TECHNIKA TRANSPORTU SZYNOWEGO

Tomasz SAMBORSKI, Stanisław KOZIOŁ, Andrzej ZBROWSKI

RECONFIGURABLE SYSTEM FOR FEEDING THE PAPER SHEETS IN THE TECHNOLOGICAL PROCESSES

Abstract

The article presents the structure of the mechatronic sheet feeder for printing applications. The design of the feeder and the structure of individual elements are discussed with particular attention paid to the specificity of their applications. The line and rotational actuators, clamping units and components of vacuum techniques (generator and suckers) as well as aeration nozzles are the executive elements of the system. The functional modules of the feeder can be configured independent of the level of advancement of the computer software used in order to meet individual requirements of the application. The feeder, which is a universal self-feeder, is characterized by a modular structure enabling the work parameters concerning the size and weight of the sheets fed, to be easily shaped. Practical application of the feeder in printing allows for a precise assembly of components from which the multilayer product obtained by means of gluing techniques is produced in a prototype technological line.

INTRODUCTION

A crucial element of every technological line used in printing industry that influences the accuracy, rhythm and efficiency of work is constituted by sheet feeders that supply individual operating slots. Sheet feeders are mainly applied in solutions intended for low cost production. Production of prototypes of multilayer goods that are electronically tagged with the use of RFID chips is a particular example of a small series production.

The Institute for Sustainable Technologies – National Research Institute is currently engaged in the realisation of research tasks directed at the improvement technologies for the production of multilayer documents, including those that are electronically tagged as well. Undertaken activity concerns the development of technology for the production of durable products that are forgery-proof as well as the construction of devices (technological lines) for their manufacture [3, 6] and testing [2].

The solution presented in this article, that is a precise printing sheet feeder, is supposed to be applied in small systems for the assembly of multilayer documents. In the case of low cost production lines for document prototypes manufacture the importance of the sheet feeder is significant, especially when the documents of small sizes. The feeder needs to enable the supply of sheets of different format varying from ID1 to A4 format, made of material of different properties (paper, film), weight and thickness (from 0.005 to 0.5 mm). One of the factors that decides on the final effect constituted by the multilayer document produced with the use of a gluing method, is the precise assembly of all its components. It is thus

crucial to design a feeder that would be characterised by a flexible structure of both mechatronic solutions as well as the control system applied.

1. IDEA OF THE FEEDER

The technology for the production of multilayer documents developed at the ITeE-PIB assumes that the fed in components are of the following character: roll of paper or film printed on the one side, one or two additional layers supplied in sheets. The idea for the construction of the sheet feeder for the technological line (Fig. 1) was based on the following functional parameters:

- The sheet fed in has the dimensions from 50x80 mm to 210x300,
- The tray holds 1000 sheets of offset paper,
- Work cycle is ca. 10 items/min
- Sheet alignment accuracy is ±0.1 mm.

The solution developed, due to the functions realised, belongs to the group of universal self-feeders [4, 5] applied in printing machines. What constitutes a significant difference between this solution and others available on the market is the fact that independently controlled mechatronic modules have been applied in order to realize the following tasks:

- Vertical transport of the pile of sheets,
- Collection of sheets from the pile,
- Horizontal transport of the sheet,
- Alignment of the sheet,
- Transfer of the sheet.

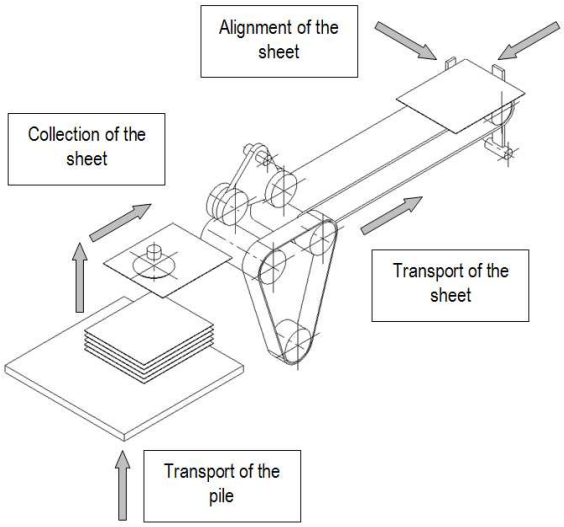

Fig. 1. Feeder functional draft.

