

Harmonic-Drive Ribbon Stuffer for Impact Printers

This paper describes a harmonic-motion ribbon-stuffing device for impact printers, which maintains a consistent placement pattern for large-capacity (120 yards) endless-loop fabric ribbons. The ribbon is uniformly placed into a cavity by eccentric drive rolls that ensure alternate ribbon switching due to the geometric relationship of drive rolls and strippers. The ribbon is positively placed in a manner much like a fixed-displacement drive, thus differing significantly from the principle used by existing ribbon packers, which achieve ribbon placement by balancing the difference in net driving force against the buckling resistance of the ribbon.

Introduction

Cassette ribbon cartridges that are used on impact printers have gained increased operator acceptance. They offer a convenient, clean, and simple method of loading ribbon into a compact and inexpensive package. Cassettes use various ribbon-handling techniques that can be broadly categorized as either ribbon-stuffing devices or ribbon-spooling devices. The ribbons used are either single-pass or multi-pass and may have one or more tracks. In stuffing or spooling ribbon, technical problems are encountered which can lower reliability. Reliability in ribbon-handling arrangements is a function of many variables, such as ribbon geometry, inking, ribbon stiffness, ribbon tension, mechanical alignment, frictional forces, and ribbon capacity. This paper describes a harmonic-drive ribbon-placement device that results in greatly improved reliability and increased ribbon capacity compared to presently used ribbon-stuffing devices.

Existing techniques

Most ribbon stuffing devices in use today can be divided into two broad categories: random ribbon-stuffing devices and uniform ribbon-stuffing devices.

Random stuffers (Fig. 1) pack ribbon into a storage cavity in an imprecise, random manner, resulting in a large number of ribbon folds that often become entangled and make the ribbon difficult to remove from the cavity. The ribbon is driven into the storage cavity by two rotating drive rolls, which are usually of molded plastic and have a

toothed profile. These drive rolls are spring-loaded and pinch the ribbon to provide the necessary driving force. The toothed profile enhances the driving capability and helps to carry the ribbon either to the left or right after it enters the storage cavity. Stripper fingers are used on both drive rolls to prevent the ribbon from tangling around the rolls. These stripper fingers are located within grooves

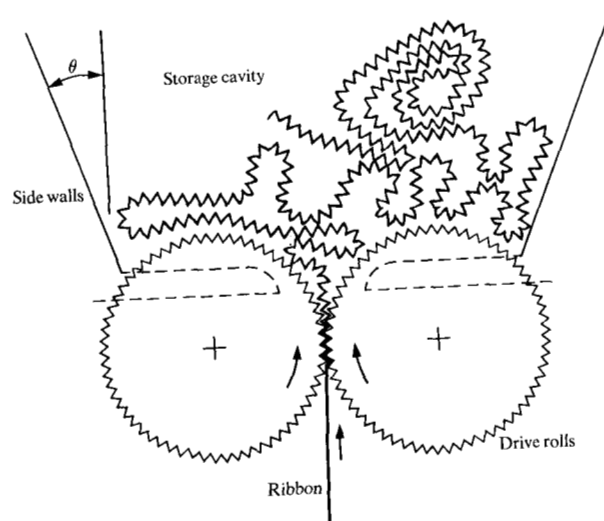


Figure 1 Random ribbon stuffer.

Copyright 1979 by International Business Machines Corporation. Copying is permitted without payment of royalty provided that (1) each reproduction is done without alteration and (2) the Journal reference and IBM copyright notice are included on the first page. The title and abstract may be used without further permission in computer-based and other information-service systems. Permission to republish other excerpts should be obtained from the Editor.

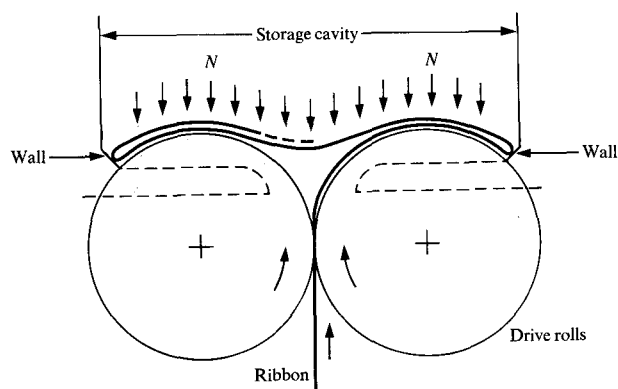


Figure 2 Uniform ribbon stuffer.

