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Intermittent Strip Stock Advancing Accuracy Analysis of a Prototype Pneumatic Cylinder Driven Roll Feeder

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공압실린더를 활용한 롤 피더의 간헐적 스트립 스톡 진행 정밀도 분석

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Abstract

This research introduces a new and improved design for a pneumatic cylinder driven roll feeder wherein each of the principal rotating feeder parts is configured so as to have feeding accuracy and to be low manufacturing cost. The feed pitch accuracy of the proposed roll feeder was evaluated by measuring lengths of cut offs of the strip stock with a shear attached to an air press. The air press was designed, manufactured, and mounted on the same table of the proposed roll feeder such that the strip stock maintained horizontal plane until the strip stock entered into the shear. The proposed roll feeder and the air press were designed to be operated automatically by a PLC employed controller. The feed pitch accuracy of the proposed roll feeder was analyzed by setting the pitch as 10, 12.5, and 15mm. At each predetermined feed pitch, the proposed roll feeder was tested 300 times as one test set and replicated three times. The average lengths of the cut offs of the strip stock ranged from 9.98 to 10.13mm, from 12.42 to 12.57mm, and from 14.96 to 15.06mm at the predetermined 10, 12.5, and 15mm feed pitch, respectively, among the total of 900 samples of each feed pitch. Main cause of variation of the length of the cut off of the strip stock fed by the proposed roll feeder was considered to be fluctuation of the air press during recompressing period of the air compressor to pressurize the air in the air tank. The largest difference between the maximum and the minimum length of the cut off was appeared while the air compressor recompressing the air. The air compressor used for this study restricted the air delivered to the proposed roll feeder while it was still running. Thus, this air delivery restriction problem should be improved by stabilizing the air press while the proposed roll feeder is running.

Key Words : Roll feeder(롤 피더), Strip stock(스트립 스톡), Air press(공압 프레스), Pneumatic cylinder(공압 실린더), Intermittent feeding(간헐적 공급)

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1. Introduction

The air feeders are widely used in the pressworking industry. The air feeders in the market are advance the strip stock precisely but these air feeders require two or three times bigger pitch size than that of actual size because of its double-act feed operation, and the double-act operation causes its size expansion.

The roll feeders are widely employed in the pressworking industry because the roll feeders having great versatility and are not limited by width or thickness of the stock[1].

The angle index cam, which is a mechanism for transforming the continuous motion associated with crank shaft which drives the press slide into an intermittent motion for driving the main feed roll, has a smooth motion from the stopped condition to the rotating condition and back to the stopped condition.

The shape of the cam provides a high dependability of the precision of the feeding operation by the roll feeder.

Since the angle through which the angle index cam rotates during one pitch is fixed, conventional methods for changing the lengths of the material to be fed by the roll feed device have been practiced such as exchanging the feed rolls of the roll feed device or changing variable speed gears provided between an output shaft of the angle index cam and a shaft on the main feed roll.

However, the conventional methods are inconvenient in that many lengths of material to be fed cannot be accommodated and also it requires an extensive time for changing and adjusting the feed device regard to a given different condition.

Meanwhile, the cam feeders have advantages on high speed feeding and easy of material fixing and processing. But the cam feeders also have inconvenience in changing gears when the feed pitch needs to be changed because these feeders operated by change of speed with the gear, also these are inconvenient to install onto the press.

To improve disadvantages of the conventional roll feed device mentioned above, Takahashi and Hachioji[2] introduced a roll feed device for feeding material to a press in which the output shaft of the angle index cam and the drive shaft of the main feed roll are connected by variable speed disks, so that it is capable of selecting the pitch of the feeding of the material freely. This roll feed device was simply needed exchanging variable speed disks to change the feed pitch of material.

The NC feeders are capable of accurate feeding and are very quick to set and to adjust pitch. Also they work at very high speed and have advanced programming features such as the memory and speed control. But the NC feeders are very expensive in initial purchase and requires specialist service if maintenance requires[3,4].

