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Proposal of Automatic Control System of the Processes for the Ketchup Production

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Abstract:
The technological processes for the production of ketchup are examined in Vital company–Parvomay, Bulgaria and the fundamental technological scheme is shown. The automatic control system in the production of ketchup at the same company is shown and viewed. The following are recommendations for improving of the implemented automatic control system. The proposals are consistent with the management of the company and steps were taken to implement them.

Keywords **—Production of ketchup, Automation of Process, Ketchup automatic control system**

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I. INTRODUCTION

The canning industry is only one of the oldest, important and promising sectors for the food industry in Bulgaria. The sector produces about 6% of the total output and employs about 9% of the employees in the industry [1]. The Bulgarian canning industry is traditionally export-oriented. In recent years, Bulgaria has between 58-67 thousand tons of canned food [2]. Bulgarian canning industry recasts mainlylocal raw materials . (Significant quantities of canned food are produced at home.) A large number of canned food is produced (The canning industry requires significant amout isolates of vegetables, fruits, water, large labor force, solid preparation for transportation of raw materials. The production has a strong seasonal character - 1/2 of the canning is produced in the third quarter. In Bulgaria there are conditions for the development of the canning industry - availability of raw materials, markets/stocks, experience.

The industrialization of production products can be defined as the development of production devices and production research, by having them combined, where the transformation and the convey of the materials, generated power and information is done without human involvement.To describe a specific automation system, it is necessary to describe: man-made control; the control realized by the devices and a composition of the economic production, which is from the machines [3, 4, 5].

The purpose of this article is to give suggestions for improving the system of automatic control in the process of making ketchup.

Technological processes in the production of ketchup

The technological processes in the production of ketchup are: taking the raw materials; stretching the ingredients and mixing them; preheating up to 60 ˚C; Air separation; homogenization; pasteurization at 90 ˚C; cooling to 60 ˚C; dosing/applying; closing caps; labeling, marking; packaging, foiling

Thebasictechnological plan of ketchupproductionispresented in fig. 1 and covers 8 mainstages: 1 - mixingtheingredients, 2 - preheating, 3 - air separation, 4 - homogenization, 5 - pasteurization, 6 - cooling, 7 - dosing, 8 - closing, labeling, marking.

Theconsists of: tomatomash (tomatoconcentrate), sugar, salt, vinegar, flavors (according to theclass - withpronounceddifferentflavors), starch, preservative, water. One of theingredientsthatgivestheappearance and main taste of theproductistomatomash.

Ingredients mixing - for the production of ketchup ready quality products are used, which according to the recipe are stretched on an electronic scale (pos. 1). They are manually poured into a preparation vessel (pos. 2) equipped with a stirrer driven by an electric mixer (pos. 3). The required amount of water is supplied via a hand tap (pos. 5). The preparatory vessel is designed for 300 kg. cooking, manually monitoring the level of the product with a dipped level gauge. The maximum upper level is 61 cm and a minimum is 3 cm. The mixer turns on and off manually from a dashboard.

Preheat – using a screwpump (pos. 4) manuallyoperated and stoppedby a dashboard, theproductistaken to a preheater (pos. 6), whichis a skin-tube-in-tube-typeheatexchangewith serpentines forbetterhomogenization of theproduct. Thewaterheated up to 120C, using a gas boiler goesthroughthe pipeline and then comes back to thevessel (pos. 8). Thepurposeis to heattheproduct up to 60 °C, whichpassesthrough a preheater (pos. 6) and isreturned to thepreparationvessel (pos. 2). The mixture circulatesuntilthedesiredtemperatureis60°C.

Deaeration- afterreachingtheproduct up to 60 °Cmanually, a three-waysolenoidvalve (SV) isswitchedfromthe panel (pos. 10), whichtakesit to thedeaerator (pos. 11). Itisanairtightcontainerwith a conicalbottom and lid. Itismountedon a frametogetherwith a vacuumpump (pos. 13), a dischargescrewpump (pos. 15) and a homogeni-