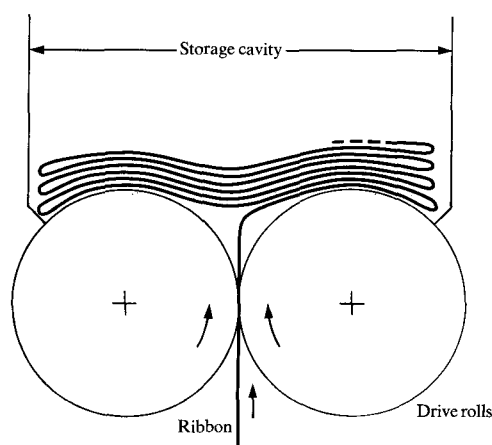


Figure 3 Ribbon buckling outward and toward the left.

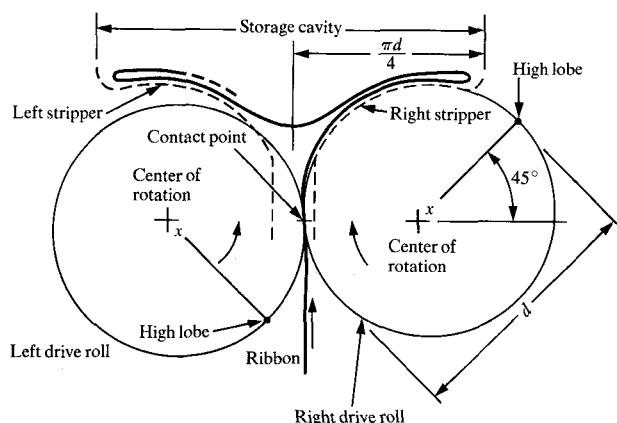


Figure 4 Harmonic-drive ribbon stuffer.

in the drive rolls, and additional fingers are sometimes used above and below the drive rolls. When the ribbon passes the pinch point of the drive rolls and enters the storage cavity, it proceeds rather unpredictably either to the right or left; it may, in fact, first accumulate in the v-shaped area above the drive rolls and move as a wad while being carried to the left or right by the rolls.

This random positioning, in addition to the large number of folds, causes the ribbon to expand in the direction of the sides and toward the front and back of the storage cavity. The highest ribbon pressures are localized near the entrance of the cavity. The sides of the cavity are often sloped to form an expanding area that alleviates this uneven pressure distribution, allowing the ribbon to move toward the exit of the cavity.

The use of an expanding storage cavity [1, 2] makes it easier to remove ribbon from the exit of the cavity, but jams often occur as a result of the ribbon becoming entangled around the drive rolls, and wads of ribbon often jam at the exit.

Although innovative designs have improved the deficiencies found in this type of stuffer, its reliability is generally poor, and the packing density is low.

Uniform stuffers (Fig. 2) place ribbon into a storage cavity in an orderly, predictable folded pattern [3]. Many of the physical dimensions are the same as those used on random stuffers; however, the drive roll surface that contacts the ribbon is made of an elastomer having a coefficient of friction between its surface and the ribbon which is greater than the coefficient of friction between ribbon and ribbon. This frictional relationship results in a net driving force that is capable of moving the ribbon either to the right or left; that is, the driving force between the drive roll and the ribbon is greater than the resisting force of ribbon against ribbon. This means that if the ribbon begins to move toward the right above the right drive roll, it continues in that direction until it runs into the side wall of the cassette. At this point the ribbon stops if the buckling resistance of the ribbon is greater than the net driving force. That is:

$$F_D - F_R < F_B \text{ and} \quad (1)$$

$$F_D > F_R, \quad (2)$$

where F_D is the driving force between drive roll and ribbon, F_R is the resistance force between ribbon and ribbon, and F_B is the buckling resistance of the ribbon.

