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Designing the ACS of Cutter Winding Section

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***Abstract*—Functional diagram of automatic control of rolled material winding with realization of target winding modes on various tension phases according to production needs is constructed. Based on the ATmega328P microcontroller, the automatic control system (ACS) was designed that provided reliable and trouble-free work of winding section of roll material on SummaCut D120R wide-format cutting machine for acceleration of production line in operational printing.**

Keywords—automatic control system, technological process, large-format cutting machine, winding mechanism.

I. Introduction

The rapid development of printing market has contributed to formation of large number different types of advertising products, and this in turn led to emergence of new printing-oriented technologies, which aimed to accelerate the execution of individual orders of varying complexity. In addition to wide-format printers, auxiliary equipment is also actively used in operational printing institutions, in particular for post-printing processing of printing orders. Among such machines, cutting plotters stand out favorably as devices for clipping any stencils or images from different materials, under which cutter knife is adapted: billboards, shop windows decor, signs, as well as pattern from heat-transfer film on various surfaces from clothes to consumer goods [1].

It should be noted that most productive work the operational printing institution is possible only with a carefully selected of equipment skeleton, taking into account all factors, including its maintenance. However, branded solutions use in machines fleet is not always possible in conditions of small printing, because not all devices are able to work with maximum efficiency on a flexible technological routing order map. This state of affairs, in turn, pushes such institutions to find and implement their own solutions for optimizing key components of machines fleet [2].

Due to the increased requirements for the timing of production and quality of advertising manufactures by the customer and the specifics of small business in limiting financial costs there is a need to improve the efficiency of existing production resources. This, in turn, encourages institutions to improve the components of printing equipment or to develop original new ones that can significantly improve the devices performance. Which will obviously allow a small business to reduce the number of shortages and the cost of the finished product and increase safety at work [3]. Therefore, the need to design new and optimize existing automated control systems integrated into production lines is seasonable and relevant.

II. Determining the Optimization Directions of Cutting Plotter

Wide-format plotter cutting is the basis for creating a variety of polygraphically orders [4]. It is due to the introduction of wide-format cutting in the list of services of the institution that a number of bold atypical ideas become realistic, which distinguishes an extraordinary goods between the current standards and the use of ordinary products. Cutter hew out provides a virtually limitless range of options that make advertising more multifaceted and unique.

Plotter hew out in the printing industry involves a whole complex of tasks to create a finished product using special wide-format cutters. The process of plotter hew out (actually, cutting) is to cut the raw material along the contour so that the blade cut nick the vinyl layer of the film only, while the base of the product remained intact. Making a printing order on a plotter consists of a number of stages. First of all, the machine operator lays the necessary material, orienting relative to the guide line on the desktop to maintain maximum symmetry.

This is done to reduce the likelihood of mowing the material during cutting. Next, selected the desired layout in a graphics editor suitable for integration into service software built into equipment by the manufacturer company. Finally, using the functionality of the cutting device, the operator uses the test to determine the depth of slit at which the plotter will cut the film and the adhesive layer, and will not damage the base (substrate).

Despite the versatility and other significant advantages of SummaCut D120R wide-format cutting plotter researched in project, during the execution of the printing order against background of design features at high loads revealed a number of significant shortcomings that directly damage for main units and elements and do not allow to qualitatively organize the production process, and sometimes cause failure of key components. In turn, this leads to an increase in production time, obtaining a higher percentage of substandard goods - and as a result of excessive costs due to unprofitability.

Given the pricing policy of spare parts manufacturers and attendant details, it will not be advisable for a start-up company to replace spare item often enough, as this will lead to unprofitable use of equipment. The solution to such problems and ways to correct the identified shortcomings in the operation of printing equipment is exactly targeted optimization or construction of original key components in accordance with the principles of economic activity of small businesses with a limited number of jobs [5].

III. Expansion of Winding Modes for Rolled Material

Almost everything that produces a wide-format cutting plotter is wound with the representation on the outside, because it does not allow the carved order to peel off from the base [1]. This prevents the deformation of the self-adhesive goods and the ingress of dust particles into its mucilage layer, to wit avoids the creation of defective products. However, study of technological processes at cutting stage revealed a number of exceptions, which include in particular the thermal transfer film. Due to its structure, such a film is able to stretch in the winding process the representation outwards, which is why there is a need to wind the dissected side into a roll. The novel introduced reverse mode will also allow to quickly unwinding the material from tube [5] without having to remove it from winding mechanism and ensure the adjustment of system by matching the winding parameters with the dissecting speed of the wide-format cutting plotter for ensuring the stability of the deployed production line.

The calculation of the rated power of the DC motor (DCM) of the winding section [4] is carried out relative to the specified mass of the filled tube m=25 kg:

$$P=M\times V/\mu_m=218\ W, \qquad (1)$$

where the nominal weight of the cargo
$M=m\times g=25\times 9{,}81=245{,}24\ N$;
energy conversion efficiency of winding mechanism μ_m=0,9;
cargo rotation speed V=0,8 rps.