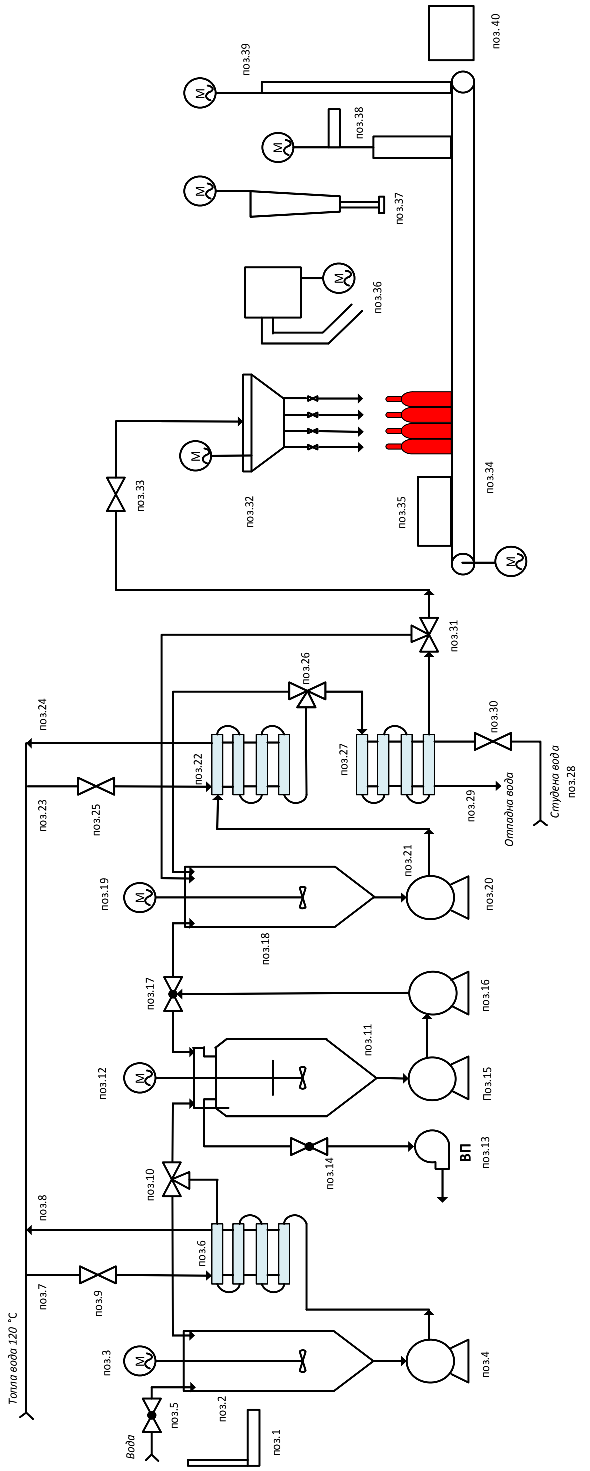

Figure 1. Basic technological plan of ketchup production

zingpump (pos. 16). Theproductiscomingout of thethe pipeline goingintothevessel and fallson a rotating disk with a sieve and a stirrerdrivenby a mixer (pos. 12). Undertheaction of thecentrifugalforce, itisevenlydistributed, directedtowardsthesides of thevessel and flowsdownthem in a thinlayer. Hittingtheleaking sauce at highspeedimproveshomogenization. Thevacuumpumphelpsthe air to be separatedfromtheproductWiththehelp of a vacuumpump (pos. 13) the air isseparated (deaerated) fromtheproduct. Thescrewpump (pos. 15) helpsthe mixture to passthroughthehomogenizingpump (pos. 16), throughwhichtheparticlesizeisreduced and returned to thedeaeratingvessel (pos. 11). Deaerationlastsabout 3-4minutes.

Homogenization - after deaeration of the product, a hand tap (pos. 17) is opens, which takes it to a collecting vessel (pos. 18), equipped with a stirrer driven by a mixer (pos. 19). The product is homogenized in the collecting vessel and with the help of a screw pump (pos. 20) takes the tomato sauce is taken through the pipeline (pos. 21) to a pasteurizer (pos. 22).

Pasteurization – pasteurizationtakesplaceinafurheatexchangertype "tubeintube" (pasteurizer) (pos. 22), whichisheatedwithhotwateratatemperatureof 120 °Cfedbythegasboileralongthepipeline (pos. 23), passesthroughthepasteuriser (pos. 22) andthepipeline (pos. 24) istakenbacktothegasboiler. Thepurposeistoheattheproductup (pos. 22) to 90 °Cinorderto perish the harmfulmicroorganismstoperish. Theproductpassesthroughathree-way SV (pos. 26) andisreturnedtotheassemblyvessel (pos. 18). Repeatthecycleuntiltheproductreachesthedesiredtemperatureof 90 °C. Acontainerisattachedtothecollectionvessel (pos. 18) incaseofoverflowofthetomatosauce.