Also,

$$F_D = N\mu_1 \text{ and} \quad (3)$$

$$F_R = N\mu_2, \quad (4)$$

where N is the normal force, μ_1 is the coefficient of friction between drive roll and ribbon, and μ_2 is the coefficient of friction between ribbon and ribbon.

After the ribbon contacts the wall and stops moving, ribbon continues to enter between the two drive rolls; the convex surface where the ribbon lies against the drive roll buckles outward and toward the left (Fig. 3). This ribbon buckling progresses to the left until the ribbon becomes driven by the left drive roll. The left drive roll continues to drive ribbon to the left until the ribbon contacts the left wall, at which time the ribbon stops moving to the left. Incoming ribbon causes buckling away from the left drive roll toward the right. The ribbon is then driven to the right by the right drive roll. This process continues uninterrupted as long as inequalities (1) and (2) are satisfied.

Although this pattern of stuffing appears to be precisely controlled, many of the variables of the equations undergo changes. The ribbon buckling force changes through its life as a result of ribbon wear. Ink depletion results in different lubricating properties which change the effective coefficient of friction. The normal forces change under certain stuffing conditions and with sidewall contact. As a result of these changes, the driving forces and resisting forces also change. When these variations are significant enough to upset the balance of inequalities (1) and (2), the stuffing becomes random.

Harmonic-drive ribbon-stuffing device

The harmonic-drive ribbon-stuffing device is a form derived from the uniform ribbon-stuffing device. Its evolution was based on a need to simplify the operation of the uniform stuffer, so that it did not have to satisfy inequality (1). Inequality (2) must still be satisfied; however, no limit is imposed on how large F_D can be made.

Figure 4 shows the operation of the harmonic-drive ribbon-placement device. Two eccentrically contoured drive rolls drive ribbon into a storage cavity. One drive roll is positively driven from a source; the other drive roll is energized from the first roll through a shaft and two eccentric gears mounted below the drive rolls. The amount of eccentricity of the drive rolls is not at all critical. We use in drive rolls of about 64 mm an eccentricity of 1.8 mm. Strippers are located within grooves in the drive rolls and also above and below each drive roll. The geometric relationship of the stripper to the drive roll is shown in Fig. 4. The left stripper is symmetrically located relative to the right stripper. This geometric relationship between the drive rolls and the strippers determines the direction of ribbon motion: either to the left or right.

