ADVANCED TECHNOLOGIES IN THE IRRIGATION AND DRAINING SYSTEMS FOR THE INTRODUCTION OF THE UNDERGROUND PIPES, WITHOUT DIGGING

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In modern technology, the direct introduction, into the soil, of the underground pipes, without an open ditch, becomes possible in Romania too, as an air rocket (type FORI, 80 mm diameter) has been created and produced, for the first time in this country. Our suggestion is to extend the applications of the FORI rocket irrigation systems as well, in order to fight draught, and to draining systems, to eliminate exceeding humidity in the soil.

Nowadays, in the construction of the irrigation and/or draining systems of advanced technology, specialists consider the necessity of introducing underground pipes of water distribution and/or drainage, without open ditches at surface. The new, ecological, state-of-art technology is applied in the developed countries of the world. It has become operational in Romania too, through the production of the FORI 80 pneumatic rocket and the specific accessory kit. Our proposal is to create irrigation and/or draining system, completely automatic, equipped with sensors and an integrated computerized system of data collection and processing, which is regulated to maintain the optimal pre-established degree of humidity. The system of water distribution and/or collection underground pipes will be created in advanced technology, without ditch.

***Keywords**: pneumatic rocket, irrigation system, drains, without ditch.*

Nowadays, in the construction of the irrigation and/or draining systems of advanced technology, specialists consider the necessity of introducing underground pipes of water distribution and/or drainage, without open ditches at surface. The new, ecological, state-of-art technology is applied in the developed countries of the world. It has become operational in Romania too, through the production of the FORI 80 pneumatic rocket and the specific accessory kit. Our proposal is to create irrigation and/or draining system, completely automatic, equipped with sensors and an integrated computerized system of data collection and processing, which is regulated to maintain the optimal pre-established degree of humidity. The system of water distribution and/or collection underground pipes will be created in advanced technology, without ditch.

MATERIAL AND METHODS

The pneumatic rocket remains the basic component of the underground, without ditch pipe introduction system. This one may generate a micro tunnel and may simultaneously or separately pull the pipe inside the formed hollow.

The description and operation of the pneumatic rocket, including the modern technology of introducing and installing the underground, without ditch pipes has already been presented [1].

Innovative technical solutions for doubling or tripling the weigh of the main piston generating percussions in order to increase the energetic percussion parameters of the pneumatic rocket have been proposed [2]. Choosing the material is essential to increase the rocket's force to penetrate the soil and reach the energetic parameters achieved by the reference models created in the USA and Germany.

The duty cycle of the pneumatic rocket as a self-maintained percussion generator, without classical (compressed air) distributor, with mobile pieces in motion has been minutely detailed [3].

As technical novelty, the operationalization module of the new technology has been proposed [4], using the FORI 80 pneumatic rocket and the specific accessory kit, as a product conceived and accomplished for the first time in Romania.

A compared analysis of the known pneumatic high-speed cylinders, with automatic operating cycle to generate percussions, has been performed [5].

The execution of efficient stand for dynamic trials of the FORI 80 rocket has been proposed, with real-time monitoring display of the analyzed phenomena.

We suggest extending the application area of the FORI 80 rocket to create irrigation and/or draining systems, in an advanced technology, which eliminates the traditional open ditch, and to introduce underground pipes. As technological novelty, we present the complete technology and working equipment, including the pneumatic rocket and the accessory kit, as well as advanced technologies to create irrigation and/or draining systems, completely automatic and set to maintain the optimal pre-established humidity in the soil, regardless of the weather-climate, regional-temporal conditions.

RESULTS AND DISCUSSIONS

2.1 Existing solution to introduce underground pipes

According to the classic technology, underground pipes are introduced only in open ditch at surface.

2.2 Proposed solution for the introduction of underground pipes, without ditch

The pneumatic rocket and the accessory kit for the introduction of underground pipes, without ditch, were the subject matter of the research contract [8] no. 43/1996 of SC MITECO SA from Iaşi.

The *working equipment* includes: the pneumatic rocket and the accessory kit.

The *pneumatic rocket* is a linear pneumatic motor with oscillatory, self-maintained motion of the main piston into the body of the rocket. The rocket (which is motor generating percussions) has an automatic operating cycle, and it is fed with compressed air.

