Using Laser Doppler Velocimetry to increase profits and reduce downtime on converting lines

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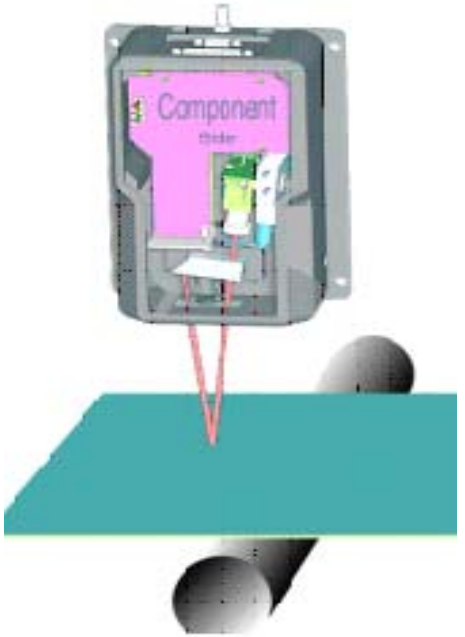

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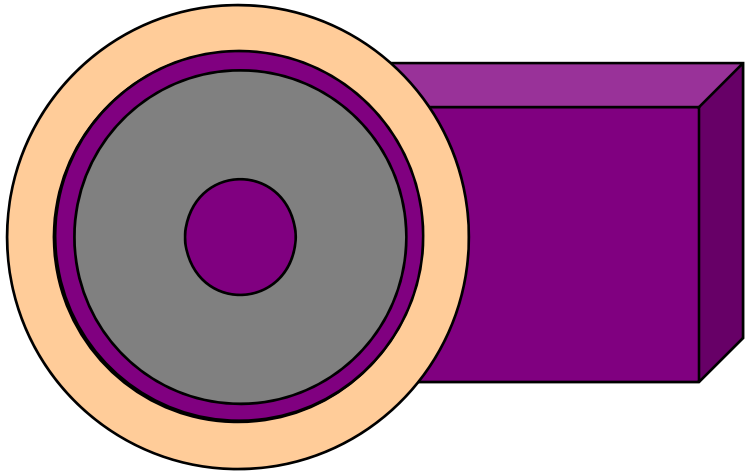
Traditional Length & Speed Measurements

- Accomplished by using a roller that contacts the material being measured
- The material turns the roller as the material moves
- An encoder or tachometer is attached to the roller
  - Generates pulses as the wheel or roller rotates
  - Relies on friction between the wheel and the material

Causes of inaccuracy

- Wheel slip due to low coefficient of friction between wheel and web
- Angular misalignment (also causes marking and premature wear on the wheel)
- Dirt or other material build-up on wheel
- Calibration error
- Wheel wear

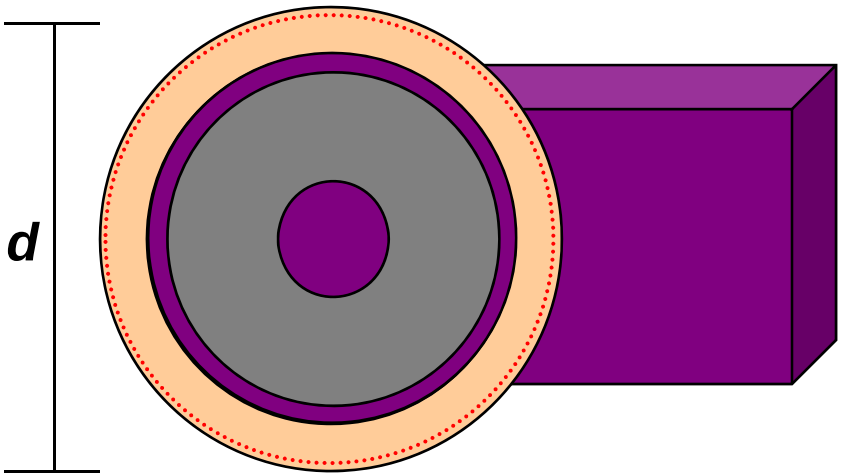
The Effects of Wheel Slippage



Wheel contacts the product and relies on friction to turn. The wheel surface typically lags by 1%-2%

1% - 2% Long

The Effects of Wheel Wear



Originally:

d = 3.819”

1 rev = 12”

After 1/32” of wear:

d = 3.757

1 rev = 11.8”

= 1.6% SHORT

What about Shaft Encoders/Motor Feedback?

