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SYSTEM OF AUTOMATIC CONTROL OF EMULSION PLANT BASED ON MATHEMATICAL MODEL OF ITS OPERATION PROCESS

Technical facilities and corresponding control algorithms of bitumen emulsification technological process, based on analysis of mathematical modeling results. System of automatic control takes into consideration basis indices of equipment, used for emulsion preparation, emulsification technology stages, parameters of raw material and evaluation of the product obtained.

***Key words**: emulsion plant, bituminous emulsion, cavitation diffuser, remote automatic control system, mathematical model of technological process, vapor-gas bubbles*

Introduction

Nowadays cold technologies of preparation of bituminous building materials (asphalt concrete mixtures, roofing materials, hydraulic insulating materials) gain wide application. As compared with hot technologies, cold of bituminous building materials preparation provide considerable saving of bitumen (up to 30 %), reduction of energy consumption 1,5 times, ecologically safe fabrication and usage, as will as the possibility to perform civil engineering works and road – building works since early spring till late autumn [1].

Bituminous emulsions – main component of cold technologies – are the mixture of the fine dispersive bitumen and water with addition of special substances, which emulsify and stabilize dispersive system. Preparation of various emulsions, including bituminous emulsion is energy consuming process, which forms physical mechanical properties and determines quality and price of the product. Violations of technical regulations at the given stage led to considerable economic losses. Hence, elaboration of the system of automatic control of technological equipment provides the observance of technological regulation is very actual problem

Analysis of the latest research

Control system and information – measuring units are basic construction blocks, determining both the quality of production and functioning of technological equipment on the whole. The given unit enables to monitor the parameters and characteristic of the current technologies process aimed at preparation of bituminous emulsions with preset properties. Greater part of existing used for preparation of bituminous is based mainly on the application of information – measuring devices and control system with human participation who manually selects corresponding operation modes and monitors their functioning [1 - 3]. Such technological procedure does not always allow to obtain required results, as it depends on various objective and subjective factors, connected with operation experience of the operator, accuracy of measuring instruments etc. However there exist a number of productions, for instance, manufacture of ceramics, metallurgy, power engineering, others, where systems of automatic control, based on statements and results, obtained from mathematical models of current technological process are widely used [4 – 6].

Formulation of research goal.

Research, performed within the range of the given subject, is aimed at study of the peculiarities of technological process dealing with production of bituminous emulsions, carried out by means of special installation, developed at research laboratory of hydrodynamics of Vinnytsia Technical University [2].

On the base of mathematical model of technological process the algorithm of functioning of automatic control system providing attainment of rational efficient operation modes and required

quality of production is to be elaborated.

Main part

The construction of installation for preparation of bituminous emulsion [Fig 1] where cavitation powder dispenser used for emulsion preparation was developed at research laboratory of Vinnytsia National Technical University (VNTU).

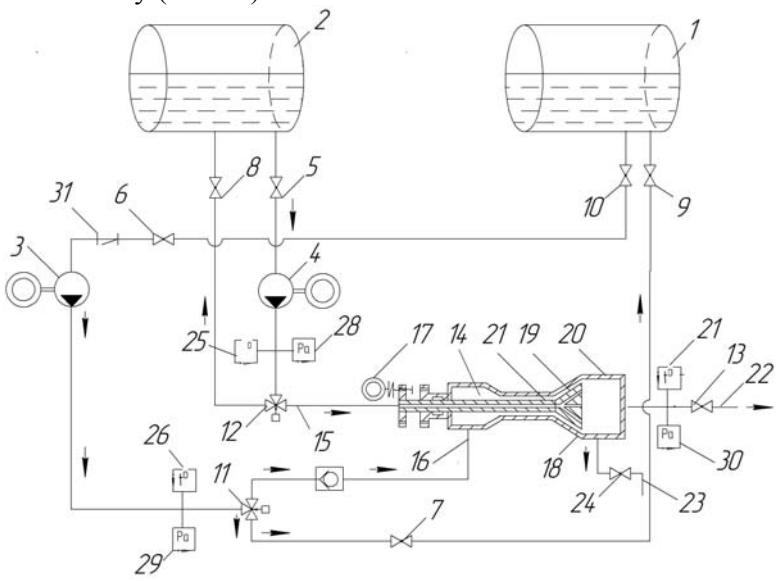

Fig 1. Schematic diagram of the second installation for bituminous emulsions preparation:
1,2 – vessels, correspondingly, with bitumen and aqueous solution of technological filling agents; 3, 4 - bitumen and water pumps; 5, 6 – inlet valves: bitumen and water; 7, 8 – by – pass valves: bitumen and water ; 11, 12 – there – way valves; 13 – discharge valve; 14 – accumulation chamber; 15, 16 – pipelines for supply of aqueous with technological filling agents and liquid bitumen; 17 - step motor; 18 - diffuser part of cavitator; 19 - cone – shape operation mechanism; 20 – mixing chamber; 21 – guide rod; 22 – pipeline for emulsion take off; 23 – sampler; 24 – sampler cock; 25,26, 27, 28, 29, 30 – temperature and pressure sensors; 31 – water filter

