

The Influence of Feeding Accuracy of Gear Train on Printing Quality for Printers

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Abstract

The influence of feeding accuracy of gear train on printing quality, in particular the banding problem, for the ink-jet printer was explored in the paper. One method of band spectrum, as to mathematical method, was first presented to study the banding problem of print that was often encountered due to bad feeding accuracy of gear train of printers. Following the method, one physical model was then built up to solve a specific band problem, which was totally comprising of seven gears in the delivery train. Thus, some experiments for the feeding accuracy of the gear train were done for numerical analysis. At the mean time, there were two specified test patterns to be printed such that two individual groups of experiments were used to capture the cause of problem. As a result, it's found that one special gear, named cam gear, caused the problem mostly. The most of banding problem caused by the accuracy of gear train can disappear much after the cam gear was taken away in the train. This method could be expectedly a helpful tool to analyze the influence of feeding accuracy of gear train in many types of printers in the future.

Introduction

As many mechanical designers know, the gear train in printers that could be either thermal printers or inkjet printers, often resulted in some problems of feeding accuracy of medium. In fact, some types of feeding problems were explored much for the past years.[1,2,3] It's recalled that there are three major types related to the accuracy of feeding for print media, which is sometimes also called mis-registration. In general, they include the types of rotation, lateral direction, and feed direction. Meanwhile, in particular, the type of rotation is very often dealt with for thermal transfer printers since the influence of roller surface characteristic on the registration is significant.[4] However, the type of feed direction seems to appear much for the inkjet printers. And this type of mis-registraion could be mainly caused by the accuracy of gear train in feeding direction. Hence, it is important to understand how to search for any reason that causes the problem in the gear train of design.

Therefore, this paper has tried to solve the problem by a new method of band spectrum. By analyzing the specific spectrum of band line, some main causes could be identified in a numerical way. It will be hopeful to further improve the design of gear train.

Mathematical Method and Physical Model

It's well known for many that some situations seem to happen periodically in nature. Consequently, it's always believed for people that one or several reasons might result in them. Meanwhile, it's helpful to remind us that these physical situations can be well dealt with by a so-called periodic function. Herein, it's useful to define a periodic function f (x) as following equation (1).

$$f(x+p) = f(x) \tag{1}$$

Note that the period of the function f (x) is p. In physics, it will repeat the same thing for every period of p in order to hold the relation. Furthermore, it must be some reason to have it occur in such a periodic way. Specifically for inkjet printers, the print quality can be influenced a lot by the accuracy of feeding accuracy of gear train. One true physical model would be useful to study the influence as follows.

In reality, one gear train of inkjet printer was designed to deliver the print medium for printing. It was composed of seven gears in the train. All of seven gears differ from the periods of rotations. Moreover, it's defined in equation (2) that the period is equal to one of second print swath.

$$p \equiv period \equiv \text{times of print swath for } 1/2 \text{ complete rotation} \tag{2}$$

Since each gear has individual size, its period p is depending on the radius of connection with each one as the first gear of stepping motor starts running, transports the rotations almost simultaneously, and feed the print medium in and out. The periods of gear can be found in **Table 1**. And the complete corresponding physical model (configuration) is shown *Figure 1*. It's also noted that some of them might be inaccurate in the periodic rotation such that banding problem could be induced thereof.

Table 1. Periods of Gears

Gear #1 (Stepping Motor)	P=1
Gear #2	P=4.5
Gear #3	P=6
Gear #4 (Cam Gear)	P=7.5
Gear #5	P=11
Gear #6 (Pinch Gear)	P=16.5
Gear #7 (Feed Roller)	P=48