- Very high resolution but…
- Relies on friction and tension to turn at the same rate as the material

Affects of Inaccuracy

- Slip, misalignment or material build up
  - 1000ft roll
  - 1% - 2% slippage
  - 1.5% results in 1015ft on the roll with an indicated 1000ft
- Wear
  - Previous example of 1.5%
  - Wheel turns too fast, not enough material is put on the roll
    - 985ft instead of 1000ft

The problem is that the operator does not know if the reading is too high or too low. To compensate, the usual practice is to wind extra material on the roll "just in case"

Traditional Contact Encoder Summary

- Contact encoders are notoriously inaccurate
- Contacting the web has the potential of damaging the material
- Efforts to correct for encoder inaccuracy are usually short lived
- Frequent recalibration is costly in manpower and downtime
- Because of the known accuracy issues, operator frequently compound the problem by adding a saftey factor of product to each roll

At best, contact encoders are an indirect measurement of the material

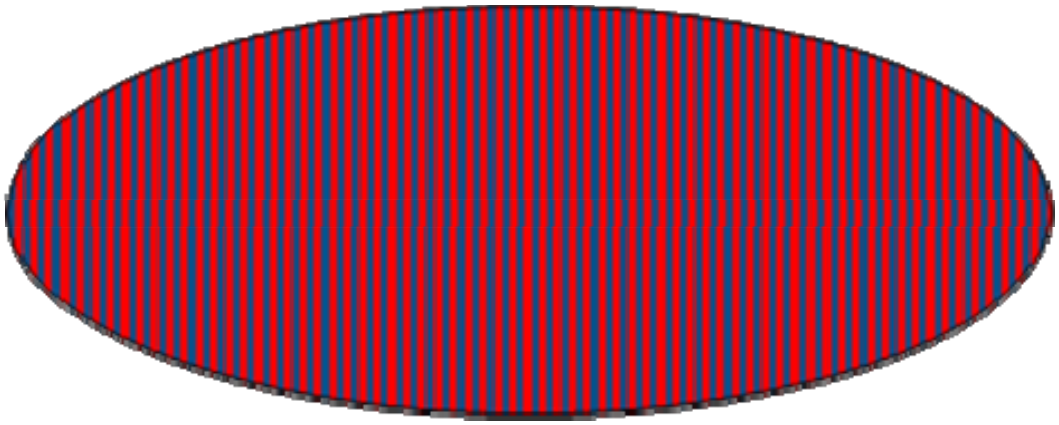
Non-Contact Encoders

- Use Dual Beam Laser Interferometry
  - Accurate and repeatable measure of surface speed
- No wearing parts
- LDV devices currently being produced
  - Permanently calibrated at the factory
    - Factory certified to NIST standard length
    - Only variables are:
      - Laser Temperature which is controlled to +/- 0.1 °C
      - Laser Wave Length can be controlled to better then 0.01 nanometers