The procedure of technological process for production of bituminous emulsion is the following. Initially, tap water (if necessary, softened water) is heated to the temperature of 50 ° C and mixed with special additives, intensifying emulsification, bitumen is heated to the temperature of 150 ° C. In let water valve 5, inlet bitumen 6, by – pass water valve 8, by – pass bitumen valve 7 and shut – off valves 9, 10 are set in open position. Bitumen and water proportioning pumps 3 and 4 function and three – way valves 11 and 12 are set in position of supply to by – pass, in this case, components are supplied to vessels 1 and 2 by return pipelines.

When bitumen and aqueous solutions with technological fillers reach necessary temperature parameters discharge valve 13 is partially open for supply of bituminous emulsion at the stock – room and after balancing water pressure and bitumen three – way valve 1 is switched, 1 -2 seconds later three – way valve 12 is switched to supply the components into cavitation dispenser.

Aqueous solution with technological fillers is supplied across the pipeline 15 to main channel of guide rod 21. To intensify mixing additional channels are located in cone – shape operation mechanism of the cavitator.

Aqueous solution with technological fillers is supplied to mixing chamber of cavitator 20 across main and additional channels of guide rode. Liquid bitumen across the pipeline 16 is supplied to accumulating chamber 14; after which the motion of bitumen is accelerated due to reduction of passage opening in reducing part of the cavitator. While passage of liquid bitumen across the clearance between conic surface of cone – shape operation mechanism 19 and internal surface of diffuser part of the cavitator 18 pressure differential occurs in mixing chamber 20, which provides the emerge of cavitation.

Due to cavitation process, constant preparation of bituminous emulsion with required initial

quality parameters occurs. Emulsion is supplied across the pipeline 22 to the vessed of finished product or is immediately charged into autobitumen distributor.

Regulation of the clearance between the conic surface of cone – shape operation mechanism 19 and internal surface of diffuser part of the cavitator 18 is performed by means of guide rod 20, one the end of which is fixed to cone – shape operation mechanism 19, and the other – to step motor 17.

The installation is designed for continuous operation in technical production line of mixture preparation. The installation is equipped with the system of remote control of technological process of caviatation treatment. Modeling of the process of bituminous emulsion preparation is based on the application of energy conversation law, heat and mass exchange laws [7].

Variety of output data, connected with the properties of the raw materials, temperature mode, relations of components supply in the area of mixing and cavitation generates a great number of models and control techniques. Proceeding from the mathematical model of technological process in equation for pressure determination in the area of cavitation is divided:

$$p_r = p_v - \frac{4\sigma}{3R_r}, \tag{1}$$

$$R_r = R_0 \left[\frac{3R_o\, p_{g_0}}{2\sigma} \right]^{\frac{1}{2}}, \tag{2}$$

where R_r - size of vapour - gas bubble, $p_v\ \sigma$ - pressure of saturated steam and coefficient of surface tension of the liquid, correspondingly, which depends on the form, proporties and temperature of liquid environment; p_{go} - initial balance of gas pressure in the bubble, R_o - initial size of the bubble.

In the process of adjustment of emulsion installation of emulsion installation operation during preparation stage and in course of current technological process, the system of automatic control monitors in the pressure in cavitation area and, according to corresponding algorithms, pressure at the outlet of each line of components supply is regulated.

Structural diagram of computer – aided production control system of bituminous emulsion preparation is shown in Fig 2.

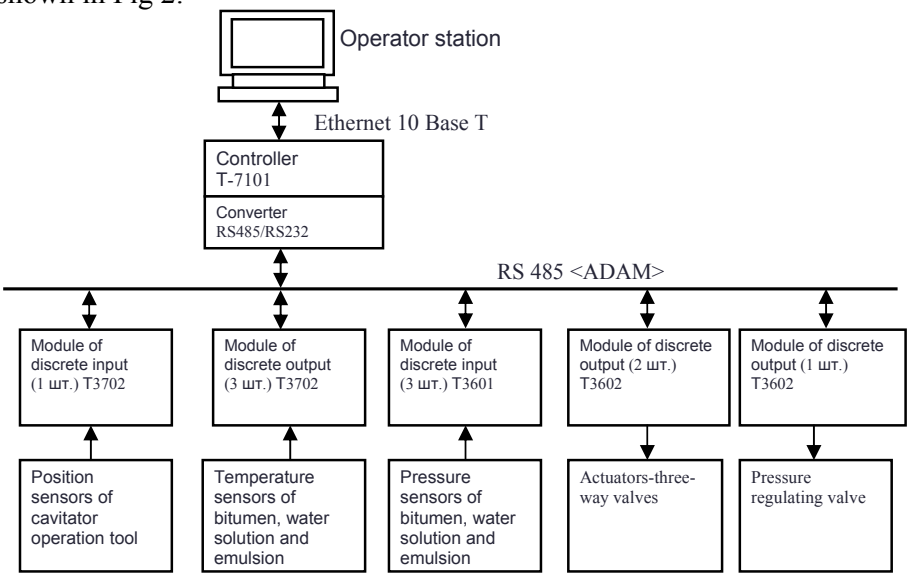

Fig. 2. Structural diagram of computer – aided production control system of bituminous emulsion preparation

