Selecting the Proper Web Handling Equipment

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INTRODUCTION

A key requirement of every web processing line is the ability to properly handle and convey the web among the various machine sections.
INTRODUCTION

Though much time is typically spent focusing on the unwinding, winding, coating, drying, laminating and embossing sections, typically very little time is spent on the equipment sections that are required to allow for the proper handling and conveying of the web from section to section.
INTRODUCTION

The proper handling and conveying of the web covers many areas including:

• assuring that proper web tension is provided and maintained into, out of and between the various equipment sections
INTRODUCTION

The proper handling and conveying of the web covers many areas including:

• assuring that the web is provided to the next section and removed from the previous section at the proper speed/rate
INTRODUCTION

The proper handling and conveying of the web covers many areas including:

• assuring that the web is delivered to the next section at the required temperature
Additionally, in certain web processing lines there is the need to change the orientation of the web, whether by:

- turning it at right angles to the main web direction
- inverting it during processing
INTRODUCTION

In this presentation we will discuss the equipment that is required to allow for the above to occur.

We will break the equipment into four major categories which are:

• Pull Rolls
• Heating and Cooling Rolls
• Accumulators
• Web Turns and Web Flips
INTRODUCTION

For each of the above equipment categories we will discuss:

• the need for it
• the uses of it
• the factors and considerations that go into the design and selection it
• the pros and cons associated with the selection
PULL ROLLS

Overview

• A driven roll or series of rolls that are used to assist in conveying the web through the process line

• Can be found in virtually every web processing line

• Can take one of many forms, with the selection often determined by the web handling requirements
PULL ROLLS

Uses

Pull Rolls are incorporated in web lines for many reasons including:

• conveying the web at a set speed
• controlling the web tension as it travels between sections
• changing the web tension between sections
• isolating one equipment section from another
• feeding web to/removing web from a process point/operation
In order to assist in conveying the web, the pull roll must impart a force (tension) on it.

This force is provided by the motor and drive set that is attached to the pull rolls. It is calculated as follows:
PULL ROLLS
Types and Selection

\[ \frac{F_1}{F_2} = e^{m \eta \theta} \]

Where:

- \( F_1 \) = the force (tension) on the web prior to the pull roll
- \( F_2 \) = the force (tension) on the web after the pull roll
- \( \eta \) = the coefficient of friction between the pull roll and the web
- \( \theta \) = the wrap angle on the pull roll(s)
As shown by the previous formula, the amount of force that is generated by the pull roll to assist in conveying the web can be varied by:

- changing the web’s wrap angle on the rolls
- changing the coefficient of friction between the web and the rolls
There are several different designs that are used for pull rolls. We will look at a few of them, discussing their:

- design features
- advantages and disadvantages
The most basic pull roll design
Feature a single driven pull roll that is wrapped by the web
PULL ROLLS
Types and Selection
OMEGA WRAP PULL ROLL

Pros:
This is the least expensive pull roll design
Only contacts one side of the web, which for certain applications is helpful
Cons:
Because the web wraps only a single driven roll, the amount of wrap angle and therefore the amount of force that can be applied is limited.
Two driven rolls are used, with the web passing about them in an “S” configuration.
Pros:
Because it features two (2) driven rolls that are both contacting the web, the cumulative wrap angle and therefore the force is greatly increased.
Cons:
Because of the two (2) rolls this system is more expensive than the “omega” wrap pull roll
Results in both sides of the web being contacted by pull rolls, which may be undesirable
As indicated previously the coefficient of friction between the web and the pull roll impacts the ability to impart a force on the web.

As the coefficient of friction increases so too does the force.

Changing the pull rolls surface finish will change the coefficient of friction.
Several choices exist for the pull rolls surface finish, each with pros and cons:

- **Steel, with or without chrome:**
  
  - **Pros:**
    - least expensive
    - least wear (greatest lifetime and lowest maintenance)
  
  - **Cons:**
    - lowest coefficient of friction
Several choices exist for the pull rolls surface finish, each with pros and cons:

- **Rubber:**
  - **Pros:**
    - higher coefficient of friction
  - **Cons:**
    - high surface wear
    - certain rubbers may not be compatible with certain products
Several choices exist for the pull rolls surface finish, each with pros and cons:

- **Friction enhancing coatings (Plasma):**
  - **Pros:**
    - higher coefficient of friction
  - **Cons:**
    - high surface wear
    - certain coatings may not be compatible with certain products
Another way to enhance the pull rolls’ ability to apply a force to the web is by adding a nip roll.
Another way to enhance the pull rolls’ ability to apply a force to the web is by adding a nip roll.

– Pros:

• enhances the frictional force between the web and roll, particularly at higher speeds where it can iron out any entrapped air that would reduce the frictional forces
Another way to enhance the pull rolls’ ability to apply a force to the web is by adding a nip roll.

– Cons:
  - certain webs/products cannot be nipped
  - more costly
A final means to increase the force generated by a pull roll is by using a vacuum roll.

In this type of pull roll the designed allows for air to be drawn through the rolls’ surface, pinning the web to it.
A final means to increase the force generated by a pull roll is by using a vacuum roll.

