Tension on a web must be understood if using a machine vision system

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Tension and the materials you produce make a difference to inspection systems

Another area where defects can be introduced into the inspection process is due to tension variation. This can happen where there is poor tension control, particularly when the tension is too low or due to the material properties of the web.

Tension control can really affect your performance when doing print inspection

Print inspection systems often use a golden template algorithm. This is when a master image is compared to each printed image. These algorithms must accommodate the random web shift of the web for every repeat. Depending on the resolution of an inspection system this allowable shift may vary up to 3-4 mm per repeat. Therefore, if the fluctuations in the tension are larger, inspection can become very difficult due to the loss of alignment *(matching if golden image to the printed image)*. However, the tension cannot be set too high either, as it will result in deformation of some materials while in other cases it will result in web breaks.

Another effect of low or high tension is that the resulting *"repeat-length"* will be either too long or too short. Often stretchy or elastic substrates are printed on while stretched by excessive tension and end up with a short repeat when the substrate contracts after printing. An inspection system will see this as a gradually increasing pixel difference over the image *(most pronounced at the bottom of each repeat as the run out is cumulative).*

Tension control during lamination will affect golden image comparisons

As plies are laminated the resultant tension is increased to pull both plies through the press. If a third ply is laminated further along the press, the tension is further increased. This tension increase is directly linked to the total sum of the constituent plies. It is a difficult enough task to maintain one overall tension on a press, therefore maintaining up to 5 different tension zones compounds the problem.

In the laminating process it is important that the individual substrates not be of equal tension but be strained by the same % length *(1% Young's Modulus)*, i.e. both substrates need to be strained so that they deform by a pre-set length. This is so that during the curing process so they contract by the same amount so that no puckering of the material occurs. This is another variable to be considered during inspection if it occurs after a lamination station.

As the press is attempting to maintain constant tension during lamination, speed variations occur. It is this attempt to maintain constant tension that over large distances allows the top of a printed image presented to the camera to vary from the start of repeat signal.

Understanding material properties

While it is critical to maintain constant web tension, the inherent properties of the web can act against this goal. AL foil is the most stable substrates for inspection as it has low elasticity *(low tension variation*) and low thermal expansion *(low repeat length variation*). On the other hand, materials such as light gauge low-density polyethylene have high elasticity and high thermal expansion coefficients. It is in this latter case especially a number of mechanisms should be put into place to counteract problems.

1. "**Chill rolls**" should be used to keep the web at the same temperature so that any negative effects of thermal expansion are avoided. With some poly substrates a repeat length can go

from 600mm to 601mm due to thermal expansion. Such a difference in repeat length can change the relative position of each physical top of repeat from the actual start of repeat signal. This difference can result in a slow constant drift in the y-axis over time. The press heats up over a period of up to 45 minutes at the start of a print run. It is during this time the y-shift can drift in the positive direction. After the heat phase stabilises the y-shift stops.

2. **PID controllers** may be used to maintain even tension.
3. **Well-balanced idlers** (low rotational inertia) with low overall inertia mounted on low drag bearings will also help maintain constant tension. If the drag is too high it may not even be possible to pull a particular substrate through a press without exceeding its plastic deformation point.

Some important Web Tension terms:

- **Idler roller:** A roller, which is driven by the web rather than by an electric motor, belt or other external means.
- **Nip:** Two parallel rolls pressed together on converting machinery between which the web passes. Used particularly to maintain tension and in lamination process to set both plies together. It is particularly difficult to maintain constant tension at this point.
- **Rewind Zone:** A tension zone, typically on converting machinery, created between a driven nip roll or other tensioning point and the driven core onto which the web is wound. This zone occurs for a length preceding the rewind station. This zone can work itself back into the inspection zone and can cause problems for inspection alignment.
- **Soft start feature:** A tension controller feature used in unwind zones; soft start causes the controller output to drop to a pre-set low level to prevent brake lockup when the machine starts; the feature is actuated automatically upon loss of tension below a pre-set trip point, by a change in machine speed, or by an external contact closure.
- **Taper tension feature:** A means of decreasing web tension as roll diameter increases in a rewind zone; Taper tension helps produce a roll of better quality by eliminating telescoping, crushed cores, and overly tight or loose rolls.
- **Tension Zone:** A length of machine in which the web is under nominally the same tension, usually between driven rollers. Ideally it is required that start of repeat signal, new line signal and imaging all occur in one tension zone.
- **Unwind Zone:** A tension zone created between a driven roll or driven nip and the core from which a roll is unwound. Tension is often created by torque applied to the unwind shaft by a pneumatic brake.

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