Principle functions of automatic control system include regulation (stabilization) of the set values of components mass losses, necessary for formation of bituminous emulsion of high quality. Besides, the given system realizes control and monitoring over temperature modes of heaters and sends commands for mechanical operation of valves, three – way valves, regulation devices.

In case, when certain operation parameters of technological process (temperature, pressure, components, mass losses) exceed prescribed norms, the supply components is blocked, safety valves start operation and components return across bypass pipelines to technological vessel. In the process of operation the system constantly regulates the supply of each line if the deviation from the set volumes occurs. Concentration of emulsion is determined automatically depending on the difference of temperatures of bitumen and bituminous emulsion, bituminous emulsion, bituminous emulsion and water.

Information support of the system is realized by means of operator video terminal APM. Composition, location and interconnection of the equipment of technological process are presented in graphic form on mimic diagram. Numerical values of direct and average variables, characterizing technological parameters of the process and state of the equipment are indicated on videoterminal. Data of interactive input, date and time of batching lines from the moment of their start for preparation of the given composition, graphs of mass losses variation and stabilization errors of each component, as well as text information regarding process disturbance, which contains time and identification of the origine of accident, are shown.

The system automatically prepares the protocols and archive events. The protocol and archive can be accessed at videoterminal of the station during the process.

Operator, in interactive mode, can edit the current composition of the emulsion, control gate valves, three – wave valves, pressure regulation valves, start bitumen pumps and aqueous solution pumps, regulate the position of cavitator operating mechanism.

In automatic mode the system of automatic control supports percent relation of mixture components in accordance with preset values of losses at the expense of stabilization of components mass losses, calculates the following values: preset value of each component mass, preset value of mass losses of each component.

Tests of pilot installation were performed at one of asphalt concrete plats of Ukraine. Direct emulsions obtained differ by high dispersivity and stability.

Conclusions

Special technological equipment – emulsion installation with cavitational powder dispenser for preparation of bituminous emulsion, equipped with remote system of automatic control is proposed.

2. Analysis of existing systems of automatic control of emulsion installation is carried out. The analysis proves the lack of perfect equipment in the sphere, providing the possibility realize necessary functional designation of installation for bituminous emulsion preparation and obtaining finish products of high quality, taking into account initial raw material as well as thermal and hydrodynamic characteristics.

Proceeding from the analysis of mathematical model of technological process and the results of its study the algorithm, of parameters setting selection of control system of emulsion installation is proposed. The given automatic control system, unlike the existing ones, provides prior forecast of finish product quality – bituminous emulsion, and enables rational usage of energy resources.

REFERENCES

1. Битумные эмульсии. Особенности состава и применения [Електронний ресурс] / В.А. Будник, Н.Г. Евдокимова, Б.С. Жирнов // Нефтегазовое дело – 2006. – Режим доступу до журн.: http:www.ogbus.ru.

2. Бауман К.В., Борисенко А.А. Нова технологія та устаткування для виготовлення бітумної емульсії // Автомобільні дороги і дорожнє будівництво. – 2008. – № 75. – С. 47 – 50.

3. О механизмах фазовых превращениях в каплях водотопливной эмульсии [Електронний ресурс] / А.Я. Исаков // Научный журнал КубГАУ – 2006. – №21(5) – Режим доступу до журн.: http://ej.kubagro.ru//archive.asp?n=21.

4. Москвіна С. М. Проблеми оптимізації управління технологічним процесом виготовлення цегли / С. М. Москвіна, Д. О. Ковалюк // Вісник ХНУ. – 2005. – № 5. – С.121 – 125.

5. Лисенко В. Г. Математическое моделирование теплообмена в печах и агрегатах / В. Г. Лисенко, В. В. Волков, А. Л. Гончаров – К.: Наукова думка, 1984. – 232 с.

6. Жученко А. І. Оптимальне керування процесом випалювання керамічної цегли / А. І. Жученко, І. В. Ярощук // Автоматизація виробничих процесів. – 2002.– № 2 (15). – С.45 – 50.

7. Бауман К. В. Кавітаційна установка для приготування бітумних емульсій / К. В. Бауман // Вісник Національного технічного університету «Харківський політехнічний інститут». – Харків: НТУ «ХПІ». – 2008. – № 30. – С. 136 – 141.

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