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Forming of Technical Creative Work by Future Engineers in Vocational Education

Statement of the problem in a general view and its ties with important practical tasks. The Ukraine with its considerable intellectual potential is characterized by the low competitions being in the seventh dozen according to the global competition index [10]. The substantial part of responsibility for the low level of scientific-technical development falls on the engineering education and retraining [11]. There exists today a number of research and training centers, which have to deal with vocational training and the improvement of professional skill of specialists in enterprises and organizations [13; 15]. The key direction for ensuring the experience of engineering creative work is to be the forming of ability by a specialist to search for necessary information, to find definite rules in the aggregate of data, to find optimal solutions of complicated production tasks [3].

Distinguishing the earlier unsettled parts of the general problem. The problems of rise of creative skills by engineers and the transformation

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of the paradigm of higher technical education have been working out by U. Abdulgasis, A. Bolshakov, Yu. Kuznetsov, A. Kornilova, O. Markovska, O. Mashkina, M. Meerovich, I. Pirogov, Yu. Salamatov, Yu. Stolyarov, G. Hataenaka, G. Horuji, G. Hemel, F. Yakubov a. o.

Professional skills of future engineers require a definition of categories of those, who are taught, the choice of methods, programs and teaching forms, the information and communication technologies, using of terms, the surroundings and place of education, the provision with teaching and methodical documentation, the qualified personnel of scientific-pedagogical collectives of chairs and with a sufficient teaching and material, and the normative-technical base [14; 15]. The aim of professional training the managers and specialists is the forming of professional competency on level of the program requirements, which foresee the study of separate subjects, branches of science, technique and technology, which are necessary for realization of the future professional activity [11].

For involving the students into the rationalization and invention activities in the study process of special disciplines, the experience of organization of engineering creative work is being used (G. Altshuller [1], V. Zaenchik, V. Kudryavtsev, M. Lazarev, T. Lazareva, A. Lilikov, V. Molyako, V. Nilova, A. Polovinkin [8], B. Prakhov, M. Turov [12], S. Uvarov, M. Chechevitsina, Z. Shmakov, A. Yesaulov, P. Yakovishin [14] a. o.). On the up-to-date stage of reforming of higher education, the complicated process of adaptation by professional training the engineers to the new management conditions is not taken into account, what is braking the economic progress of society.

Formulation of the aim of work. The aim of this article is to substantiate the necessity of transformation in professional training of engineers in a direction of forming the creative inventive and the rationalization competency by utilizing the computer simulators of the type «Operator Trainer» with aim of simulating the appearance of the non-ordinary ideas while prognosticating and elaborating the innovations.

Exposition of the main research material. The achievement of the put aim is possible under conditions of introduction of realistic versions of organization and management in the teaching and cognitive activities by future engineers with the accent on creative skills, that requires the supplement to the functioning teaching plans and programs. For to-day there exists the low level of correspondence of graduates from higher technical schools to the requirements and conditions of innovation economics and technical policy in the modern production, because of the

not sufficient creative skills of specialists. In connection to that the strive of higher schools for adaptation to dynamic socio-economic processes and the scientific-technical achievements of a society becomes weaker [4]. The scientists substantiate the possibility of competition advantages owing to intellectual leadership in comparison with the increase of the market part in economics [10]. As the highest level of competition advantages it is considered the bank of own patents, innovation elaborations and licences, the availability of higher qualification of the personnel and the effective administration system [9]. The main source and the defining factor of competition in economics is producing of innovations, the intellectual potential of a nation [13].