Source: Author's elaboration

The system for the control of the executive module (servo, pneumatic systems, vacuum conveyor) in the function of signals coming from the sensors that confirm the tasks have been completed (inductive transducers, reed converters and optical transducers) is realised with t he use of a local controller that constitutes one of the integrated elements of the valve unit controlling the work of the pneumatic executive elements.

2. STRUCTURE OF THE FEEDER

When building the feeder, the optimum design of each of the modules as far as their work parameters are concerned, was of priority [4].

The design stage concerned all the aspects connected with the operation of the feeder starting from the kinematic analysis of the systems, through MES calculation and ending with the final design of the device.

The pneumatic systems realizing individual tasks of collection, precise alignment and transfer are the executive elements of the functional modules.

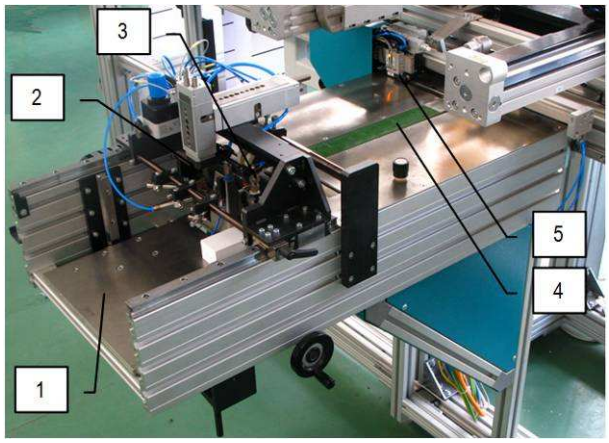

Fig. 2. Photo of the feeder: 1 – module for the vertical feed of the pile of sheets, 2 – sheet collection module, 3 feed rolls, 4 – belt conveyor, 5 – sheet alignment module

Source: Author's collection

The designer pneumatic system (Fig. 3) is composed of the valve unit and the executive elements it supplies by FESTO. The configurable valve unit is composed of impulse controlled valves (eight 5/2 and six 3/2), a PLC controller, communication module and digital input module that connects the signals from the sensors confirm the realization of individual task.

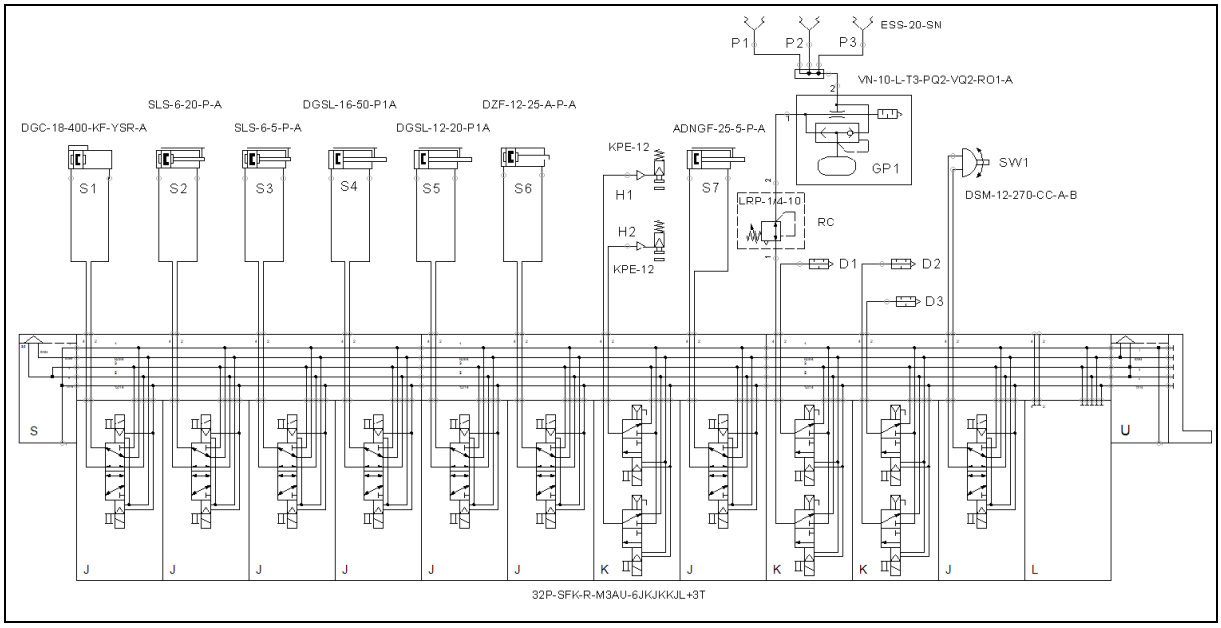

Fig. 3. Draft of the pneumatic system of the feeder

Source: Author's elaboration

The executive elements of the system are rotational line actuators, clamping units, vacuum components (generator, suckers) and aerating nozzles.

