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Guidelines for web conveyance and winding tension levels

Scope

Web conveyance is a requirement that transcends across many industries. The requirement is to convey a web flat and straight through the process without generating defects such as wrinkles. To accomplish this, the web needs to be stressed under a certain amount of force commonly referred to as web tension.

The scope of this TIP is to provide guidelines for suggested amount of web tension that should be used to convey certain types of web materials that are common to the paper, paperboard, polymer film, extrusion coating and flexible packaging industries.

Safety precautions

For web conveyance, the amount of web tension should be as little as possible to convey a web straight through the process without scratches from lack of traction on web driven rollers and/or without wrinkles. The values of suggested tension in this document are general guidelines and the actual web tension should be kept at or below these values. The required amount of web tension is affected by many variables which include: characteristics of the web, web handling roller design and process parameters such as speed, width and environmental conditions.

Introduction

Web tension is the amount of force that is applied to a web material to produce the desired stress and resulting strain in the web material so that it can be properly conveyed through the web forming, processing or converting processes. The amount of web tension applied for this desired stress is a function of the web's cross sectional area which is a function of the web's width and thickness. Web tension is normally referenced in terms of force per unit width for a specific product. The units for web tension are normally kilograms force per centimeter (kg-f/cm), Newtons per centimeter (N/cm) or pounds force per unit inch (lbf/in.). In this TIP we will use web tension units of N/cm (lbf/in.) with conversion factors to kg/cm

The suggested amount of web tension is typically between 10% and 25% of the web material's elastic limit (tensile strength for non-elastic materials). That means that if it takes 100 Newtons of force (23 lb) of tension to stretch a 2.5 cm (1 in.) strip of web to the point it will permanently deform or break, then the web should level should be between a minimum tension of 10% or $100\text{N}/2.5\text{cm} \times 10\% = 4\text{ N/cm}$ (2.3 lbf/in.) and with a maximum tension of 10N (57 lbf/in.) = 25% of the elastic limit.

TIP Category: Automatically Periodically Reviewed (10 years)



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Film web conveyance and winding tension

When conveying and winding film webs, empirical data has determined that the maximum web tension for plastic films is below the level that the film is stressed to 1.5% of the modulus of elasticity of the film material.

Table 1 gives typical modulus ranges for films. Typically this would be the maximum tension for the start of the winding of the film. The unwinding and conveyance film tension would typically be in the neighborhood of 50% of this maximum tension.

Table 1. Typical secant modulus of elasticity for films

Flexible PVC	3500 – 5500 N/cm ²	(5000-8000 lbf/in. ²)
LDPE	10,000 – 18,000 N/cm ²	(15,000 -25,000 lbf/in. ²)
LLDPE	20,000 – 28,000 N/cm ²	(30,000 – 40,000 lbf/in. ²)
HDPE	56,000 – 91,000 N/cm ²	(80,000 – 130,000 lbf/in. ²)
BOPP	77,000 – 240,000 N/cm ²	(110,000 – 350,000 lbf/in. ²)
PET	140,000 – 390,000 N/cm ²	(200,000 – 550,000 lbf/in. ²)

Conversion: kg/cm² = Newton/cm² x 0.1

Example of determining maximum web tension – metric

To determine the maximum web tension to wind 50 µm (0.05 mm) low density polyethylene (LDPE) film, calculate the tension to stress the film to 1.5% of its elastic modulus. From the modulus of elasticity chart (Table 1), we can assume an average modulus of 14,000 N/cm² for LDPE.

$$1.5\% \text{ of } 14,000 \text{ is } 0.015 \times 14,000 \text{ or } 210 \text{ N/cm}^2 = 2.1 \text{ N/mm}^2$$

If the film sheet is 1500 mm wide and 0.05mm thick, then the cross sectional area is 1500 mm × 0.05mm = 75 mm². Therefore the maximum allowable tension would be:

$$2.1 \text{ N/mm}^2 \times 75 \text{ mm}^2 = 158 \text{ N total web tension}$$

Try to keep web tension at or below this level during the winding process.

Example of determining maximum web tension – English

To determine the maximum web tension to wind 2 mil (0.002 in.) low density polyethylene (LDPE) film, we need to calculate the tension to stress the film to 1.5% of its elastic modulus. From the modulus of elasticity chart (Table 1), we can assume an average modulus of 20,000 lbf/in.² for LDPE.

$$1.5\% \text{ of } 20,000 \text{ lbf/in. is } 0.015 \times 20,000 \text{ or } 300 \text{ lbf/in.}^2$$

If the film sheet is 60 in. wide and 0.002 in. thick, then the cross sectional area is 60 in. × 0.002 in. = 0.12 in.². Therefore the maximum allowable tension would be:

$$300 \text{ lbf/in.}^2 \times 0.12 \text{ in.}^2 = 36 \text{ lb total web tension}$$

Try to keep web tension at or below this level during the winding process.

Table 2 gives the suggested range of web tensions per mm of web thickness that should be applied to various materials used in the film extrusion and laminating processes.