Gauge Calibration is controlled to better then 0.0012%

Interferometry

- Two laser beams cross
- Same polarity
- Same wavelength
- Fringe pattern



Laser Doppler Velocimetry (LDV) Theory

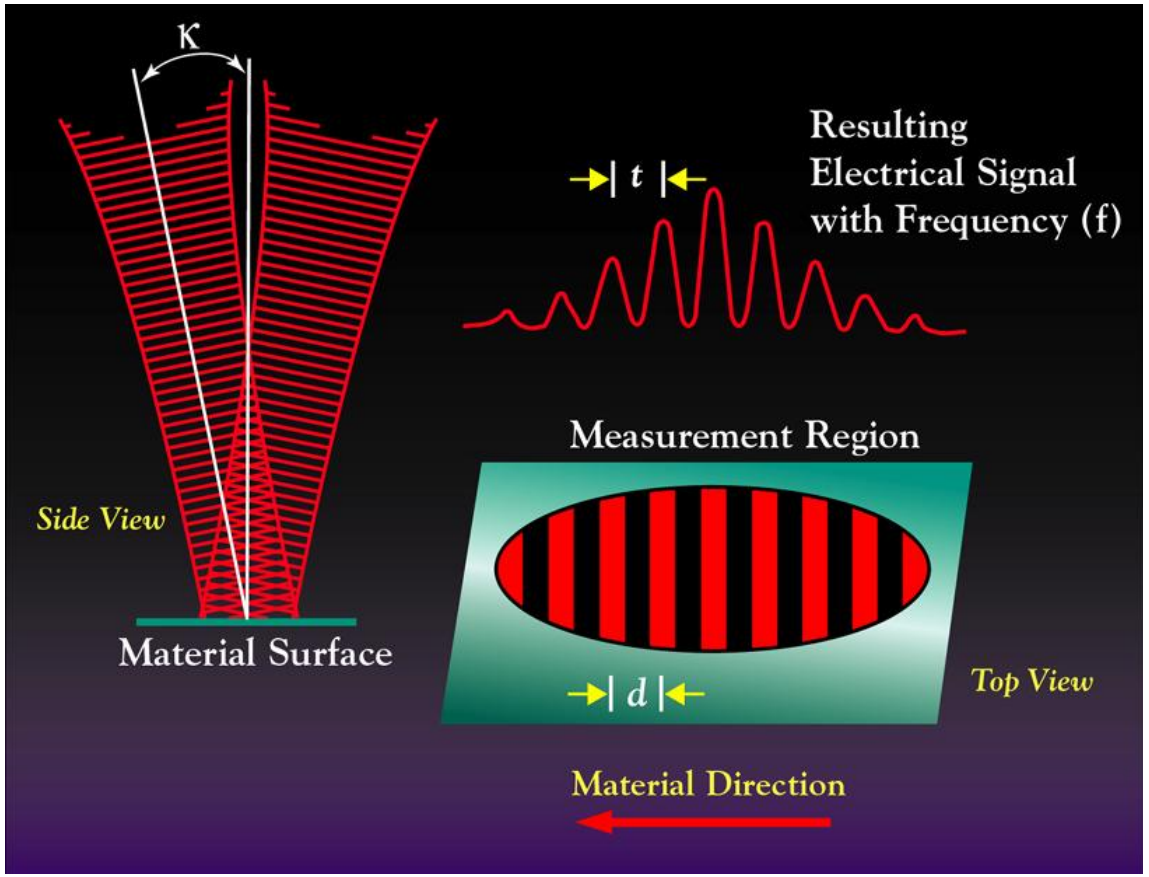
$$d = \frac{\lambda}{2\sin\kappa}$$

$$v = \frac{d}{t}$$

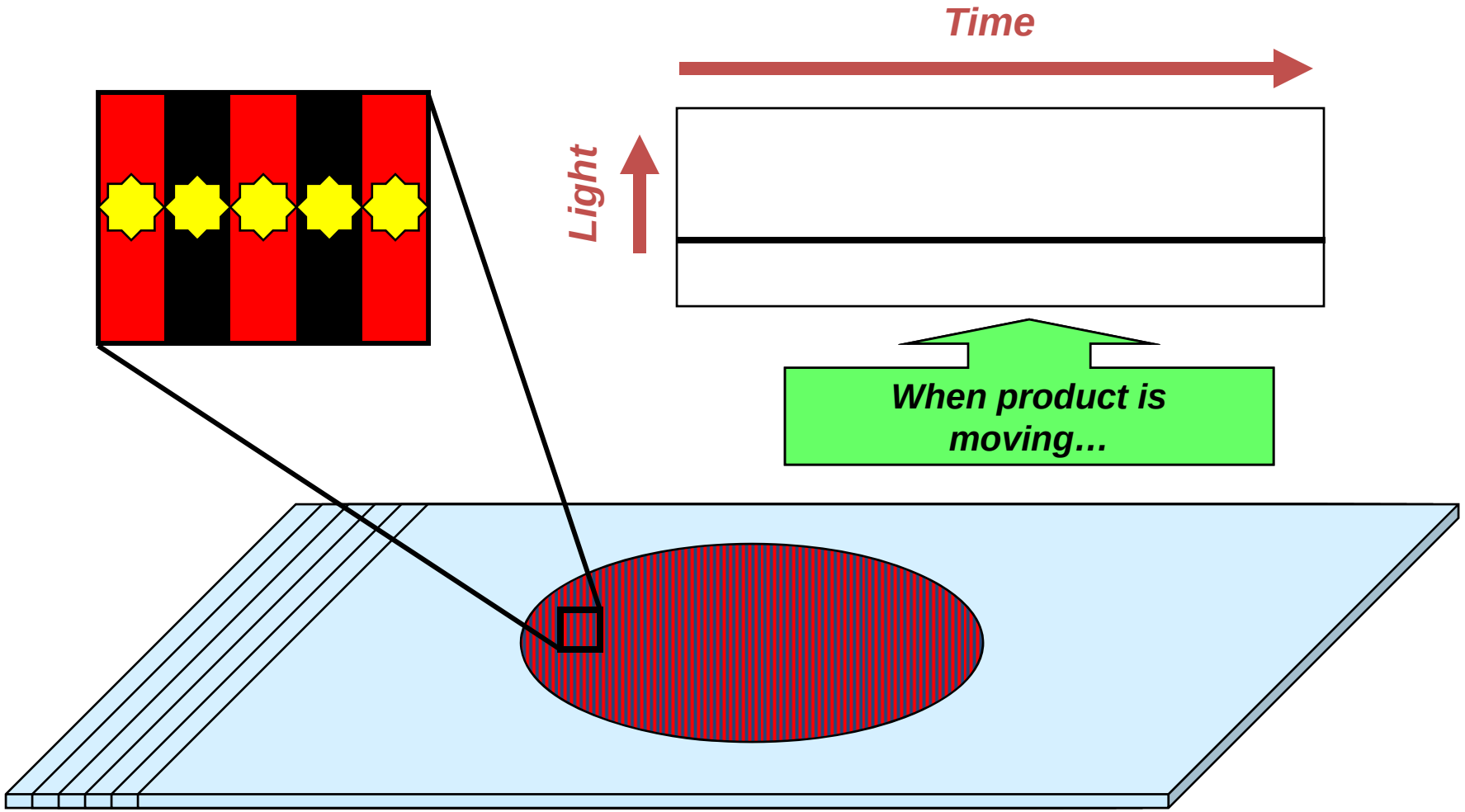
$$t = \frac{1}{f}$$

$$v = d * f$$

$$L = \int_0^T v\,dt$$



How LDV Works



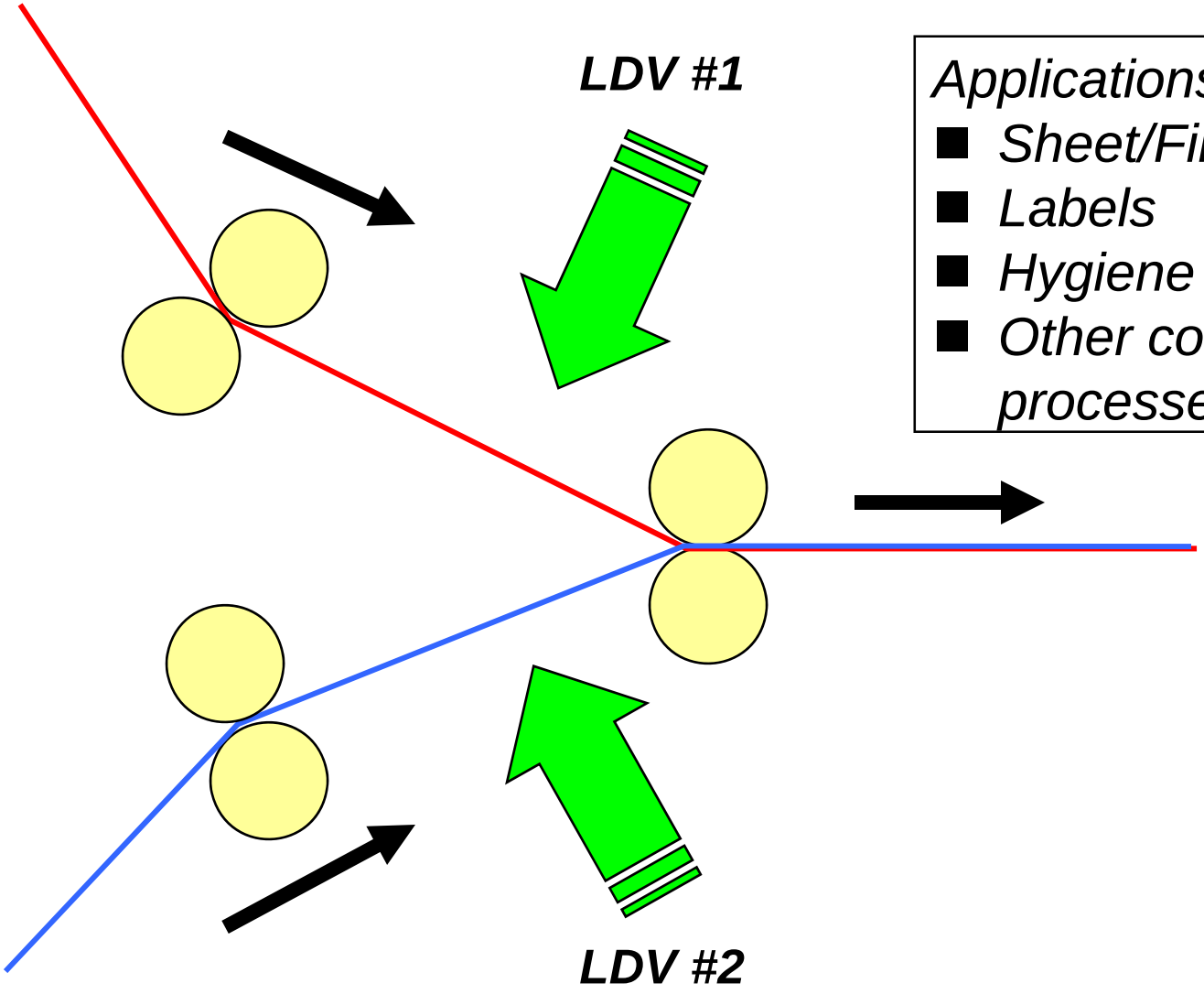
LDV Capabilities/Features

- Permanently Calibrated
- Optical system with no moving parts to wear out