In the teaching process of the most technical disciplines the higher schools apply the reproductive forms and methods of teaching. The insignificant part only of the engineering disciplines («Engineering creative work», «Bases of technical creative work», «Technical creation», «Bases of invention and rationalization», «Methodology of scientific investigations» as well) is taught on the near to the creative level of organization the teaching and educational process, that integrates knowledges, skills and experience of the to-day existing vocational education in higher schools. The broadening of the students' competency in creative innovation activity was believed to be facultative (selective), secondary disciplines, which are not always included into curricula. In the process of teaching special disciplines it is necessary to focus the key knowledges and skills on their practical and inventory application in corresponding branches of techniques and technology, strengthening herewith the interdisciplinary ties and forming the system-creative foundation for schooling of the innovatory engineer-inventor. In this period it is expedient to introduce into the curricula of a higher technical school the study of bases of the science of theory and practice in patenting and protection of author's right, the generalization of invention and rationalization knowledges. It arises the necessity to raise the status of disciplines on development of technical creative work to the compulsory ones and to carry over their study, beginning from the first year of studies with increase of class-studies with the laboratory-practical direction and with a detailed mastering of the branch data bank of inventions with an uninterrupted and through training of invention and rationalization [3].

The outdated paradigm of engineering training is the learning by the students a considerable volume of knowledges, abilities, habits and ways of their applications, aiming the forming of a qualified engineer-performer.

For ensuring advantages on the labor market there is a necessity in training the specialists able to make an effective contribution to strengthening of competition advantages of a firm, through a creative inventive attitude to post duties, the producing of material-technical and intellectual patent defended resources. Therefore the rely of higher schools on that the creative inventive training will spontaneously be carried out in the process of vocational training stands up to no criticism. The new paradigm of higher education has to include into training of engineers not only the ability of professional fulfillment of post duties, what very important is, but also the accumulation of intellectual potential and experience in producing of new rational ideas with their introduction and realization in restricted terms. The substantial factor for development of technical creative work is the rise of significance of the scientific-research work of students, the independent treatment of inventive themes of the special disciplines, the critical analysis of production objects and technologies, the advancement of alternative decisions. The practical production training has to foresee the inclusion into the reports on practice the own analysis about an enterprise or organization activities, the offering of peculiar technologies and projects, the working out of applications on inventions, useful models, industrial patterns as well.

The leading direction in development of a creative component of professional competency of an engineer is the attraction to solutions the invention and rationalization tasks. Such an approach stimulates additionally to a firm and comprehensive mastering by the students the base and branch contents of engineering education [15]. Many scientists forecast the perspectives of rise of the level of creative skills on a basis of the creative paradigm on account of taking down restrictions, the stimulation for searching the innovations, the attraction of heuristics, the application of methods of creative work [4; 5; 8; 12]. In the opinion of the most inventors there is no difference between clearly determined classical engineering tasks, which are to be solved in accordance with the existing technical and technological requirements, and the creative ones, incomparably more complicated, without statement of a task, determination of output data and algorithms and methods of solving, the expected results [1; 2; 8; 12; 14]. The development of the inventive thinking is stimulated by means of fulfillment by students the tasks on intuitive creation of new technical and technological units, the obtaining of uncommon alternative makings, modelling of characteristics and dependencies of elements on the basis of the obtained experience in rationalization activities. It is expedient

for future engineers to use the system of methods in the engineering creative work: «the brain attack»; the heuristic and logical methods; the morphological analysis and recombination; the automatized syntheses of the physical principle of operation and technical solution; the programmed searching for optimal technical solutions; the function and value analysis of technical objects; the algorithm of solution of inventive tasks as well [1; 2; 8; 12; 14].

One of the examples of conducting such an analysis can be utilization of the program complexes AspenOne, GasCondNeft and others for optimization of technological processes in preparation of hydrocarbon production. Creating various technological schemes after functions, and purpose and analyzing them, a student gains skills and experience of up-to-date designing and modernization. By utilization of computer programs the future engineers have an opportunity, before receiving practical tasks in the production works, to learn the working parameters of the concrete technological schemes, the interconnection of versions of their modernization and optimization (Fig. 1).