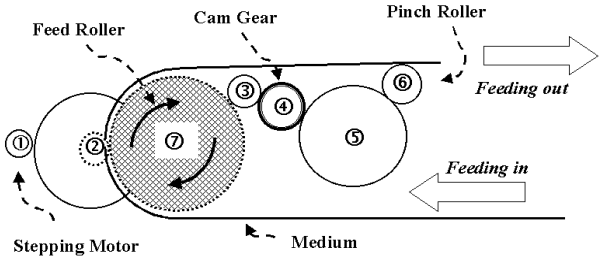

Figure 1. Physical Model of Gear Train

In addition, one method of band spectrum can be applied to work out the banding problem. First of all, one linear region of medium is defined as and called a band that the no ink dots can be found in the neighborhood even though they were supposed to be shot onto by the inkjet print head of printer. In other words, it looks like empty space (white line) in the band region (line) around the other the black/color regions. In reality, these band lines might occur periodically if they were caused by one specific gear of the gear train in the printer. Secondly, it's helpful to realize the band pattern by simply drawing the periodic banding lines in the swath direction. They exactly act like band spectrums in the sense. Thirdly, one test pattern with almost full page of color (black) should be printed to check if it could fit into any one of band spectrums. At last, the trouble gear could be identified if the fitting was found. Seven basic types of band spectrums are shown in *Figure 2.* However, it must be also noted that any combination of the seven basic types could be either found if more than two of gears make troubles and result in the inaccuracy of feeding lines. In the case, the band spectrum will be more complex and need further more careful analysis in the method.

Experimental Result and Discuss

It's reminded that one test pattern need to be printed on the medium in the method of band spectrum. In our all of experiments, this pattern with almost full black page of legal size was demonstrated in the pattern 1 of Figure 3. In addition, in order to verify the experimental results of test pattern 1, another test pattern with grids was offered as well, shown in the pattern of Figure 3. Note that each spacing of grid in pattern 2 was given to be exactly of one swath.

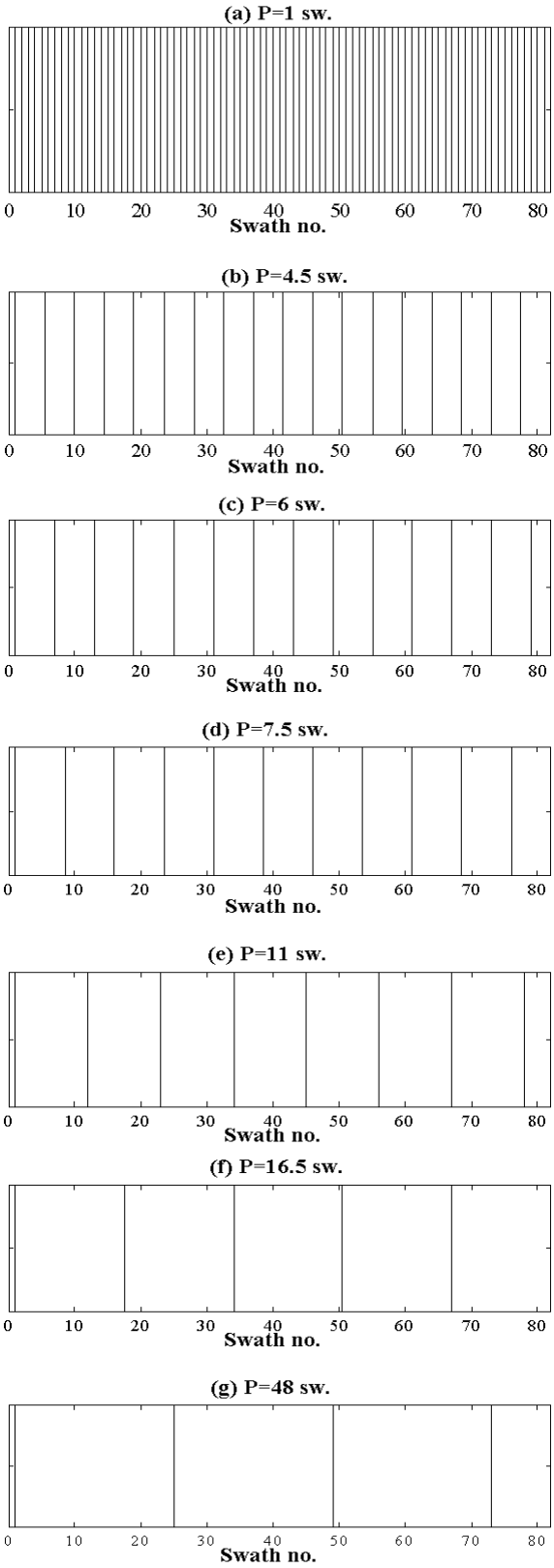

Figure 2. Seven Basic Types of Band Spectrums

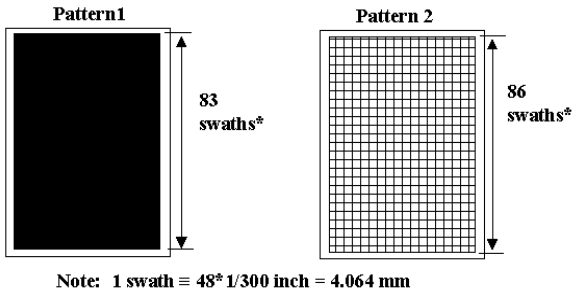

Figure 3. Two Test Patterns

In the three experiments, it's defined as one band line if the width of banding region is greater than 0.3mm that would be very obviously identified by the human eyes. The experimental results for test 1, 2, and 3 were shown in the following *Figure 4*. It's seen clearly that the band spectrum with the period of 22 was happening; i.e. the band lines at the positions of swath no. 21, 43, and 65 were found in the three tests. Actually, it's exactly double of the period of gear#4 (Cam gear) and yielded a good fitting.