The sheets of paper that are to be further processed are placed on the plate of the vertical pile feed module (Fig. 4). The position of the pile on the plate is initially set from the feed direction with the use of resistance bar and guiding bars regulated manually to the size of the sheet fed. The lift system composed of the S7 actuator cooperating with two alternately operating pneumatically controlled brakes H1 and H2 lifts the pile of sheets to the position identified by the optical sensor. Once all the sheets are collected or the maximum top position is achieved, the plate is lowered so that another batch of sheets can be transported.

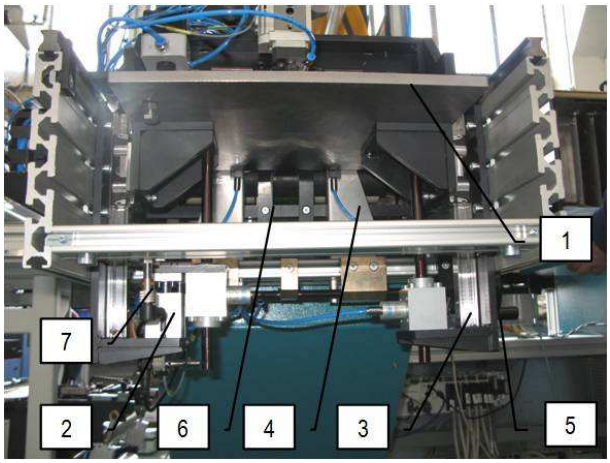

Fig. 4. Photo of the vertical pile feed module: 1 – plate, 2 – pneumatic lift unit, 3 – ball rail systems, 4 – side guiding bar, 5 – side bar alignment regulation screw, 6 – resistance bar, 7 – plate location sensor

Source: Author's collection

In the feeder of this type of structures (fig. 5), individual sheets are collected from the pile and transferred onto the belt. The collection is realised by the module equipped with vacuum suckers P1, P2 and P3 that are supplied by the pneumatic pressure generator GP1. The application of the precise pressure regulator RC allows for the optimum sucking force to be selected for the sheet transported.

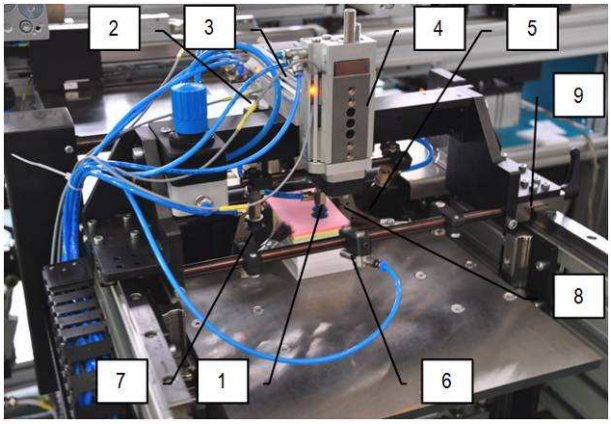

Fig. 5. Photo of the sheet collection module: 1 – suckers, 2 – vacuum generator, 3 – horizontal actuator; 4 – vertical actuator, 5 – hold-down brushes, 6 – back separator, 7 – side separator, 8 – optical sensor, 9 – guiding side bars

Source: Author's collection

The complex supply movement is composed of the vertical movement of the S5 actuator with P1, P2 and P3 suckers that lift the sheet, as well as the horizontal movement of the S4

actuator with the lift unit. The position of the module with relation to the pile and the movement of actuators realizing the horizontal and vertical shifts are set depending on the format of the sheets fed. The horizontal movement is preceded by the front resistance bar being tilted with the use of the S6 actuator, which enables unobstructed conveying of the sheet of paper in the direction of feed rollers. The module is to collect one sheet of paper at a time. This can be achieved by the application of back (D1) and side (D2 and D3) separators with aeration nozzles that separate the sheets with the use of compressed air. Hold-down brushes prevent the collection of any other additional sheets of paper.