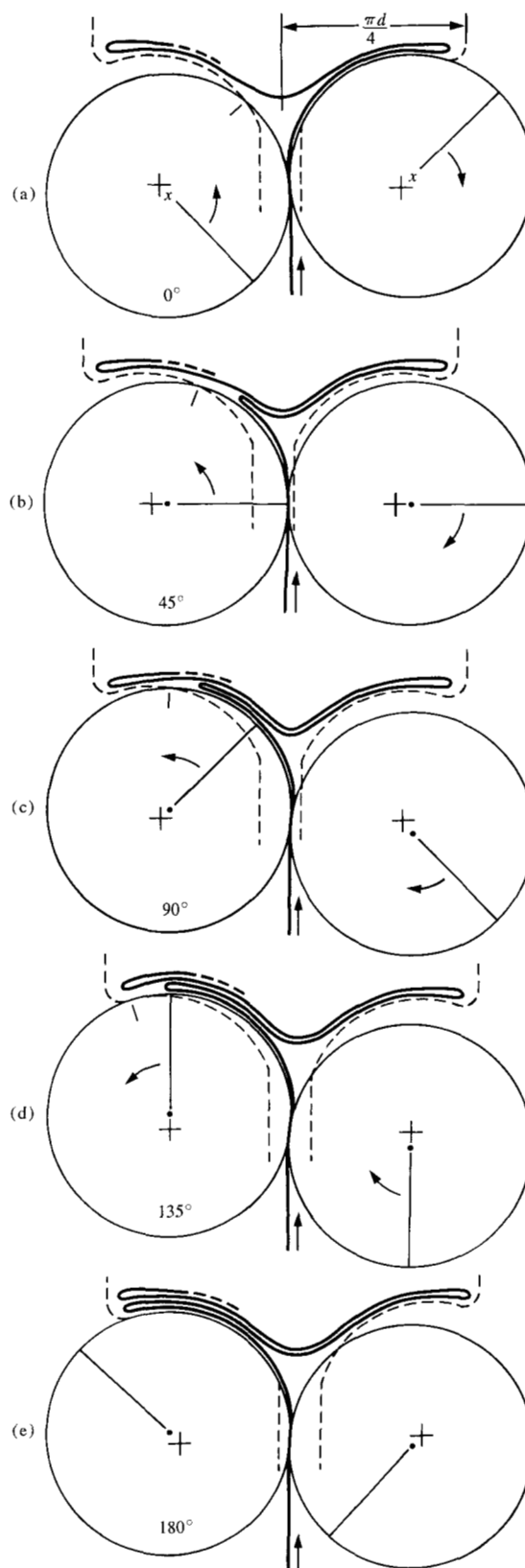


Figure 5 Operation of harmonic-drive ribbon stuffer.

The right drive roll is shown superimposed over the stripper fingers in Fig. 4. The rotation of the right drive roll is clockwise. Therefore, any rotation of the right drive roll beyond this point in the figure causes it to withdraw within the stripper fingers, making it impossible to contact or drive the ribbon to the right. However, any rotational advancement of the left drive roll causes its peripheral surface to extend beyond the left stripper fingers and advance the ribbon to the left.

Figure 5 shows this ribbon motion in detail. Motion is shown in 45° increments starting at 0° and continuing up to 180° of motion. At 0° the high lobe of the right drive roll has moved ribbon as far to the right as possible, and the drive roll is about to withdraw below the strippers. When this occurs, ribbon continues to enter the storage cavity past the contact point, and it buckles toward the left; it is then acted upon by the peripheral surface of the left drive roll and becomes driven to the left. Since the coefficient of friction between the drive roll and ribbon is greater than the coefficient of friction between ribbon and ribbon, the net driving force continues to move ribbon inward and to the left without any slippage between the drive roll and ribbon.

The intersection between the periphery of the left drive roll and the upper surface of the stripper shown in Figs. 5(a)–(d) always progresses in front of the ribbon fold, ensuring that incoming ribbon will be driven by the drive roll surface. Under these conditions, only a small portion of previously placed ribbon is in contact with the left drive roll. This motion continues until the left drive roll rotates to the 180° position [Fig. 5(e)] and begins to withdraw below the strippers. At this time the ribbon buckles away from the left drive roll and toward the right and is driven by the right drive roll in the same manner as previously described for the left roll.

A laboratory model of the harmonic-drive ribbon-stuffing device has been built and has been subjected to extensive reliability testing. These tests indicate that it is five to ten times as reliable as conventional ribbon-stuffing devices.

Ribbon capacity of the laboratory model allowed up to 200 yards of 3/4-inch-wide ribbon to be stuffed with no problems. The 200-yard limit was a result of the physical size of the stuffing cavity.

Summary

The pursuit of truly uniform ribbon stuffing independent of a complex frictional balance has resulted in a reliable ribbon-placement device that achieves ribbon placement primarily by controlling the geometric relationship between the drive rolls and strippers. This device is capable of handling high ribbon capacities in a relatively small package. The high packing density comes from using larger diameter drive rolls that result in fewer ribbon folds for any given ribbon length. The ribbon velocity is nearly constant and is directly related to the eccentricity of the drive rolls and drive source. The cost of this device is comparable to present-day uniform stuffers and yet it offers significant advantages over conventional ribbon-stuffing techniques.

References

1. G. P. Bonner and P. Q. Brumbaugh, "Controllable Tension Ribbon Cassette," U.S. Patent 3,758,012, 1973.
2. A. E. Carson, Jr., "Ribbon Storage and Transport Mechanism," U.S. Patent 3,989,132, 1974.
3. W. R. Johns, "Ribbon Mechanism for Typewriters," U.S. Patent 539,683, 1895.

Received November 21, 1978; revised February 22, 1979

The author is located at the IBM System Products Division laboratory, Endicott, New York 13760.