The roll feeders have barrier on high speed material feeding due to limited linkage rotation angle within 90 degree, also the roll feeders are not easy to install onto the press.

This research proposed a pneumatic cylinder driven roll feeder wherein each of feeder parts is configured so as to have simplicity of its structure and easiness of installation, and analyzed the its performance regard to the stock feed accuracy.

2. Materials and methods

2.1 Pneumatic Cylinder Driven Roll Feeder

The pneumatic cylinder driven roll feeder (190L x 140W x 180H) consisted of a pair of feed rolls, one is an upper idle roll and a lower drive roll, a lifting lever which allowing the strip stock installation between the two rolls, a circular friction plate and a tension unit, an one-way clutch bearing, an pneumatic cylinder and a stopper, and a four-way solenoid valve.

The size of the upper idle roll is slightly smaller in diameter than the lower drive roll. The diameter and the length of the lower drive roll is 50mm and 130mm, respectively.

The lift lever allows the installation of the strip stock between the two rolls. Two tension springs were installed at an upper plate in which the upper idle roll was installed. The two tension springs, inserted both side-ends of main body, maintain the pressure of the upper idle roll, thus the feeding material is pressed and maintains its

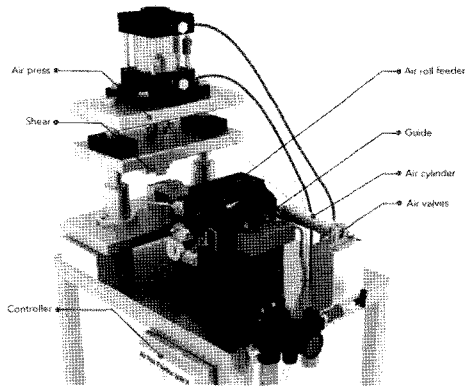

Fig. 1 Prospective view of the pneumatic cylinder driven roll feeder testing system

position between the two rolls by friction.

The circular friction pads, which was located at one-end of the lower drive roll shaft, were installed to prevent the lower drive roll from the reverse rotation by maintaining friction at each feed cycle of the strip stock. Also, a spring is installed to adjust the friction pressure of the friction pads.

The one-way clutch bearing was inserted at one end of the lower drive roll shaft to protect the reverse rotation of the lower drive roll. The lower drive roll shaft was connected to the pneumatic cylinder actuator by means of an aluminum block wherein the one-way clutch bearing was inserted. Thus, the strip stock can be intermittently advanced in one direction between cylinder strokes. The intermittent feed speed of the proposed roll feeder can be controlled by a timer of the custom designed controller described below.

The feed pitch of the strip stock can be adjusted by moving the position of the stopper, which is located at opposed end of the aluminum block in which the one-way clutch bearing inserted.

The air press (Left-top, figure 1), which was powered by pneumatic power, consisted of an air cylinder (KCC Co., Ltd, Model ACM N-B80-S25), a die set, and a shear. The shear was installed to the air press to cut a strip stock fed by the roll feeder.

The air press was operated as liaison with the roll feeder by the custom designed controller. Thus, the roll