Training of an engineer-inventor foresees the work from the first year of studies in the following directions:

1. Psychological adaptation to participation in a competition for leadership in the future working activity; formation of motivation and desire to master the inventiveness and rationalization; the introduction of inventions and defended patents. Psychological activization of searches for variants in solution of inventive tasks on basis of involving and mobilization of the system of competencies and the conception about

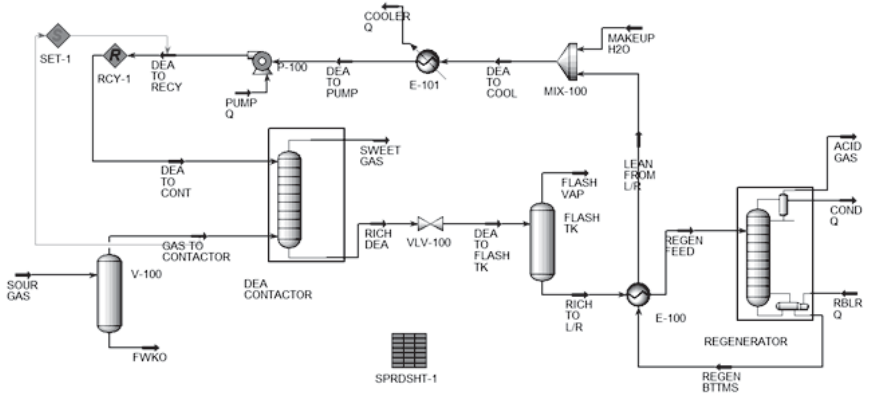

Fig. 1. The technological scheme done in the HYSYS

working out of alternative and effective solutions. Breaking the ascertained ideas about teaching and its results. Walking away from a routine in engineering activity, a keen feeling of a new, a weighed understanding of problems.

2. Theoretical and practical training in inventiveness on the basis of learning the principles and laws of development of technical systems. Use of the theory for solution inventive tasks (TSIT) [1; 2]. Utilization of the information fond of physical, geometrical and chemical effects and phenomena, application of the standard ways for solution technical and technological discrepancies, standards in solution of inventive tasks [8; 14].

3. Formation of abilities, skills and the accumulation of experience in inventive activities and the development of creative thinking. The study of the branch inventions and the suggestion of own alternative solution with stepping away from the typical instructions, requirements, formulae, algorithms. Taking into consideration the laws of development of techniques and technologies, determination of shortages and weak places, putting the inventive tasks, the prognostication of perspectives of further development of technical objects and the periods of their vitality.

4. Stimulation the students to use, every time in a new fashion, the obtained knowledge, to analyze critically the investigating objects, to define weak places and to ascertain directions of innovation changes, to propose alternative inventive solutions, to impel to study the experience of utilization of new knowledges in practice, the search for potential opportunities of theoretical knowledge in inventiveness. Accumulation the bank of data and methods for solution of inventive tasks.

The heightened requirements are put to the work of the engineering and designing groups in the oil and gas branch nowadays. The terms of working out the projects become substantially restricted, what was caused by desire of a customer to put a new object into operation as soon as possible and to receive profit. Therefore the specialists, that have modern skills and experience in work with program methods of managing the technological processes of production, will have advantages in a competition. That is why the main task of higher educational institutions is the practical training of specialists with application of achievements in modern computer technologies. For example, when comparing the time for composition a project of the block pumping station by a projecting group with utilization of classical (outdated) operation methods and by the analogous staff of elaborators, which use the modern programs

for 3D-projecting, the reduction of the project manufacturing terms is achieved by 2 – 3 times.

Aiming the strengthening of creative and inventive education of students, we elaborated the course of psychological supporting in a competitive rivalry of producing and realization of innovations, the study of laws and theories of development of technical systems, the foundations of inventiveness, the methods of solution the invention tasks with development of creative thinking and conception. The development accent of a creative idea and inventive training of future engineers is concentrated on elaboration the program ensuring of teaching and educational process. The scheme solutions of the modern settings are proposed to the students (Fig. 2, 3), where the last technical and technological achievements and elaborations are concentrated. The study of the proposed systems foresees the analysis of the objective side of their existence and the investigation of the further development perspectives. The base of development is the systematic solution of contradictions between the available quality level of the technical and technological index and the prospective requirements of a society, taking into account achievements of science. Every technical