According to the obtained characteristics, DCM MY1016 with power P=250W, voltage U=24V and rated current I_n=13,7A was selected. To further simplify the scheme and increase the energy conversion efficiency of finished mechanism, it was decided to use the pulse-width modulation (PWM) method to control the DCM [7]: by changing the filling factor of the PWM regulates the average voltage on motor, namely speed. To set the speed used potentiometer.

Since the direction of rotation DC-motor shaft depends on the polarity, to regulate it, it was decided to use an advanced electronic circuit "H-Bridge" with a conjunctive control unit (Fig. 1: A, B, C, D), which makes it impossible to close two keys in one branch and prevents short circuits.

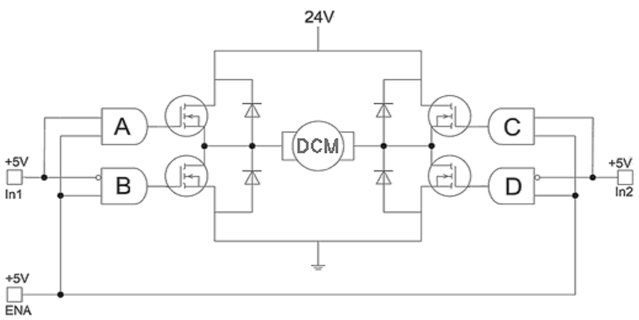

Fig. 1. Functional diagram of material winding modes control

In this way, the presented engineering solution allowed to achieve full control of the DCM: the direction of rotation will be responsible for advanced H-Bridge, and speed regulation will be carried out through the receipt of PWM signals from the controller-regulator [6]. To create a more compact design of the winding section, it was decided to use DC 3-36V 15A motor driver, which supports a combination of previously introduced control methods.

IV. Implementation of Analytical Apparatus the Winding Section

A number of additional components have been used to ensure performance of designed control system for direction and rotation speed of DC motor based on Arduino computing platform [7]. Thus, in addition to DCM with a nominal voltage of 24 V and Arduino UNO control module, DC 3-36V 15 A driver and 100 kΩ potentiometer, two DC sources with voltages of 5 V and 24 V were used as power.

The potentiometer is powered directly from the control board and, depending on its value, thanks to the analog connector A0, the Arduino module is able to receive an analog signal (Fig. 2). By converting such a signal into digital, the control board with the help of developed software flexibly implements DCM rotation speed control using PWM signal. The main control commands are directed from connectors 10 and 11 (on Arduino) to PWM 2 and DIR 2 pins (in DC 3-36V 15A motor driver).

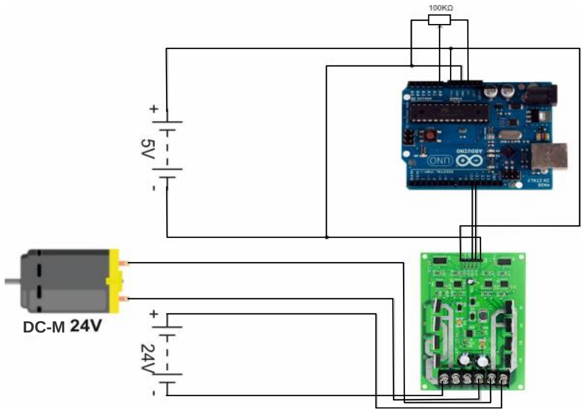

Fig. 2. Assembly diagram of analytical apparatus the winding section

Conclusion

Thus, implemented software in combination with builded analytical apparatus provides reliable and trouble-free operation of designed rolled material winding section by different sides in accordance with the production needs of small enterprises and with introduction of extended speed control modes to accelerate of production line in operational printing.

References

[1] Lutskiv M. Digital printing technologies: monograph. Lviv, Ukrainian Academy of Printing, 2012. 488 p. [in Ukrainian].

[2] Durnyak B., Strepko I., Titov G. Devices and systems of digital printing: monograph. Lviv: Phoenix, 2002. 106 p. [in Ukrainian].

[3] Neroda T. Designing of multilevel system the distributed resources administration in polygraphically oriented network infrastructure. Computer technologies of printing. 2019, Vol. 42. P. 64-72.

[4] Voiedilo V. Determination of optimal production capacities for post-printing processing of printing order. Modern youth in the world of information technology, 2022, Vol. III. P. 36-39. [in Ukrainian].

[5] Voiedilo V. Method of modernization of a roll cutting plotter. Young Printing, 2021, Vol. 21. P. 63-64. [in Ukrainian].

[6] Nikolaenko A., Minaylo N. Microprocessor and software automation: textbook manual. Zaporizhzhia, ZSEA, 2011. 444 p. [in Ukrainian].

[7] OneWire Arduino Library [Online resource] – Access mode: www.pjrc.com/teensy/td_libs_OneWire.html .