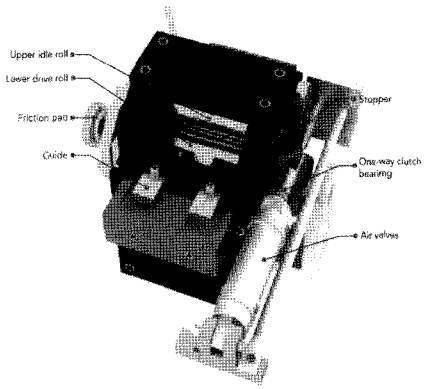

Fig. 2 Prospective view of the pneumatic cylinder driven roll feeder

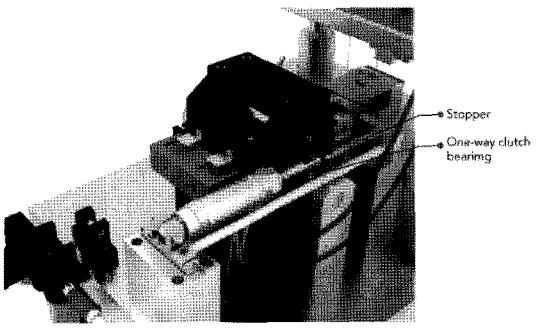

Fig. 3 Connecting feature of the pneumatic cylinder actuator to the lower drive roll and the stopper

feeder testing system was operated by itself after the strip stock was installed between the upper idle and the lower drive roll of the roll feeder.

2.2 Controller and Electric Circuit

The custom designed controller consisted of a programmable logic controller (PLC; Model K7-DR10S, LS Industrial Systems Co. Ltd), a counter (Model FX6Y-1, Autonics), two power relay controller (Model GPL2L, GSR), and a terminal lug. Figure 4 shows a schematic diagram of the controller and electrical wiring with the PLC to power and control the roll feeder testing system. The controller was designed and manufactured to operate the roll feeder either in auto-mode or manual-mode by

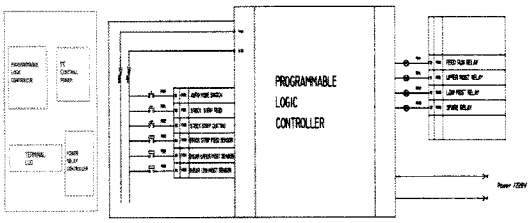

Fig. 4 Electrical components and connections with the PLC for the roll feeder operation control

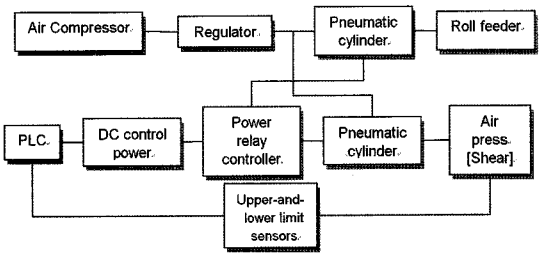

Fig. 5 Schematic diagram of the pneumatic cylinder driven roll feeder testing system

switching over an auto/manual switch.

When the strip stock was installed between the drive and the idle roll, the controller initiated the roll feeder by switching the power on. Then the roll feeder, which was rotated intermittently by the pneumatic cylinder, fed the strip stock as a predetermined feed pitch.

The feed pitch of the strip stock was determined by adjusting the stopper position. Then, the shear, which was installed onto the air press, was lowered and cut the strip stock, and reversed to return to its initial position. This procedure repeated until the power of the roll feeder turned off. Speeds of the stock feed and the vertical motion of the shear were as designed to be adjusted by the controller.

Two position sensors were installed at the pneumatic cylinder of the air press to locate the upper- and low-most position of the shear. The controller controlled the direction of motion of the shear attached to the pneumatic cylinder actuator by scanning of the signals from the two sensors.

During the test the operation mode of the roll feeder testing system described below was set as auto-mode thus the controller operated the roll feeder testing system automatically by activating the roll feeder and the air press to feed and cut the strip stock.

2.3 Roll Feeder Testing System

The accuracy of the strip stock feed pitch of the proposed roll feeder was tested by using the air press (380W × 160L × 425H) with the shear which was manufactured by this research. The air press was mounted at the same table where the roll feeder mounted such that the strip stock was allowed to maintain horizontal extension after it passed through the roll feeder and then it reached to the shear.

The roll feeder and the air press were operated as a sequential procedure associated with a combination of pneumatic system and the controller which was described as above.

2.4 Sample

The strip stock used for the test was made of brass. The thickness and the width of the strip stock was 0.2mm and 15mm, respectively.