A single sheet is then placed between rotating drive rollers and feed rollers connected with pneumatic rotary drive SW1 (Fig. 6). The oscillatory motion of the actuator, preceded by the switching off the vacuum generator GP1, results in front and back rollers being pressed against the conveyed sheet of paper making it move towards the feed belt. The position of the feed rollers perpendicularly to the axis of the feeder is set depending on the width of the sheet fed. When the paper and the perforated film meet, the paper is sucked onto the film and then they together are conveyed towards the alignment module. Depending on the format and the weight of the sheets fed, the optimum vacuum in the sucking collector and the speed of the belt are set.

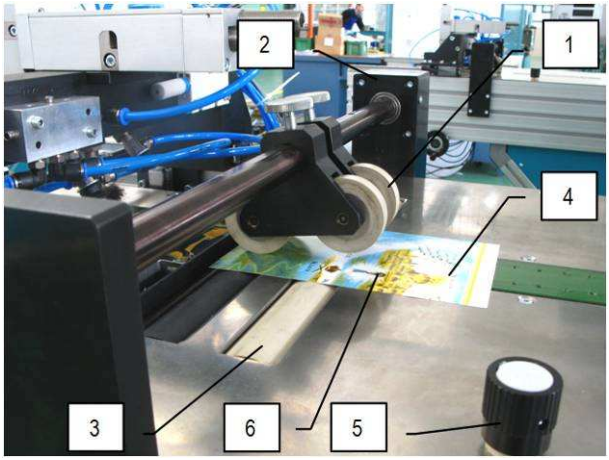

Fig. 6. Photo of the horizontal module for sheet conveying: 1 – feed rollers, 2 – pneumatic rotary drive, 3 – driver rollers, 4 – feed belt, 5 – vacuum regulation system, 6 – transported sheet

Source: Author's collection

In order for the products with assumed geometry to be achieved, the components fed need to be precisely aligned on the belt. In the solution developed (fig. 7) the sheet transported on the conveyor belt is placed against the fenders located perpendicularly to the axis of the feeder – front marks. Correct placement of the sheet of paper is identified by the optical sensor and the transverse alignment procedure is signaled. The steel roller that is lowered by the S3 actuator presses the sheet against the rack placed along front marks. The rack is powered by the pneumatic actuator S2 and makes a reciprocating motion with which the sweet is conveyed in the direction of a side marks. Proper alignment of the sheet is also signaled by the optical sensor. The location of the side mark, depending on the format of the sheet, is set with the use the adjustable fender of the rodless drive S1, onto which the mark is mounted together with the S3 actuator with the hold-down roller.

The alignment system used, allows for the application of the feeder in technological lines that require different ways of the supply of the components that are to be processed. The controller horizontal movement of side marks enables for instance the application of the manipulator with the sucking plate for the transportation of the paper sheet in vertical plane to the next technological unit. The application of tilting side marks allows for the sheet to be

conveyed with the use of, e.g. receiving rollers.

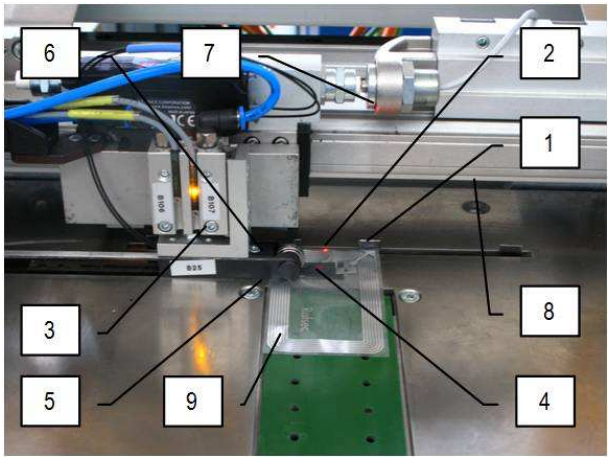

Fig. 7. Photo of the sheet alignment system: 1 – front marks, 2 – optical sensor for the detection of the front of the sheet, 3 - actuator with a hold-down roller, 4 – actuator with a rack, 5 – side mark, 6 – sensor for the detection of the side of the sheet, 7 – regulation screw for the positioning of the side mark, 8 – drive of the side mark, 9 – base sheet

Source: Author's collection

When designing the control system of the feeder the structure of the autonomic device was assumed for the realization of cyclical functions. In auto drive the accuracy of tasks realised is controlled with the use of a local PLC controller of the valve unit (Fig. 8).