- Accuracy capable of > +/-0.05%
- Repeatability capable of +/-0.02%
- Easy to setup and operate
- Fast pay back for most applications
  - Saves material cost
  - Saves calibration costs
  - Saves maintenance costs

Example Rewind Line

- 355 Production days per year
- 22 hours per day
- Current solution accuracy: 1.5%
- 300 ft/min
- $0.08 per linear foot

Lamination



Applications include:

- *Sheet/Film Lamination*
- *Labels*
- *Hygiene Products*
- *Other converting processes*

Lamination Example

- Two materials being laminated together
- The operator normally matches the motor speeds to reduce tension between layers
    - This assumes the material is moving the same as the roll
- The result is that the materials are laminated under tension and curl when de-laminated during secondary operations

Laminating Example

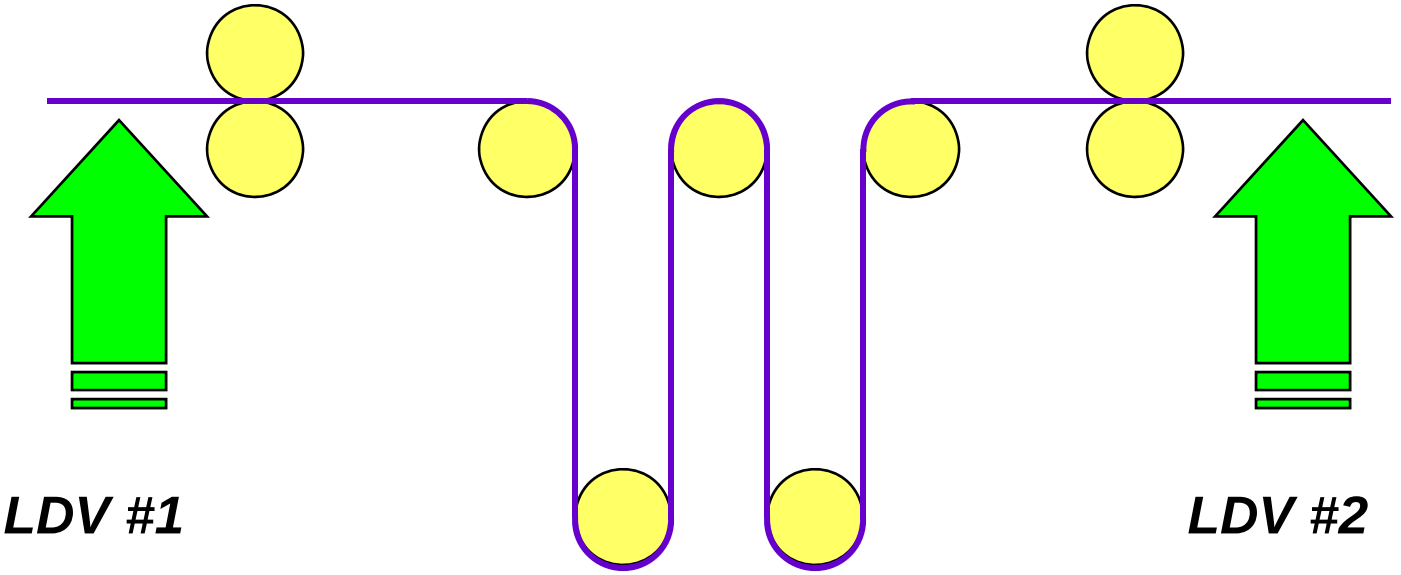
- Solution is to use two LDV devices to directly measure each web speed to reduce tension
- With better than +/- 0.05% accuracy, the true product speed is measured