2.5 Test Methods

Accuracy of intermittent advancing length of the strip stock by the proposed roll feeder was analyzed by measuring lengths of the strip stock cut off by the air press. The feed pitch was set as approximately 10.0, 12.5, and 15.0mm by adjusting the length of the pneumatic cylinder stroke and the position of the stopper.

The test was replicated three times in each selected feed pitch with the same condition, and the total number of the observations was 900 in each selected feed pitch. In each trial, the test was carried out by obtaining 30 observations as one-test cycle, and 10 test-cycles completed as a test trial. The length of the strip stock cut off was measured with a digimatic caliper (Model CD-20CX, Mitutoyo) of the resolution of 0.01mm.

An average length of the strip stock cut off in each trial was calculated, and it was used for the feed pitch accuracy analysis. As the proposed roll feeder testing system operated automatically, this experiment let the

proposed roll feeder run by itself in each trial, samples were then gathered and each strip stock cut off length was measured.

The strip stock feed speed was set as 19 SPM and the air pressure of the proposed roll feeder testing system was set as 5kg/cm^2 by adjusting the regulator of the air compressor.

3. Results and discussion

▪ Feed Pitch Accuracy

The average of the strip stock cut off length from the total of 300 samples ranged from 9.98 to 10.13mm, from 12.42 to 12.57mm, and from 14.96 to 15.06mm at each feed pitch of 10.0, 12.5, and 15.0mm, respectively. Meanwhile, the standard deviation of each feed pitch ranged from 0.107 to 0.120mm, from 0.091 to 0.017mm, and from 0.103 to 0.130mm, respectively. Table 2 shows the statistic status of the strip stock cut off using the proposed roll feeder.

Figure 6, 7, and 8 shows the max, min, and mean of the strip stock cut off lengths of one test-trial of 10 replications of the 30 measurements in each selected strip stock feed pitch of 10.0, 12.5, and 15.0mm, respectively.

The largest difference between the maximum and the minimum measurement of the cut off lengths was appeared when the air compressor started to recompress the air while the system was still running as shown as the 6th replication in figure 6, as the 8th replication in figure 7, and 2nd and 8th replications in figure 8.

The air compressor used for this study restricted the air delivered to the system while the proposed roll feeder was still running such as the continuously-operating unloading controls in the air compressor[5]. Thus, this air delivery restriction problem should be improved by stabilizing the air press while the proposed roll feeder still running.

Other means such as installing guide pins at the proposed roll feeder and punching holes at the strip stock edges are should be other methods to improve the feeding accuracy of the strip stock.

Table 1 Specifications of the proposed pneumatic cylinder driven roll feeder

Coil width (mm)	15
Coil thickness (mm)	0.2
Thickness × coil width (mm)	0.2 × 15
Feeding speed (SPM)	19
feed pitch	adjustable
Main power (air pressure; kg/cm^2)	5

Table 2 Statistic status of the cut off lengths of the strip stock by the proposed roll feeder in each feed pitch

Feeding pitch (mm)	Test No.	Total number of samples	Average of cut off length (mm)	Standard deviation (mm)
10.0	#1	300	10.03	0.120
	#2	300	9.98	0.107
	#3	300	10.13	0.116
12.5	#1	300	12.51	0.107
	#2	300	12.57	0.107
	#3	300	12.42	0.091
15.0	#1	300	15.03	0.130
	#2	300	14.96	0.124
	#3	300	5.06	0.103

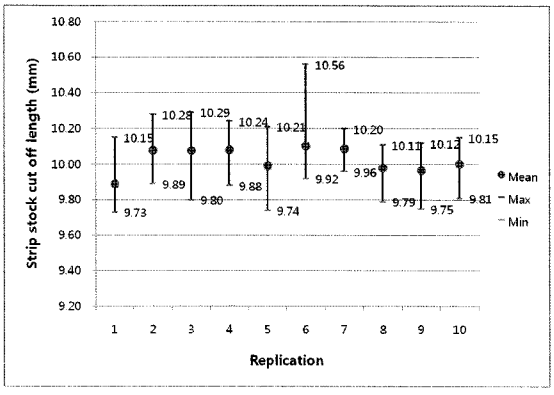

Fig. 6 The max, min, and mean of the cut off length of the strip stock with the feed pitch of 10.0mm