Cooling – when reaching 90 °C manually from a dashboard, a three-way SV (pos. 26) is switched and the product is drained to a fur pipe heat exchanger type "tube in pipe" (cooling serpentine) (pos. 27). Through it passes cold water fed by a probe along the pipeline (pos. 28) and is drained along the pipeline (pos. 29) into the sewage network. The purpose is to cool the product through (pos. 27) to 60 °C.

Finally, the finished product is tested in a dry matter concentration laboratory.

Dosing - after the product has cooled down to 60 ℃, a three-way SV (pos. 31) is manually switched from the panel and taken through the pipeline to a dosing machine (pos. 32) equipped with a float, which protects it from overflow.

The bottles are placed manually on a conveyor belt (pos. 34), passed through an ultraviolet lamp (pos. 35), which kills all microorganisms in them and fed to the dosing machine (pos. 32). It is equipped with dosing heads that have a measuring vessel (dispenser). It is connected in series with the dose measuring tank and the package to fill it..

Closing, labeling, marking - thefilledbottlesaretakenalongtheconveyorbelttoaclosingmachine (pos. 36), whichputsthecapsonthebottles, andthemachine (pos. 37) closes (stuffs) thecapswiththehelpofaplunger.

The closing machine consists of four main units - a conveyor for feeding the package, a mechanism for placing a lid, a closing mechanism and a draining conveyor. The closing mechanism is called a closing head. It includes all the organs that carry out the formation of a strong - tight joint lid-package and some of the elements that provide their specific working movements.

The closed bottles are led to the labeling machine (pos. 38) to be marked bu the marking machine (pos. 39). The labels to be affixed, arranged in bundles, are placed in a label shop. Taking the labels from the store is done in different ways, but most often pulling the label from the package, the body of which is pre-coated with glue. The marking machine (pos. 39) prints on the bottles the batch, date of manufacture and expiration date of the product. The filled bottles are taken manually, they arebeing placed on the table for finished products (pos. 40) and taken away for packaging and foiling (manually).

Processautomationinthecanningindustry

Fig. 2 shows the ACS in the production of ketchup.

The stretched products and ingredients are poured into a preparatory container (pos. 2). Using a screw pump (pos. 4), the mixture passes through a tubular preheater (pos. 6) for preheating. After reaching the set temperature, the product enters a deaerator (pos. 11) and from there into a collecting vessel (pos. 18). From it with a screw pump (pos. 20) is taken to the pasteurizer (pos. 22). It then passes through a coolant (pos. 27). The cooled product is fed to a dosing machine (pos. 32). Along the conveyor belt (pos. 34) the bottles pass through an ultraviolet lamp, a dosing machine (pos. 32), a cap closing machine (pos. 36, 37), for labels (pos. 38) and for marking (pos. 39) .

The following control and management systems mounted on a panel and on site are built to the technological scheme described in this way.

For preparation vessel (pos. 2) - the required amount of water for the preparation of the product is supplied by means of a hand tap (pos.5).

The ingredients made already, are weighed on an electronic scale (pos. 1) and also are manually poured into the preparation container (pos. 2). The mixing of the ingredients is madeby a mixer with a stirr (pos. 3), and the circulation goes on with a screw pump (pos. 4). A dashboard switches them on/off manually. There is one for each of the circuits 1 and respectively for the screw pump circuit 2, a warning light is also provided. Another device is showing the level of the fusion/mixture (submerged level meter)- This is presented here incontour3.

