# Tension Control

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## Issues

Maintaining precise web tension is a critical factor in label printing and converting operations. Inconsistent or improper tension can result in defects such as print misregistration, web wrinkling, slack, or tearing, all of which compromise product integrity. Ensuring consistent tension throughout the process—from unwinding to rewinding—optimises web stability and alignment. This not only enhances product quality but also minimises material waste, reduces operational downtime, and maximises production line efficiency.

**Defects from poor tension control**

- Slip, scratching
- Web breaks
- Increased wrinkle sensitivity
- Loose or tight roll defects
- Web curl
- Width variation

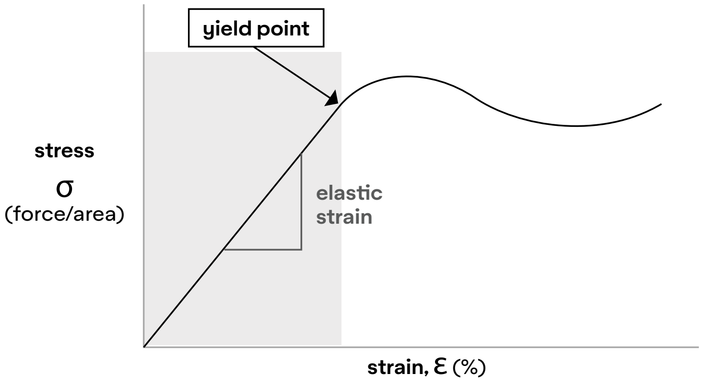
## How is tension created?

Tension in a material is generated by the application of tensile stress, which is determined by two primary factors: torque and relative speed. Torque refers to the rotational force applied to induce angular motion, while relative speed represents the relative velocity ratio between rollers.

In the unwinding process, maintaining constant torque results in variable tension as the roll diameter decreases. To sustain consistent tension during unwinding, torque must be proportionally reduced in accordance with the diminishing roll diameter. Conversely, during the rewinding process, torque needs to be incrementally increased to accommodate the increasing roll diameter, ensuring uniform tension throughout the operation.

## Material Yield Point

Yielding is a permanent, non-elastic dimensional change. Each material has a characteristic stress and strain where yield begins – called the yield point. The yield point of a material is relative to its thickness and width.




A good rule of thumb to follow is the tensile stress applied should be 10 - 20% of the yield stress. Below are some typical tension applied on paper and filmic materials.

**Paper**

| Basis Weight (lbs/ream) | Tension (lbs/inch) | Paperboard (points) | Tension (lbs/inch) |
|---|---|---|---|
| 15 | 0.5 | 8 | 3.0 |
| 20 | 0.75 | 12 | 4.0 |
| 30 | 1.0 | 15 | 5.0 |
| 40 | 1.5 | 20 | 7.0 |
| 60 | 2.0 | 25 | 9.0 |
| 80 | 2.5 | 30 | 11.0 |
| | | 40 | 14.0 |
| | | 50 | 16.0 |
| | | 60 | 18.0 |

**Film**

| Material | Tension per thickness (lbs/inch/mil) |
|---|---|
| Polyester (PET) | 0.50 - 1.50 |
| Polypropylene | 0.25 - 0.50 |
| Polyethylene | 0.25 - 0.50 |

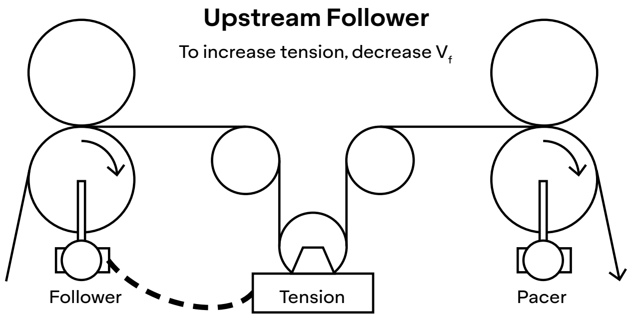
## Tension Control

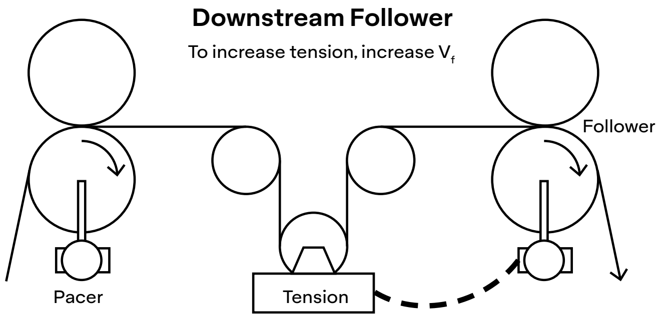
**Which variable is adjusted?**

| | Torque | Relative Speeds |
|---|---|---|
| No tension feedback | Torque Control | Draw Control |
| Tension feedback by roller reaction | Tension Control | |

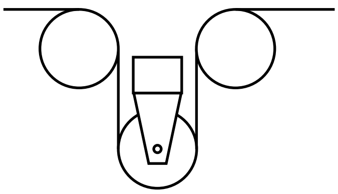
Having established that tension results from the interplay of torque and relative speed, we can now examine the methods for tension control. The diagram on the left illustrates the specific variable that is regulated.

