Advanced Techniques for Minimizing Ribbon Wrinkle in a Thermal Printer

Background

Most thermal printers have two modes of operation: direct thermal and thermal transfer.

In direct thermal mode, the printer energizes chemicals in specially treated paper which, when subjected to heat, turns black to form the printed image. Direct thermal media is used primarily in applications where the label life is relatively short (less than one year), where label durability is not a requirement, and where print quality is not a priority. Typical applications include point-of-sale receipts and some shipping labels.

Thermal transfer mode requires the use of so-called ribbons. Ribbons use a mylar substrate (typically around 5um thick), which is coated on one side with a wax or resin formulation (or a blend thereof). When heated, wax melts and transfers onto the media to form the image. With resin ribbons, the transfer process is different slightly, but the concept is similar.

Ribbons provide a depth of applications not possible with direct thermal paper. Wax-based ribbons work well with paper and tags to provide durable labels and good print quality. Resin-based ribbons, while more challenging to print with, provide a high level of durability for harsh environmental applications. An example: automobile under-the-hood applications, where the printer uses resin ribbons and specially treated polyester labels that must withstand extremes of temperatures and resist various chemicals.

When developing the thermal printer application, it is important to match the ribbon with the media and the printer. Most printer manufacturers recommend their own ribbon and medial combinations, which have been pre-tested to ensure an acceptable level of performance.

Ribbon Challenges

One of the challenges for thermal printer designers is managing the ribbon within the print system. Due to the very thin substrate, ribbons are vulnerable to puckering and folding. This effect, commonly known as ribbon wrinkle, results in streaks or voids on the printed image. This can be a serious issue for applications that use bar codes. If the bar codes cannot be scanned the otherwise automated process must be handled manually, resulting in inefficiencies and additional operational costs.

Factors that can cause ribbon wrinkle include:

- Ribbon tension
- Parallelism of the ribbon supply spindle, the ribbon take-up spindle and the print nip
- Absolute nip pressure and nip pressure uniformity
- Print head heat intensity
- Printing on one side of the ribbon only
- Ribbon quality
- Proper installation of media and ribbon

- General upkeep of the printer

Most users can avoid these issues with proper pre-testing of the application, correct installation, operator training and ongoing scheduled maintenance. However, the first two issues are printer-design dependent.

The Need for Ribbon Control

Advanced thermal printers include two key design elements to compensate for ribbon wrinkle:

- Fixed and dynamic tension compensation
- Supply-spindle and take-up spindle tension control

Tension compensation elements attempt to overcome fixed and dynamic cross-web imbalance. Without perfect parallelism between the ribbon spindles and the print nip, fixed tension errors occur. This is particularly critical on wide-web printers where the spindle length amplifies the offset. Even high-end wide-web thermal printers cannot achieve perfect parallelism on an ongoing production basis. A precision stainless steel roller suspended by leaf springs sometimes provides compensation on the ribbon supply side. The roller automatically adjusts to balance the tension across the width of the ribbon. On the ribbon take-up side, a pivoted stainless steel roller has been found to be very effective at countering fixed tension offsets. The pivot point is adjustable to allow for operation with different width ribbons.

Dynamic tension issues can result from occasional dust particulates and ribbon imperfections working their way through the print system. Intense printing on one side of the ribbon also may cause them. Most dynamic tension issues result in transitory wrinkling that can cause bar-code quality issues, which is explored later here. The fixed offset compensation elements can help to minimize the affects of dynamic tension errors.

The Shortcomings of the Clutch Approach

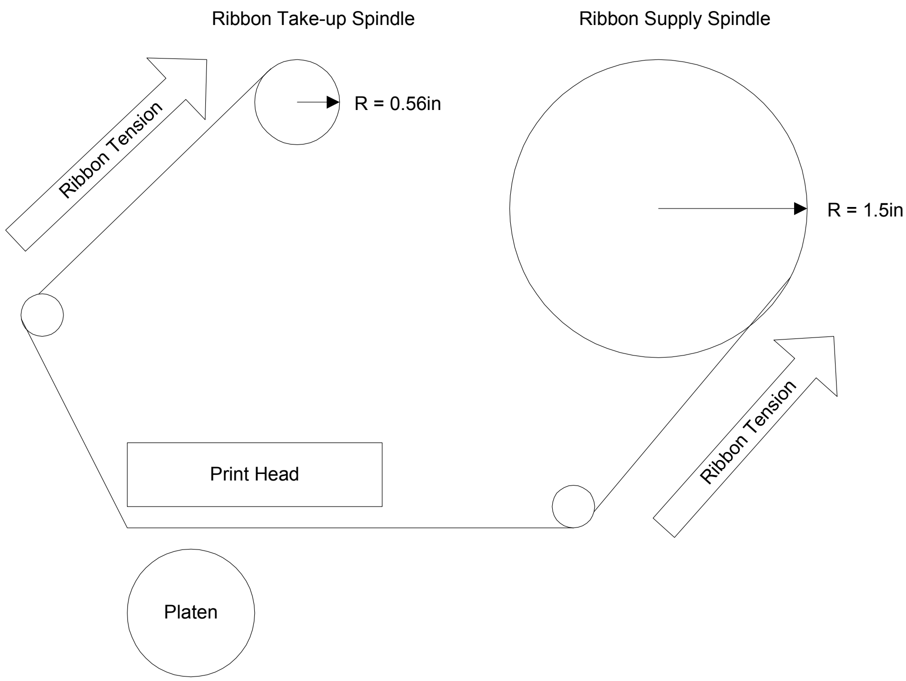
Key to minimizing ribbon wrinkle is the overall ribbon tension control. The printer must provide reverse tension behind the print head and forward tension in front of the print head. The optimal tension for thermal ribbons to minimize wrinkling has been determined empirically and is related to ribbon width, ribbon thickness and the stresses generated during the print process. The key is to maintain this tension (or controlled stress) over the full length of the ribbon.