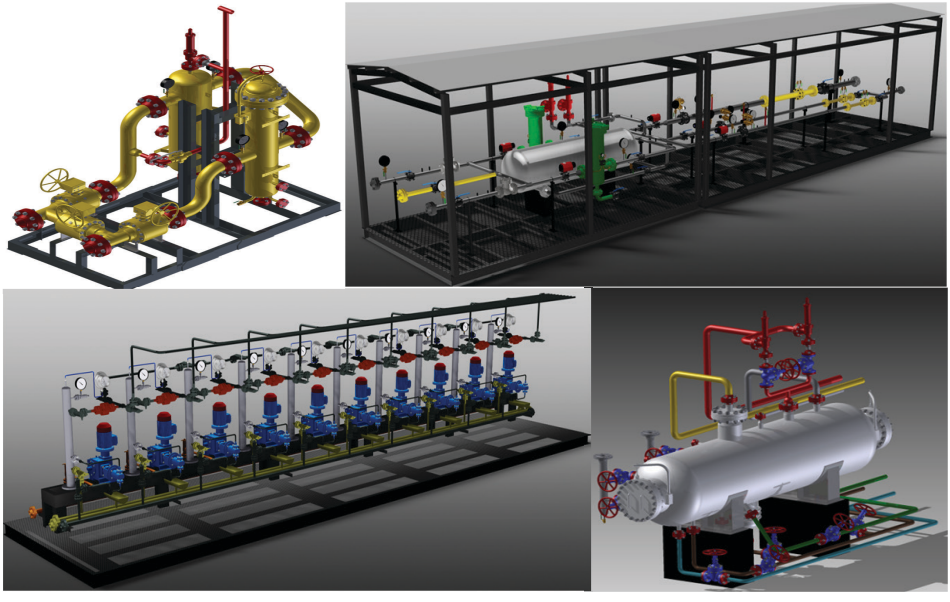

Fig. 2. Virtually elaborated analogues of the oil and gas industry settings for learning dynamics of their development and the perfection perspectives in 3D

object to be studied is described after the signs: 1) demand; 2) technical function; 3) functional structure; 4) physical action principle; 5) prognosis; 6) technological solution; 7) project.

In the process of laboratory investigations it is used the elaborated by us methodology of the complex of inventive knowledge and learnings of industrial technologies, objects and processes in statement of the system of scientific principles on the base of choice of the aggregate of cognitive methods, algorithms and ways [6]. The methodology of laboratory research contains a system of methods with peculiar functions: 1) it determines the way and sources of scientific knowledges, that reflects dynamics and prognosis of processes and phenomena; 2) it foresees the optimum way to achieve the scientific-research aim; 3) it ensures gaining from the experiment, the study of the process, phenomenon, the model of comprehensive and substantiated data; 4) it helps in interpreting, clearing and introduction of new information; 5) it ensures specifications, argumentations, corrections, the systematization of terms, laws, dependences, conceptions in science; 6) it creates a system of scientific information, indicates on possible innovations, which are based on the objective phenomena and logico-analytical device of scientific epistemology of reality.

An important moment of professional adaptation of engineers to fulfillment of future duties is their training in laboratory-practical