A standard tension control configuration consists of a tension feedback device that monitors and measures the tension in the system, providing real-time data to the control mechanism. The control mechanism, or follower, regulates tension by dynamically adjusting the roller velocity, either by accelerating or decelerating as required to maintain optimal tension levels.



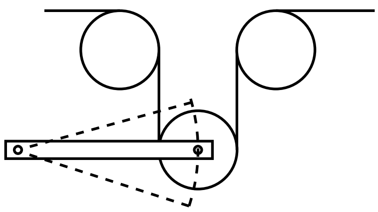




Establishing a feedback loop requires precise tension measurement, typically achieved using transducers or dancer mechanisms.



**Transducer**

Transducers consist of two primary components: the load cell and the strain gauge. Under tensile stress, the load cell undergoes slight deformation, which is transferred to the strain gauge bonded to its surface. This deformation alters the strain gauge's electrical resistance, producing a voltage signal directly proportional to the applied tensile force. This signal is used to modulate tension by increasing or decreasing it as required. In most applications, transducers operate effectively with minimal wrap angles.



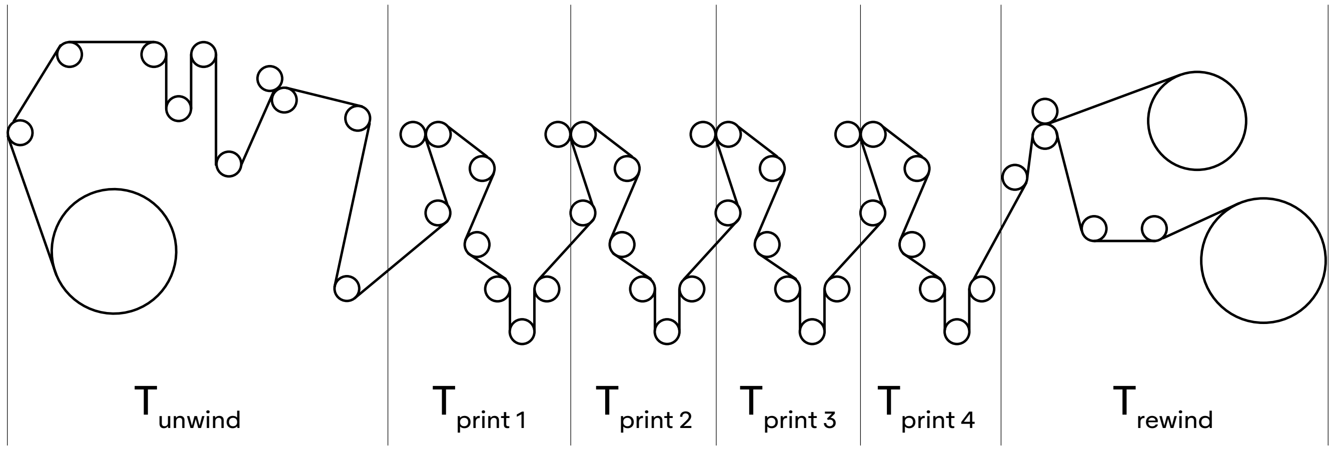
**Pivot Arm Dancer**

Pivot arm dancers regulate tension based on the position of the dancer arm. Increased tension results in an upward movement of the arm, triggering a signal to the pacer or braking system to reduce tension. Conversely, decreased tension causes the arm to move downward, signaling an increase in tension. Pivot arm dancers typically require a larger wrap angle; however, they maintain minimal tension variation despite changes in web path dynamics.

Both tension feedback tools have their respective advantages and limitations, with their applicability largely dependent on the specific context and operational requirements in which they are utilized.

## Tension Zones

Tension zones refer to the segments of a web line located between two torque or speed-regulating devices, where tension levels are precisely defined either by system design or active control mechanisms. Most web handling systems typically incorporate a minimum of three tension zones: unwind, rewind, and process tension. Increasing the number of tension zones beyond two is advantageous in cases where excessive tension is required to overcome total roller drag and inertia losses or when isolating a critical process (e.g., printing) from tension fluctuations occurring at the unwind or rewind stages. Below is the typical layout of tension zones in a typical printer.




## Summary

In conclusion, consistent tension is important for consistent product quality and reducing downtime due to web breaks. Factors such as torque, web speed must be varied during the process as the roll unwinds, so that consistent tension can be achieved.

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