The *accessory kit* includes: the energetic source (motor compressor), the launcher, the periscope, the expander, the device that couples and pulls the pipes into the micro-tunnel.

The *underground pipe introducing technology, without ditch,* has two operational stages:

- generation of the micro-tunnel;
- pulling of the underground pipe into the micro-tunnel.

The two stages may be developed simultaneously or separately, depending on the case.

The technological working diagram is presented in Fig. 1[1].

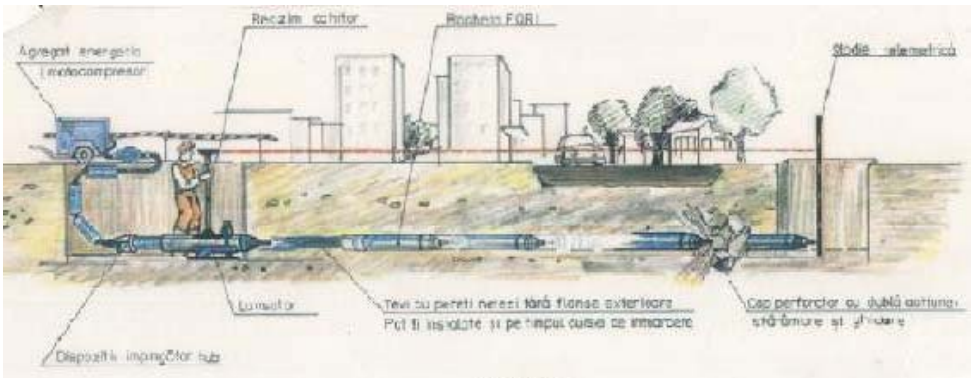

Figure 1. **Technological working diagram**

In the picture above, on the area that the pipes cross there may be various buildings or plantations, or it may be a vacant field, with no obstacles, typical for irrigation and drainage works.

The technology that introduces underground pipes, without ditch, may begin only after the creation of the launching hole where the working equipment is placed (see fig. 2) [11], and of the exit hole, at the end of the lay-out, which may be located at maximum 150 m away from the starting point.

Both holes (the launching hole and exit hole) will be created at a certain depth, which is pre-established at the starting point, as imposed for the introduction of the underground pipe that provides the perforation tube with water for drainage. The recommended depth is below the freezing one.

The energetic source is represented by an air compressor, which may constantly supply the optimal volume of compressed air (1 Nm^3/min) at a working pressure of 8-10 bar. The distributor, which is provided with a lever that regulates the volume of compressed air, and a lubricator are installed on the supply network.

Figure 2. **FORI 80 pneumatic rocket with the accessory kit**

The pneumatic rocket is connected to the air source (the motor-compressor) by means of flexible tubes for compressed air, which can tolerate a nominal pressure of 8-10 bar.

Usually, when the two main operations (micro-tunnel generation and the introduction of the underground pipe into the micro-tunnel) take place simultaneously, in only one crossing, the flexible tubes, which provide the system with compressed air, pass through the interior of the pipe that is to be installed, and they will be connected to the motor-compressor afterwards.

The pulling device, for segments of rigid pipes or flexible tubes, is connected behind the rocket.

The device that pulls the rigid underground tubes allows a firm fastening of the pipe made of steel, cast iron, PVC, PP (polypropylene) or PE (polyethylene) behind the rocket. The pipe fragment is tensioned by means of a cable or a chain. The specific rigid underground pipe pulling device [11] in Fig. 3.

Figure 3. **Coupling and pulling device for segments of rigid pipes**

2.3 Advanced technical solutions for irrigation and draining systems

Our proposal regarding the construction of the irrigation system involves an integrated set of combined techniques: mechanical, pneumatic, hydro-technical and electronic techniques, which allow the installation of underground irrigating and/or draining systems, without an open ditch, water distribution for irrigations, or collection of exceeding water for drainage, in a completely automatic manner,

maintaining the optimal pre-established degree of humidity in the soil, regardless of the weather-climate, regional-temporal conditions, including the permanent control of soil temperature at the desired depth.

The *mechanical and pneumatic part* includes the FORI 80 rocket, the complete accessory kit and the energetic source (motor-compressor), involved in the generation of the micro-tunnel, at the desired depth, inside of which the irrigation water pipe or the drainage perforated tube is introduced, according to the modern, ecologic and extremely efficient technology, without an open ditch.