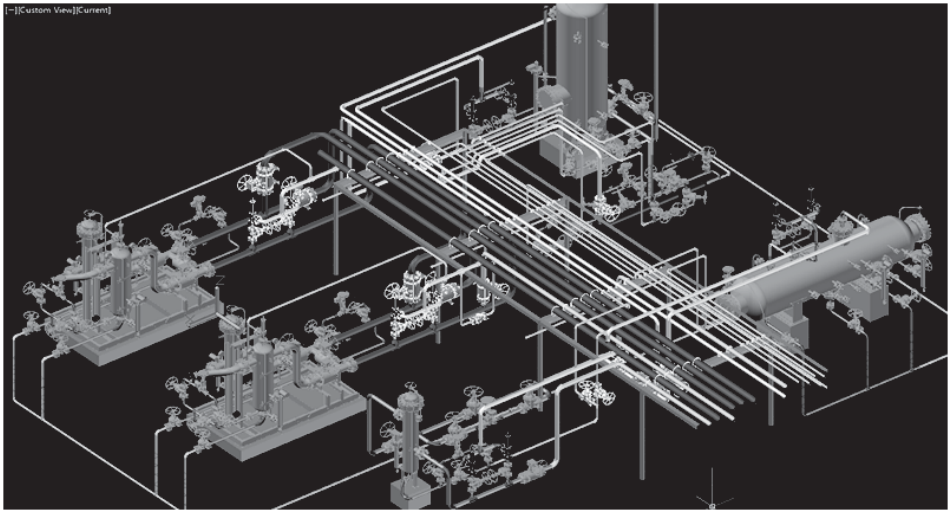

Fig. 3. Fragment of the system for complex gas preparing made in 3D

conditions. The participation of students in such studies does not always ensure an achievement of the higher level engineering qualification because of many reasons. To the substantial ones of them we take the considerable economic expenses for exploitation of the technical and technological basis of laboratories and testing grounds, and the necessity of utilization the significant quantity of materials and reactants. To solve this question it permits the organization of teaching virtual courses and trainings of carrying out the laboratory investigations. So the program, elaborated by us, gives the students an information about essence, conditions and demands to fulfill the laboratory works. The computer experiments are carried out by the students with utilization of analogues of the available material-technical base of the university with an unlimited provision of consuming materials. The fulfillment levels of virtual laboratory work are: 1) the acquainting one – investigations are conducted in form of an excursion-supervision, a student studies the process of a laboratory work and, if necessary, makes notes at key moments of the investigator activities; 2) the testing one – passing the tests on knowledge of consistency, sense and aim of a laboratory investigation, the ability to use equipment, to follow the methods of the experiment; 3) the executive one – the independent conducting of separate measurements, the systematization of data, the construction of dependencies, after results of which an admittance to the complex of investigations is obtained; 4) the scientific researching one – investigations are conducted on the virtual devices (Fig. 4) with a full application of equipment, materials and reactants, obtaining dependencies, regularities, formulating conclusions and recommendations. The final stage in practical training of future engineers is the immediate work on the equipment of laboratories and testing grounds of the university with utilization of the whole complex of investigating methods.

With the analogous methods, the production practice and training of students in the courses of working professions have been organized [7]. In the virtual production practice it is foreseen the acquaintance of students with existing industrial apparatuses and settings, the technological schemes and equipment, the organizational and administrative ties, and with functions of engineers. It was elaborated a practice for students, which study in the courses of working professions in form of a computer play (Fig. 5). There were worked out the courses for operators of oil and gas extraction in form of the computer simulator «Operator Trainer» on several levels:

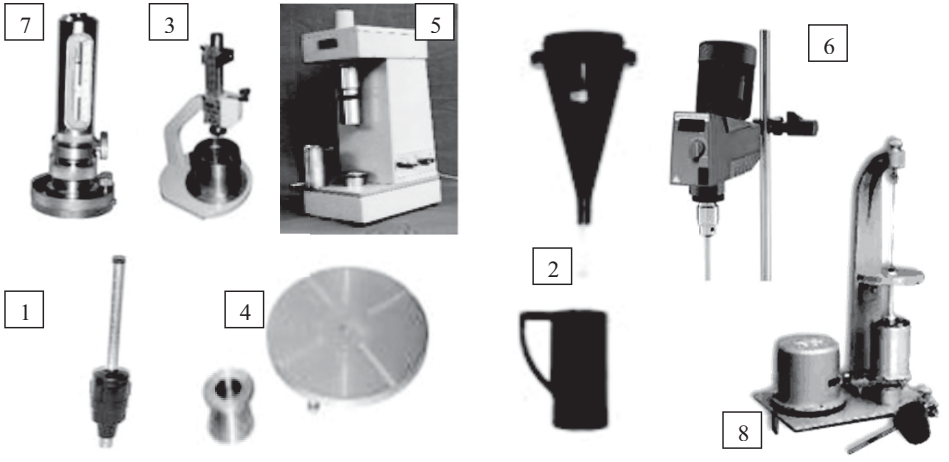

Fig. 4. The elaborated functional equipment for conducting laboratory investigations in oil and gas work: 1) aerometer; 2) viscousemeter VBR-2 and a cup; 3) the device «Vica»; 4) the cone of spreading AzNDI; 5) rotational viscousemeter VSN-3; 6) electric laboratory mixer; 7) device VM-6; 8) device SNS-2