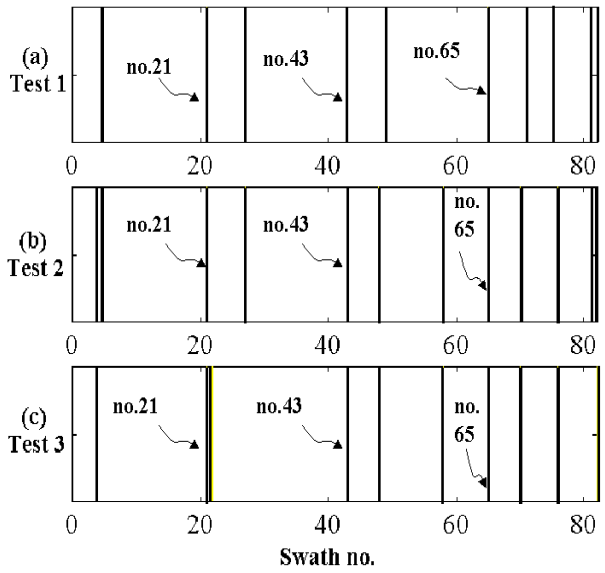

Figure 4. Three Experimental Results of Band Spectrum

In order to verify the results by the test patter 1, one independent experiment was done by the test pattern 2. In this experiment, the identified cam gear was equipped on and taken away to determine if there were any differences occurring in the error distribution of position. Note that the error of position can be detected and recorded by one appropriate encoder. The experimental results were shown in *Figure 5*. It's no surprise that some greater errors existed at swath 21,43, and 65 with the period of 22 swaths when the cam was equipped on. However, they disappeared after being taken away. So the previous results were clearly verified by the results.

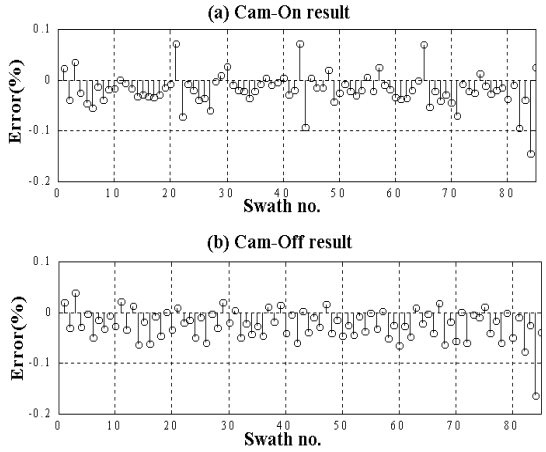

Figure 5. Two Experimental Results for Cam On/Off Status

Meanwhile, it's noted that the special configuration of cam gear in the study cases could be one reason to result in the banding because it was designed to always hold on and then release the gear train with certain abrupt discontinuity of force periodically. However, it was not studied here in the paper.

Conclusion

This paper studied the influence of feeding accuracy of gear train on the printing quality of printers. One mathematical and physical method, called band spectrum method, was presented to work out banding problems that were often encountered periodically in the print quality of printers. Some experiments were done to explore the issue in the method by one specific design of gear train that were composed of seven gears. The band spectrums of the gear train were truly found periodically; thus, the trouble gear with a period of 22 swaths, fitting period of the spectrum, was easily identified. All experimental results of the method were verified to be fine. And the method would be easy and helpful in the related of the issues.

References

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Biography

Chin-Tai Chen received his B.S. degree in Engineering Science from the National Chung-Kung University at Tainan of Taiwan in 1992 and an Engineer Degree in Aeronautics&Astronautics from Stanford University at Palo Alto of USA in December, 1997. Since 1998 he has worked at Optics-Electronics & System Labs of Industrial Technology Research Institute in Hsinchu, Taiwan R.O.C. His work has primarily focused on the ink supply system of thermal inkjet printer, including ink reservoir, ink transport, ink level detection and pressure control issue.