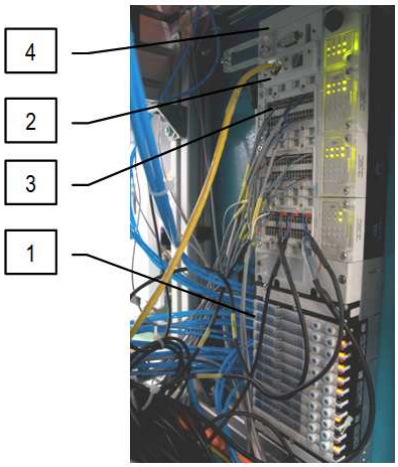

Fig. 8. Photo of the valve unit: 1 – valves, 2 – communication module, 3 – input modules, 4 – PLC controller

Source: Author's collection

Communication with the superior controller responsible for the control over the en tire technological line is realised via Ethernet network with Modbus TCP/IP line. Developed software solutions also allow for individual functions of the feeder to be realized manually under the supervision of the external PLC controller. In such a case, the Ethernet communication line is used for the switching of the valves and to check the condition of individual subsystems connected to the inputs of the valve unit.

CONCLUSIONS

Presented solution of the mechatronic printing sweets feeder is a Universal self-feeder. The application of pneumatic systems enabled the reconfigurable structure characterised by a precise accuracy of alignment of the elements conveyed to be obtained. The control systems using the valve unit with the integrated PLC controller enables the feeder to function as an automatic device that communicates digitally with the external system. The flexibility of the structure of the feeder ensures a wide range of the changeability of work parameters such as speed, shift, press force, size, weight. The functional modules of the device can be configured, independent of the level of the specialized software used, to individual requirements of the application. In the application presented, the feeder allows precise collection, transportation, alignment and arrangement of the sheets constituting structural elements of the three ply glued final product in the form of a ticket or a card with the RFID chip.

REKONFIGUROWALNY SYSTEM PODAWANIA ARKUSZY W PROCESACH TECHNOLOGICZNYCH

Streszczenie

W artykule przedstawiono budowę mechatronicznego podajnika arkuszy szczególnie do aplikacji poligraficznych. Omówiono koncepcję podajnika oraz przedstawiono budowę poszczególnych podzespołów funkcjonalnych z uwzględnieniem specyfiki ich zastosowania. Elementami wykonawczymi są siłowniki liniowe i obrotowe, jednostki zaciskowe, komponenty techniki podciśnieniowej (generator, przyssawki) oraz dysze napowietrzające. Podajnik należący do grupy samonakładaków uniwersalnych charakteryzuje się modułową konstrukcją pozwalającą na kształtowanie w szerokim zakresie parametrów pracy związanych z rozmiarem i gramaturą podawanych arkuszy oraz prędkością podawania. Praktyczne wykorzystanie podajnika do aplikacji poligraficznych umożliwia precyzyjny montażu komponentów składających się na wielowarstwowy, łączony w technologii klejenia, wyrób wytwarzany na prototypowej linii produkcyjnej.

REFERENCES

1. Ciupalski St. (2001), Maszyny drukujące konwencjonalne. Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa.
2. Kozioł S., Zbrowski A., Samborski T., Wiejak J. (2010), Koncepcja systemu testowania połączeń montażowych w dokumentach z zabezpieczeniem elektronicznym, Technologia i Automatyzacja Montażu nr 4, pp. 6 – 9.
3. Samborski T., Zbrowski A., Kozioł S. (2010), Model modułowego systemu implementacji inletów RFID, Technologia i Automatyzacja Montażu nr 4, pp. 30 – 35.
4. Samborski T, Zbrowski A., Kozioł S. (2011), Model mechatronicznego podajnika arkuszy do aplikacji poligraficznych. Technologia i Automatyzacja Montażu nr 2, pp. 31 – 34.
5. Stępniewski K. (1993), Teoria i budowa maszyn drukujących. Wydawnictwa Politechniki Warszawskiej, Warszawa.
6. Zbrowski A., Samborski T., Kozioł S. (2010), Modułowy system wytwarzania prototypowych identyfikatorów z zabezpieczeniem elektronicznym, 3rd International Conference MANUFACTURING 2010. Contemporary problems of manufacturing and production management, Proceedings abstracts, pp. 207-208, Poznań.

Autorzy:
dr inż. Tomasz SAMBORSKI - Instytut Technologii Eksploatacji - PIB w Radomiu,
dr inż. Stanisław KOZIOŁ - Instytut Technologii Eksploatacji - PIB w Radomiu,
dr inż. Andrzej ZBROWSKI - Instytut Technologii Eksploatacji - PIB w Radomiu,