For tubular preheater (pos. 6), AAS for temperature - are provided at the inlet and outlet of the product passing through it, temperature sensors (thermistor - Pt100) - circuit 4. To set the desired temperature, a microprocessor is used manually by the company Microsyst,which is attached/mounted(no matter) to a control panel. A warning light is provided. A three-way SV (pos. 10) is mounted on the pipeline of the passing product, manually switched by a panel with light signaling–circuit 7. The monitoring and setting of the tempe-

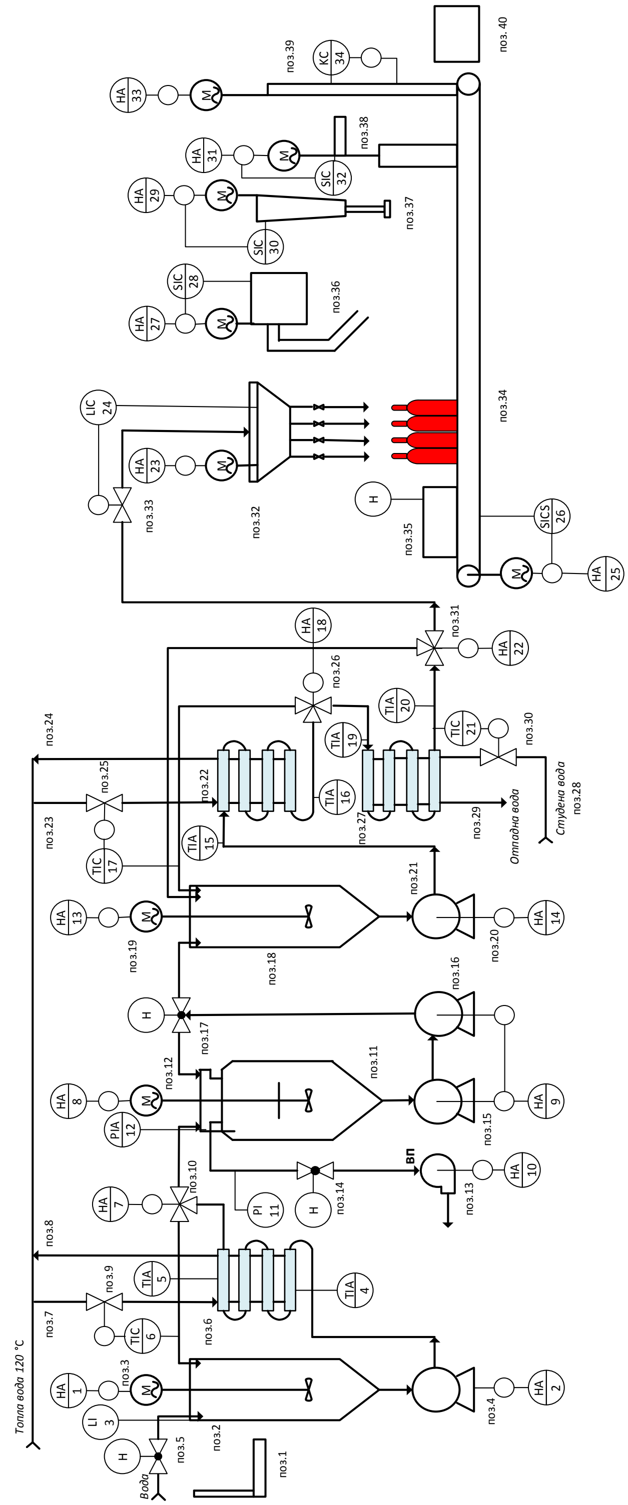

Figure 2.ACS for ketchup production

rature of the product passing through (pos. 10) is done by a two-channel microprocessor programmable controller MS8112, mounted on a dashboard. A SV (pos. 9) is mounted on the pipeline (pos. 7). Using a platinum thermistor (circuit 5), the temperature of the product is measured and if there is a difference with the set SV, it changes the flow rate of the hot water supplied to the product - circuit 6.

As for the deaerator (pos. 11) - it is equipped with a mixer with a stir (pos. 12), a screw pump (pos. 15), a homogenizing pump (pos. 16).

A power switch turns them on/off which is mounted on a panel.contours - 8, 9. A warning light is provided. A vacuum pump (pos. 13) is used for deaeration, played and stopped by a manual starter on a panel with a warning light signaling - circuit 10. Measurement by indicating the pressure of the vacuum pump on site. A spring pressure gauge is used – circuit11. A manual valve is mounted on the pipeline of the vacuum pump. (pos. 14) The pressure - circuit 12 is set via the two-channelmicroprocessor programmable controller MS8112, mounted on a panel. Deaeration lasts 3 - 4 minutes. The product is drained by a hand valve (pos. 17).