1. The acquaintance with a field and the operator's working place, the work in a testing regime. On this stage it is given to a student an unlimited time for learning the simulator interface, the investigation on the technological scheme of the suggested setting. «Intermixing» in the bounds of virtual production, there retains in memory placing of main technological equipment, and the logic of its interaction is disclosed. The peculiar attention is concentrated on the means of CMDaA (control-measuring devices and automatics), that play an important role in controlling and managing the processes.

2. The fulfillment of post duties by an operator in full volume after successful passing the examinations and carrying out the test tasks. On this level a student has to learn the main methods of control and regulation the setting operation, the control over working parameters (pressure, temperature, level of liquid as well). In a simulation process, in accordance with the qualification level of an operator (III, IV, V, VI grade), the student is proposed to fulfill the task of corresponding complexity in a limited time, for banning the violation of a technological process. The tasks correspond to the kinds of work of operators after a post instruction.

3. The work in extremely and non-standard conditions foresees the

appearance of extraordinary situations, including the breakdown ones – the program is testing on professional fitness and psychological stability of an operator or an engineering-technical worker. The last level of computer simulation is intended for retraining operators and engineers, and for checking up and determining the level of their professional competency. In the process of liquidation of emergency situations both the one student and the academic group may take part, made by analogy with the existing in production VFBs (voluntary fire-brigades). At this stage the simulator is modelling possible emergency situations (hydration plug, ignition of equipment or a unit, decompression of equipment or a pipeline, de-energizing of a unit, act of terrorism a. o.), which are to be confined and eliminated in restricted time, acting herewith according to PLAS (Plan of localization/liquidation of accidents/accidental situations).

The key signs of the elaborated project of practical training for future engineers are: a) the problematic-investigating character of

Fig. 5. Screenshot of the computer simulator «Operator Trainer»

activities – the availability of the system of cognitive contradictions and production tasks, which run across in the real activities of an engineer; b) the interactive character in connection with a peculiar role of each student, the availability of a reverse tie, promptings and explanations if necessary, – the practical work (individual and in cooperation), in groups and brigades, the mutual training; c) the reflexion-evaluating character, the gradual achievement of a result – the estimation of achievements,

the self presentation in formulation of conclusions, recommendations on practical application, the compiling of reports, an account, the writing of a scientific work in form of projects, tables, graphs, dependencies as well; d) the practice-oriented character – the work on a concrete production-field, in a laboratory, testing ground with equipment, at a control panel, the obtaining of data about results of functioning of a technological line, the statistical accounts, the possibilities of corrections; e) the methodological character – the comprehension and adding to the students' armoury the ways, forms and methods for solution problems, the modelling of situations of fulfillment the post duties; f) the combination of different actions in single engineering work with abilities of optimum application of professional competencies, the increase of significance of constructive, designing, technological, cognitive, compensatory, affective and social strategies.

The elaborated computer-program software is being conformed and copies the system of automated control and operating the technological processes by exploitation of boreholes. The first embedding of the program gives a general idea about modern working conditions in production mines, is the acquaintance-adaptive one and foresees the training of students for the choice of the optimal technological exploitation regime of boreholes. It is presented in it the stripping of a borehole and a stratum,

