENE* is displayed and the process is terminated (see Fig. 15).

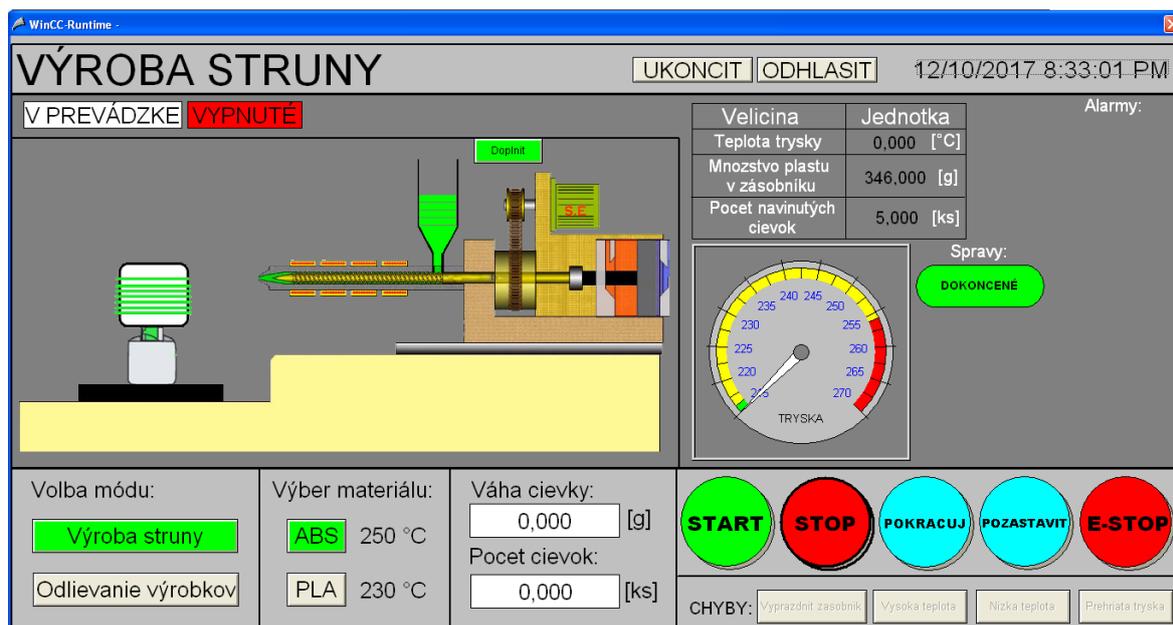


Fig. 15 Exiting the production cycle and displaying the message *DOKONCENE*

#### IV. CONCLUSION

The aim of this paper was to design and implement an HMI interface for filament extruder. After defining the basic concept of the device from a previous publication, we created the HMI using by SIMATIC WinCC software. PLC controlling software part was published in the previous paper. The interconnection of the control software of the PLC and the HMI interface was realized without any major difficulties. After the project implementation, we tested the system's functionality. We can say the system works correctly. After appropriate modification and configuration, it could be applied to the physical device for which the project was designed.

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