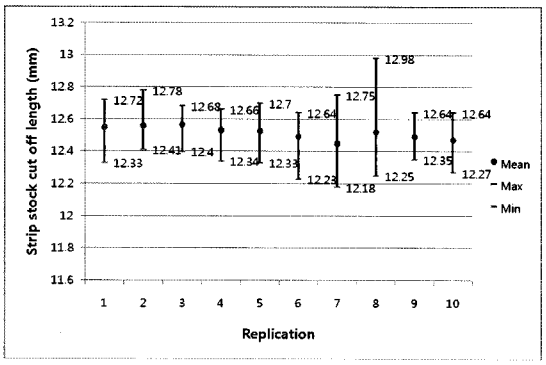

Fig. 7 The max, min, and mean of the cut off length of the strip stock with the feed pitch of 12.5mm

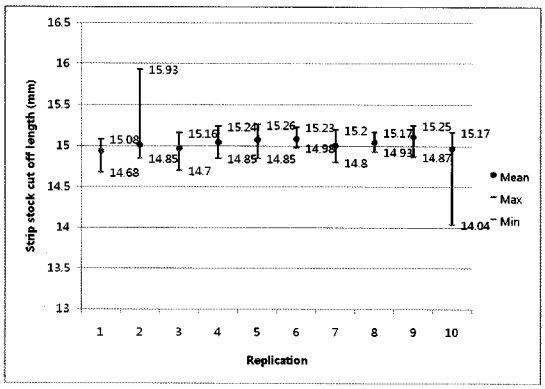

Fig. 8 The max, min, and mean of the cut off length of the strip stock with the feed pitch of 15.0mm

4. Conclusions

This research designed and manufactured a prototype pneumatic cylinder driven roll feeder and analyzed its feed pitch accuracy by using the shear installed at the air press by measuring the strip stock cut off length. The prototype pneumatic cylinder driven roll feeder and the air press were mounted at a table and aligned to maintain the strip stock as flat as possible. The roll feeder and the air press were designed to be controlled automatically by applying the PLC. The proposed roll feeder's feed pitch accuracy of the strip stock was analyzed using the shear installed at the air press. Following is summarized results obtained from this research.

(1) The prototype pneumatic cylinder driven roll feeder was capable of feeding the strip stock linearly.
(2) The designed and manufactured controller for the proposed roll feeder was capable of controlling the proposed roll feeder and the air press accurately.
(3) In the selected strip stock feed pitch of 10mm, 12.5mm, and 15mm, the average feed pitch ranged from 9.98 to 10.13mm, from 12.42 to 12.57mm, and from 14.96 to 15.06mm, respectively, from the total of 900 samples.
(4) This research found out that the feed pitch accuracy was greatly affected by the fluctuation of the air press in the air tank while the air compressor recompressing the air.

Postscript

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References

(1) Smith & Associates, 2005, viewed 20 January 2010, "Press coil stock feeding devices," <www.smithassoc.com>.
(2) Takahashi, Y. and Hachioji, 1981, *Roll feed device for feeding material to a press*, US Patent: 4294170.
(3) Metal Form Group, n.d., viewed 25 November 2008, "NC feeders," <http://www.metalform.com.au/metal_form_nc_feeders.php>.
(4) Scriber, A. W., 1992, *Pneumatically operated feeder for strip stock*, US Patent: 5125550.
(5) Ormer, H. V., 2006, viewed 8 January 2010, "Evaluate them carefully to determine their effect on energy cost," <http://www.plantservices.com/articles/2006/196.html>.