Nearly all thermal printers use a slip clutch on the supply spindle and an overdriven (relative to the main platen drive) belt on the take-up spindle. The clutch slippage torque is constant at some predetermined level set by the manufacturer. A fundamental equation relevant to this discussion is the relationship between torque, distance and force. For the thermal printer, the following basic equation applies.

Ribbon Tension = Clutch Torque / Ribbon Roll Radius

This relationship tells us that the larger the ribbon supply capacity, the lower the tension. Similarly, the smaller the ribbon supply capacity, the higher the tension. Therefore, for a 12-inch-oz clutch, the force can vary between 8 oz (12/1.5in) and 21.3 oz (12/0.56in) from one end of the roll to the other, a ratio of 2.67:1. This assumes 450m, 3-inch diameter ribbon with a core thickness of 1/8 inch.

The same principle applies to the ribbon take-up spindle making the ribbon tension variation from spindle-to-spindle 5.3:1.



Ribbon Tension Model

Further, to maintain ideal ribbon tension, the total tension across the web must be altered to accommodate variations in the ribbon width. Therefore, running a 4-inch wide ribbon in an 8-inch wide printer requires a net tension reduction of 2:1.

These effects on the ribbon spindles compound each other to such an extent that the ribbon tension per unit width can vary by more than 10:1. This dynamic range of change can have a significant impact on the printer's ability to minimize ribbon wrinkle.

It also can be a challenge in determining the optimal clutch torque as at one extreme over-tension can cause the main driver motor to stall and at the other extreme the tension may be inadequate to avoid ribbon wrinkle.

Another important point of note is that clutch torque changes with use; it sometimes increases when debris intrudes and sometimes decreases with wear. This only exacerbates the tension variations. When placed in a high-duty cycle industrial environment the clutch may cause operation problems with the printer sooner than might be expected. Further, clutches do have a finite life, and service personnel must replace them.

Some companies use compound clutches where two or three slip clutches increase the ribbon tension as wider ribbons are used. However, this technique is unable to compensate for tension changes across the full length of ribbon, and of course, this further increases the service liability.

The Optimal Solution

The optimal approach to controlling tension is to control each spindle in real-time such that as the ribbon is consumed, the tension the printer applies compensates for it automatically. This can be achieved using DC motors and feedback control. The control is automatic for ribbon length and preset for ribbon width — typically the same as the label width.

Using proprietary hardware and software control techniques, the printer can determine the amount of ribbon on both the supply spindle and the take-up spindle. With this information, the printer is able to modify the motor torque to set the optimal ribbon tension from one end of the supply roll to the other.

Other Benefits

There are a number of other benefits in using this technique to control ribbon tension.

First, as the print system knows the amount of ribbon available, this information can be fed back to the operator through the control panel or through a host-based printer-management software package. This allows for advanced warning of a ribbon-out condition, an actual ribbon-out condition or full capacity on the ribbon take-up spindle. Based on these (and a number of other) conditions, the printer management software can send alerts (emails, pages, etc) to different operations personnel based on the actual condition and the response required.

Second, because of the superior control, the printer can support higher ribbon capacities than a clutched based system. For example, some printers with DC motor control of the ribbon tension support a 625m-ribbon capacity versus the industry typical of 450m for a clutch based system. An additional 38 percent capacity results in less user intervention.

Third, the printer is able to reverse both media and ribbon back into the printer. Ordinarily this is not useful, but with a bar code verifier integrated into the printer, the print system now has the capability of backing-up labels and over-striking them should a defective bar code be detected. The printer can either then stop or automatically keep re-printing the label until a good bar code is printed. This closed loop system ensures that bad bar codes are never introduced into the application. The most popular application for this capability is in supply-chain compliance printing where unscannable labels result in fines for the supplier. One customer reported that bad labels dropped from greater than 50 percent to less than 2 percent using this application. The remaining small number of bad labels was due to other operational issues. The investment in the additional equipment was justified easily.

Last, DC motors are not subject to the service needs of slip clutches. With heavy-duty industrial applications, the increased reliability of DC motors over slip clutches results in significantly greater up time and, therefore, improved productivity.

Summary

Commonly used clutch based thermal printers are not able to maintain ribbon tension such as to minimize wrinkling. The use of DC motors not only achieves this but also brings many other benefits to the solution-oriented customer. These additional capabilities are capturing interest in corporate accounts where the cost of bad car codes is both measurable and undesirable.

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Printronix Inc, USA