For the collecting vessel (pos. 18) - the homogenization of the ingredients is done with a mixer with a stirrer attached to it (pos. 19), and the circulation happens with a screw pump (pos. 20). There is one for each of the circuits manually - mixer circuit 13 and screw pump circuit 14. A warning light is also provided. As for the pasteurizer (pos. 22), AAS for temperature - are provided at the inlet and outlet of the product passing through it, temperature sensors (thermistor - Pt100) - circuits 15 and 16 temperature sensors (thermistor - Pt100) - circuit 4. To set the desired temperature, a microprocessor is used manually by the company Microsyst,which is attached/mounted(no matter) to a control panel. An emergency/warning (both correct) light is provided. A three-way SA (pos. 26) is mounted on the pipeline of the passing product, manually switched by a panel with light signaling - circuit 18. The monitoring and setting of the temperature of the product passing through (pos. 26) is done simply/ordinary/naturally by a dual-channel microprocessor programmable controller MS8112 with a warning/emergency light mounted/attached/hooked up/added/connected to on a dashboard. A SV (pos. 25) is connected to the pipeline (pos. 23). Using a platinum thermistor (circuit 16), the temperature of the product is measured and if there is a difference with the set SV, the flow rate of the hot water supplied to the product - circuit 17 is changed. As for the/Concerning the (pos. 27), AAS for temperature - are provided at the inlet and outlet of the product passing through it, temperature sensors (thermistor - Pt100) - circuits 19 and 20. Aiming to reach the desired temperature this happens manually by a microprocessor ... from the complanyMicrosyst, which is added to the dashboard. A warning light is prvoded. A three-way SV (pos. 31) is mounted on the pipeline of the passing product, manually switched by a panel with light signaling - circuit 22. The monitoring and setting of the temperature of the product passing through (pos. 31) is done by the two-channel microprocessor programmable controller MS8112, mounted on a dashboard. A SV (pos. 30) is mounted on the pipeline (pos. 28). Using a platinum thermistor (circuit 20), the temperature of the product is measured and if there is a difference with the set SV it changes the flow rate of the cold water supplied to the product - circuit 21.

Concerning the conveyor belt (pos. 34) - It is managed by a manual starter, which is attached/hooked up/added/connected to the dashboard on site - loop 25. AAS for speed control of how the movement of the bottles would procceed - loop 26. These are inductive sensors and detectors/electric eyes that are used to monitor the minimum permissible shaft speed and the minimum permissible speed of conveyor belts. The sensors indicate the speed of the bottles in front of their active part.If the speed is higher than set, the output of the sensors is turned on,but if the speed is lower than the one set, their output is switched off. Inductive sensors and speed control sensors are moisture and dust resistant and have long-life service thanks to the non-contact switching of the electrical circuits/network in which they are connected.

There are also light sensors on the conveyor belt to determine the number of bottles in the store of the dosing machine (in a number of 4) and one following to the next machines. The function of the detectors is to send an indication to the actuators and to count the number of bottles passed. This is very important because if they do not make the count, the machine will not know when the bottles are finished. Manual start of the ultraviolet lamp (pos. 35).

As for the dosing machine (pos. 32) - The play/stop action is done by a manual starter, mounted on site - circuit 23. A warning light is also provided. AAS is used for upper and lower level regulations - a regulator with immeadiate action for speed level – contour24. When reaching the upper level the supply of ketchup it stops. The machine is controlled by the CMS.

As about the closing machine (pos. 36, 37) - A power switch starter controls themachine,which is mounted on site.A warning light is provided - contours 27, 29. AAS for speed of feeding of the caps - contour 28 and speed of movement of the piston - loop 30. The machine is controlled by the CMS.

As for the labeling machine (pos. 38) - A manual starter, mounted on the dashboard regulates the machine - loop 31. A warning light is also provided. AAS for speed of feeding the labels - contour 32. The control ofthe machine is performed by CMS. Marking machine (pos. 39) - starting and stopping is done by a manual starter mounted on site - loop 33. A warning light is also provided. The program enters the current date and expiration date for marking - loop 34. The operation of the machine is controlled by a microcomputer and this allows quick change of current information during the production process.

Suggestions for improving the ACS of the ketchup line

Duetothepresenceofamanualmodeofoperationintheproductionofketchupinfig. 3 weofferimprovementtothemanagementsystem.