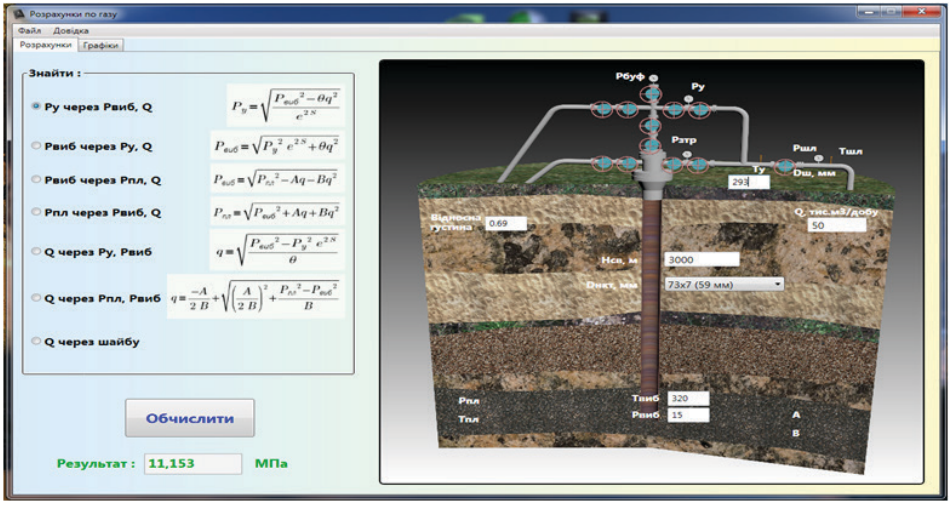

Fig. 6. Interface of the teaching program «GAZ» for the course «Technology of gas extraction»

where the possibility to set up the operation parameters of a gas borehole is derived (Fig. 6). A student chooses formulae for further calculation and analysis in the left window of the program. The working indices and geometrical dimensions are assigned in the graph window, where the field of each parameter is in the corresponding place, that contributes to quick adaptation to the interface of the program. On the embedding «Graphs» one can see and analyse the results of calculations (Fig. 7). In such a way the possibilities of creative realization of the formed professional competencies and creative achievements are opening before a student, the brain activities and associative thinking liven up due to utilization of the interesting, graphically saturated, brought nearer to reality programs such as «GAZ».

In the process of practical training the future engineers for adaptation to operation on the program software the various kinds of information and communication technologies are used. The students begin to master the methodology of computer modelling with the study of available CAD/CAM systems (Kompas, AutoCAD, Solidworks, Inventor), continue to work in the systems ANSYS, Comsol, HYSYS and in the integrated systems ANSYS, AutoCADPlant 3D, HYSYS, Comsol a. o., are mastering the skills to work in automated systems of the technological production organization, conducting a part, unit, technology under elaboration and design, from an idea (by way of projecting, constructing and testing the control systems) till immediate production and introduction. This enables

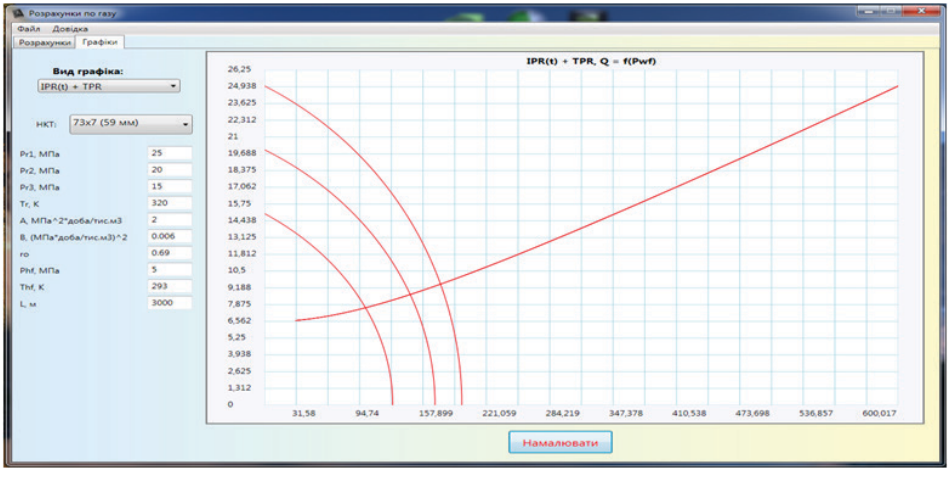

Fig. 7. Calculation results obtained in the program «GAZ»

in specially created conditions of activities of «the virtual students' project and design office» to elaborate models of real technologies and structures, to carry out designing of corresponding modules and systems.