The *hydro-technical part* includes, as an element of technical novelty, the water distribution system for irrigations, which combines the advantages of the radial disposal of underground pipes towards terminals (underground hydrant type Dn 2"), with ramification of flexible perforated and calibrated tubes for the free drainage of water in drips. The tubes are placed at the surface, and they are perfectly adapted to water plants directly at the root, with ramifications in "n" desired directions. The tubes may be collected and rolled in bunches for re-positioning at various time intervals.

The *electronic part* includes a complete set of sensors with digital display, used to detect, control and correct the humidity/temperature of the soil, or the water pressure inside the pipes, in a totally automatic manner. Here are the main sensors that may be included in the set:

– digital display hygrometer, transmitting humidity information towards the PC terminal, Fig. 4[9].

– digital thermometer with thermocouple NiCr-Ni (type K)-EBRO, which transmits, towards the PC terminal, the indicated temperatures, at pre-established time intervals: at the beginning, after 30 min, after 1 hour, with automatic indication of the stabilized value, Fig. 5[9].

Figure 4. **Hygrometer TFH100**

Figure 5**. Digital thermometer with EBRO micro-processor**

– chronometer, which transmits the signal towards the PC terminal, automatically indicating the pre-established time for the measurement/display of soil humidity, of the irrigation water volume, or of the soil temperature, at the desired depth;

– flow indicator, type TURCK FCI-D10A4P-LIX-H1141/A, linear, exit 4-20 mA, which transmits, towards the PC terminal, the values of the water flow delivered in the irrigation system or entrapped for the entrapping (draining) network;

– manometer (pressure sensor), type TURCK PT016R-14-L02-H1131, maximum pressure 10 bar, exit 0-10V, transmitting, to the PC terminal, the pressure values measured in the irrigated or drained water circuit.

The *computerized part* includes several basic components: PC unit with interactive software to monitor the technical parameters that may be programmed, visualized on digital display or printed, PC/sensor interface modules, integrated within the computerized system, which is compatible and used, and the data acquisition device, which modulates the sensor electric signal in PC video signal.

The basic components of the computerized system are presented [9] in Fig. 6.

a. Data acquisition device

b. PC/sensor interface modules

c. Irrigation Controller

Figure 6. **Constructive solution for the computerized part**

Pro-Aqua optimal irrigation controller [9] is an electronic system with micro-processor, a high level of stability, and a long-term utilization, including advanced algorithms of automatic regulation, which have been designed for an intelligent management of water resources.

Advantages

– This technology for the introduction of underground pipes without ditch, by means of the proposed pneumatic rocket, offers a set of advantages that are clearly superior to classic technologies, with an open ditch, currently applied in Romania, due to the elimination of several expensive operations, such as: digging,

bank reinforcement, filling after the pipe installation, compacting, transportation of soil surplus, ground water pumping-out.

– The new technology is ecological, efficient, and it does not disturb the normal development of surface activities, on the area that the pipes cross over;

– It secures the observance of the most astringent European and international norms of environment protection and maintenance of nature's ecological equilibriums.

So far, there is no other alternative to obtain the presented advantages without the creation and manufacture of the pneumatic rockets in our country, if their necessity is understood, or they will be imported [10,11], as, beginning with 2007, the restrictive ecological norms of the European Union shall be applied in Romania, too.

CONCLUSIONS

The components of the current irrigation or draining installations are not enough and they cannot be included in an integrated real-time monitoring system for operational intervals. Each of them is a potential source of measuring errors because of the repeated changes of used instruments.

The "key" element that makes the structural difference between the classical technology of irrigation or draining installations, known in the specialized literature [7], and the proposed new technology is the introduction of underground pipes, without open ditches, and the integration of the complex sensor system within the used compatible computerized system.

The constructive simplicity of direct introduction in the ground of water distribution or collection pipes, as well as its efficient dispersion in drips directly at the root of the plants, including the complex set of sensors integrated in the proposed computerized system, is an genuine element within the current technical environment applied in Romania, as it may be used to fight draught (by irrigations), or to eliminate excessive soil humidity (by drainage).

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