For a preparatory vessel (pos. 2) - AAS for level measurement - to create a system for monitoring and automatic definition of upper and lower level and also to regulate the level of the supplied water - contours 1, 2. For this purpose to use a sensor-transmitter for level MS9015LC and conductometric level regulator MS8105 with self-position adjustment created by the company "Microsyst". A warning light signal is also provided.

The sensor-transmitter for level MS9015LC has a capacitive sensing element, its measurement accuracy is up to 0.15% and its measuring range is up to 3000 mm. The maximum allowable pressure is up to 6 bar. MS9015LC is designed for continuous and accurate measurement of the level of different types of liquids. The sensor is a condenser whose capacity changes depending on the change in the liquid level. The measured input value is retransmitted by the transmitter as an analog output signal, most often in a unified range. Having the option for installation of a temperature sensor it is possible to measure a second technological value.

The conductivity level regulator MS8105 serves to monitor and regulate the level of all types of electrically conductive liquids in closed or open vessels at four points. The regulator works by measuring electrical conductivity.

Itissuitableforpositionalregulationofalltypesofelectricallyconductiveliquidsinthecontroloftechnologicalprocesses. TheMS8105issmallinsizeandweightandeasytooperate.

Circuit 3 - AAS for temperature - is made of temperature sensors mounted on a preheater (pos. 6) and simple/universal microprocessor controller MS8120 of the company "Microsyst" (http://www.microsyst.net). When the set temperature is reached, the three-way SV automatically switches (pos. 10). Two-position adjustment is performed. The MS8120 can have one of the following analog inputs - a Pt100, P1000 thermoresistor sensor or another on request. It is designed for measuring and regulating various technological values. Laws of management can be realized (programmatically chosen), with the possibility to limit the integral component. 2 and 3-

position modes are also built-in. The outputs are controlled by pulses with variable duration (PWM), it is possible to set different times for the formation of "positive" (K1) and "negative" (K2) output.

All data is stored in non-volatile memory, including the current state of the controller, i.e. after restoring the supply voltage, it enters the same control mode in which it was before its failure.

A seamless switch between automatic and manual mode is provided with direct monitoring of the process variable (PV), the setpoint (SP) and the output (OUT). The Autotuning function easily adjusts the parameters for P, PI or PID mode.

AAS for vacuum pump pressure (pos. 13) - to use a pressure transducer PSQA from the company "Comeco" and a microprocessor dual-channel timer MS8203B from the company "Microsyst". The operating time of the vacuum pump (pos. 13) is set when the product enters the deaerator. Automatic blocking and signaling are also provided. After the set time has elapsed, the SV (pos. 14) is closed and a three-way SV (pos. 17) is opened - loops 4, 5, 6, 7.

Pressuretransducer PSQA - isacombinationofathin-layerpressuresensormodel PSQ and aprogrammableindicatorpoweredbythecircuit. Thefive-digit LCD display allowsvisualizationofthemeasuredpressureintherangefrom -9999 to 9999 withprogrammablelimitsforthepurposeofscalingwhenusingdifferentpressureunits. PSQA is alsoequippedwithprogrammablealarmscontrollingtherelayoutput, whichcanalsobeusedfortwo-positioncontrolofvariousactuators. Thankstoitsexcellentvalueformoney, aswellasitscompactdesignandthepossibilityofaserialinterface, PSQA is widelyapplicableforsolvinglow-budgetengineeringtasksinmeasuringandcontrollingpressure.AASfortime - loop 7 - programmaticallysetsthetimeduringwhichtheproductispassingthroughthedeaeratorandwillswitchthree-waySV (pos. 17). A microprocessor dual-channel timer MS8203B is used. It is organized as two timer blocks operating independently of each other. Both timers can operate in 9.99 seconds, 99.9 seconds, 999 seconds, 99.9 minutes or 999 minutes. Each timer can be started from an external input. There are two independent RESET / START switches for each of the timers and one general STOP button for the two timers. Each timer counts down its set time and after its expiration activates the corresponding output, which remains activated until the STOP button or the corresponding switch is pressed in the RESET position.

Circuit 8 - AAS for temperature - is made of temperature sensors mounted on the pasteurizer(pos.22) and universal microprocessor controller MS8120 of the company "Microsyst". When the set temperature is reached, it automatically switches the three-way SV (pos. 26).