Result is a much higher quality product and problems, such as "curl", are eliminated

Stretch measurement

Applications include:

- *Paper and Box Board*
- *Toilet and Hand Tissue*
- *Other converting processes*



Stretch measurement Example

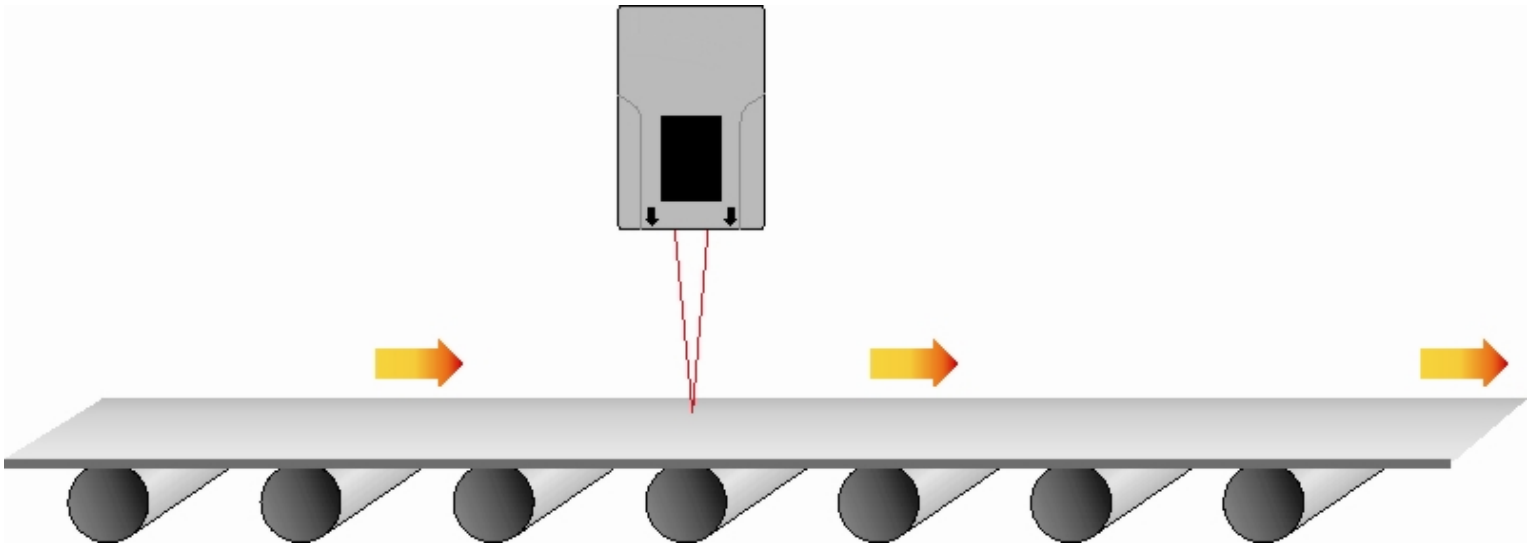
- Stretch, glue and chop operation
- One encoder at the beginning and one near the end
- A controller tracks the difference in speed to maintain proper tension
- Too little tension and product is wasted
- Too much tension and quality suffers or the web breaks

Stretch measurement Example

- Solution is to use two LDV devices in the process
- One upstream and one downstream
- A more precise speed of the web is taken so stretch can be accurately controlled

Quality is improved and web breaks are eliminated

Can Labels Example



Can Labels Example

- Classical problem where two companies are using inaccurate methods to measure length
- Company A makes 1000 ft of the label stock and sends to company B to print on the labels
- B sends it back to A, who then re-measures it to be only 950 ft
- A blames B for the shortage and says that the extra missing 50 ft must have been lost at company B
- Who lost the material?

Can Labels Example

- The answer is: no material was lost!
- The problem with inaccurate measurement methods is that the measurements aren't always repeatable
- In this case, the 50 ft of "phantom loss" was not an actual loss of 50 ft but the result of inaccurate and non-repeatable measurements

Using an LDV at both companies resulted in accurate and repeatable results. No more "phantom loss"

QUESTIONS?

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