Conclusions on the conducted investigation and perspectives of further explorations in this direction. After results of organization practical training of future engineers and the teaching disciplines on development of technical creativity in the higher technical educational institutions, the experience of introduction of computer systems for support and securing the teaching process has been generalized. The prospective directions of further work on rise of efficiency in practical training of future engineers are the elaboration of typical teaching programs and methodic recommendations for development of students' technical creativity and their attraction to designing the analogous computer simulators of the type the «Operator Trainer».

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Abstracts

АНАТОЛІЙ НІЗОВЦЕВ, МИКОЛА БЄЛЄНКОВ. **Формування технічної творчості майбутніх інженерів у процесі професійно-технічної освіти.** *У статті розглянуті питання організації практичної підготовки студентів до раціоналізаторства і винахідництва. Расскрити сутність і специфіка роботи на комп'ютерних симуляторах типу «OperatorTrainer». За результатами моделювання професійної діяльності інженерів і викладання дисциплін з розвитку технічної творчості, узагальнено досвід впровадження комп'ютерних систем підтримки та забезпечення навчального процесу вищих технічних навчальних закладів.*
Ключові слова: *технічна творчість, винахідництво, раціоналізаторство, інженерна діяльність.*

ANATOLIJ NIZOWCEW, MYKOŁA BIELIENKOW. **Kształtowanie twórczości technicznej przyszłych inżynierów w procesie edukacji zawodowo-technicznej.** *W artykule przedstawiono organizację przygotowania praktycznego studentów do innowacyjności i pomysłowości. Opisano istotę i specyfikę pracy na symulatorze kompyterowym «OperatorTrainer». W wyniku symulacji działalności zawodowej inżynierów oraz przeprowadzenia zajęć dydaktycznych w celu rozwoju twórczości technicznej, zostało uogólniono doświadczenie wdrożenia systemów komputerowych wspierających proces dydaktyczny na uczelniach technicznych.*

Słowa kluczowe: *twórczość techniczna, innowacyjność, pomysłowość, działalność inżynierska*

АНАТОЛИЙ НИЗОВЦЕВ, НИКОЛАЙ БЕЛЕНКОВ. **Формирование технического творчества будущих инженеров в процессе профессионально-технического образования.** *В статье рассмотрены вопросы организации практической подготовки студентов к рационализаторству и изобретательству. Расскрыты сущность и специфика работы на компъютерных симуляторах типа «OperatorTrainer». По результатам моделирования профессиональной деятельности инженеров и преподавания дисциплин по развитию технического творчества, обобщен опыт внедрения компъютерных систем поддержки и обеспечения учебного процесса высших технических учебных заведений.*
Ключевые слова: *техническое творчество, изобретательство, рационализаторство, инженерная деятельность.*

ANATOLIY NIZOVTSEV, MYKOLA BELENKOV. **Forming of technical creative work by future engineers in vocational education.** *The key direction for ensuring the experience of engineering creative work is to be the forming of ability by a specialist to search for necessary information, to find definite rules, in the aggregate of data, to find optimal solutions of complicated production tasks. The aim of work is the substantiate the necessity of transformation in professional training of engineers in a direction of forming the creative inventive and the rationalization competency by utilizing the computer simulators of the type «Operator Trainer» with aim of simulating the appearance of the non-ordinary ideas while prognosticating and elaborating the innovations. The questions of organization of practical training for the students' rationalization and invention activities were considered in the article. The essence and specificity of work on computer simulators by the type of «OperatorTrainer» were exposed. After results of modelling the professional activities of engineers and of teaching the disciplines on development of technical creative work, there was generalized the experience of introduction of the computer systems for support and ensuring the studies in higher technical educational institutions. The prospective directions of further work on the rise of efficiency of practical training the future engineers are the elaboration of typical teaching programs and methodic recommendations for development of students' technical creativity and their attraction to designing the analogous computer simulators of the type the «Operator Trainer».*
Key words: *technical creative work, invention activities, rationalization activities, engineering activity.*