Circuit 9 - AAS for temperature - is made of temperature sensors mounted on the cooler (pos. 27) and microprocessor controller MS8120 of the company "Microsyst". When the set temperature is reached, it automatically switches three-way SV (pos. 31).

At the output of the finished product, the Brix concentration of dry matter is measured and recorded. An industrial flow refractometer PR-23-A of the company "Bioevibul" is used - circuit 10. It consists of a sensor-refractometer and a transmitter-regulator.

The refractometer is installed on the outside of the corners (bends) of the pipes directly or using a flow angle cell. In this way, the best measurement conditions are guaranteed with a good self-cleaning effect.

The measuring range is 0-100 Brix with an accuracy of ± 0.1 and automatic temperature compensation. Additionally, low and high concentration alarms can be configured. Thanks to digital monitoring technology, the measurement accuracy is not affected even in the presence of large amounts of undissolved substances, bubbles or color changes.

Conslusion

The technological processes in the production of ketchup are considered and the basic technological plan is presented. The system for automatic control in the production of ketchup is also shown and examined. Also, suggestions for improvement of the proposed automatic control system are given.

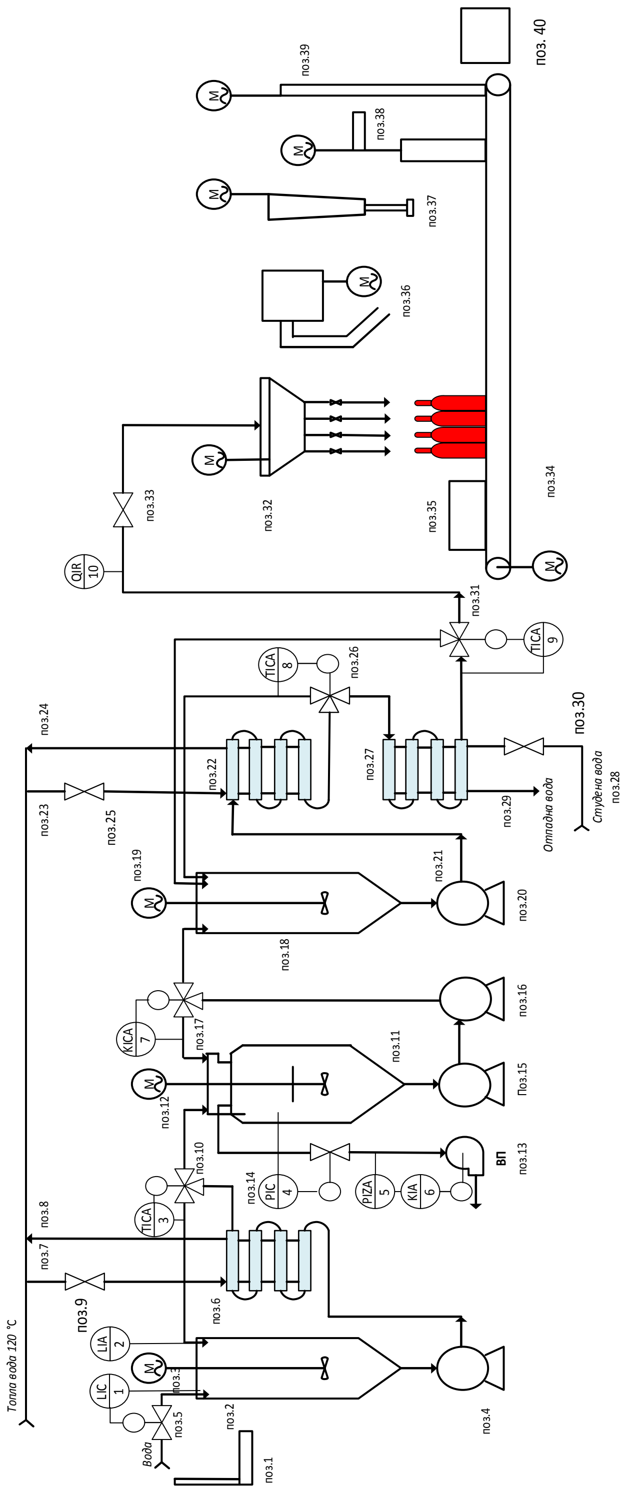

Figure 3. Improvement of the ACS of the ketchup line

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