- Pros:
  - design greatly enhances the coefficient of friction between the roll and the web
A final means to increase the force generated by a pull roll is by using a vacuum roll.

– Pros:
  • especially effective in areas where the available wrap angle on the roll is limited
A final means to increase the force generated by a pull roll is by using a vacuum roll.

– Pros:

• especially effective where only one side of the web can be touched
A final means to increase the force generated by a pull roll is by using a vacuum roll.

– Cons:
  • very expensive to purchase and operate
  • require a high level of maintenance
  • noisy
PULL ROLLS
Driving the Pull Rolls

Pull rolls’ drives are typically controlled one of two ways, with the process determining which is appropriate.

Speed regulated drive:

• motor’s speed is set to rotate the pull roll at a set surface speed
• typically the case when the pull roll is being used to establish the speed of the process or to feed a section
Pull rolls’ drives are typically controlled one of two ways, with the process determining which is appropriate.

Tension regulated drive:

• a force transducer roll is located in the web path to measure the web’s tension and automatically adjusts the motor’s speed/pull rolls’ speed to maintain the tension at a set point/level
HEATING/COOLING ROLLS

Overview

• Many processing lines include heating and/or cooling rolls to change the temperature of the web before entering the next process point.

• These rolls, which are typically driven, can also serve as pull rolls, performing many of the functions are previously described.
Heating and Cooling Rolls are included in web processing lines for many reasons including:

- heating a web prior to applying a hot coating
HEATING/COOLING ROLLS

*Uses*

Heating and Cooling Rolls are included in web processing lines for many reasons including:

- heating a web for the next process step such as before embossing or thermal lamination
HEATING/COOLING ROLLS

Uses

Heating and Cooling Rolls are included in web processing lines for many reasons including:

• cooling a web after a process step such as drying, embossing or thermal lamination
Properly sized heating and cooling rolls are designed to allow for the web’s temperature to be changed from that at the entry to the rolls to a desired exit temperature.

Selection of the number and size of the rolls is based on calculations that are performed based on the operating conditions.
HEATING/COOLING ROLLS
Roll Sizing and Design

In order to perform the calculations the following information is required:

• the web’s specific heat
• the web’s melt (or ignition) temperature
• the web’s temperature entering the rolls
• the web’s target temperature exiting the rolls
• the web’s thermal conductivity
• the target operating speed
• the web’s width
• the web mass throughput/thickness & density
HEATING/COOLING ROLLS

Roll Sizing and Design

In addition to calculating the number of rolls and their size, the above information can also be used to determine:

• the web wrap angle on each roll
• the temperature of the rolls’ heating or cooling fluid (and therefore the rolls’ surface temperature)
• how much heating or cooling fluid is required for each roll
HEATING/COOLING ROLLS

Roll Sizing and Design

Regarding the temperature of the heating fluid, the hotter it is, the quicker the web can be heated resulting in fewer/smaller rolls.

However, there are practical limits to how hot the fluid can be:

- if the fluid and therefore the rolls’ surface is too hot, the web may melt during line stops.
The same applies to cooling rolls, where using water that is too cool may result in condensation on the rolls’ surface, resulting in potential damage to the web.
The internal design of the rolls is critical to proper heating and cooling of the web, especially for larger diameter rolls and wider web widths.

A properly designed roll includes dual shells with spiraled flow channels between them, allowing for precise control of the fluid’s flow path and speed.
HEATING/COOLING ROLLS

Methods to Heat the Rolls

There are several methods available for providing the heat to the roll, each of which offers pros and cons:

• Water:
  – Pros:
    • readily available
    • environmentally friendly
    • offers precise temperature control
HEATING/COOLING ROLLS

Methods to Heat the Rolls

There are several methods available for providing the heat to the roll, each of which offers pros and cons:

• Water:
  – Cons:
    • takes significant time to change temperature
    • limited maximum temperature
HEATING/COOLING ROLLS

Methods to Heat the Rolls

There are several methods available for providing the heat to the roll, each of which offers pros and cons:

• Oil:
  – Pros:
    • good temperature range
    • offers precise temperature control
HEATING/COOLING ROLLS

Methods to Heat the Rolls

There are several methods available for providing the heat to the roll, each of which offers pros and cons:

- Oil:
  - Cons:
    - takes significant time to change temperature
    - not very environmentally friendly
HEATING/COOLING ROLLS

Methods to Heat the Rolls

There are several methods available for providing the heat to the roll, each of which offers pros and cons:

• Steam:
  – Pros:
    • good temperature range
    • rapid changes in temperature
HEATING/COOLING ROLLS

Methods to Heat the Rolls

There are several methods available for providing the heat to the roll, each of which offers pros and cons:

• Steam:
  – Cons:
    • not very precise temperature control
    • system can be high in maintenance
HEATING/COOLING ROLLS

Methods to Heat the Rolls

There are several methods available for providing the heat to the roll, each of which offers pros and cons:

• Electric:
  – Pros:
    • good temperature range
    • accurate temperature control
    • no fluids involved in heating
HEATING/COOLING ROLLS

Methods to Heat the Rolls

There are several methods available for providing the heat to the roll, each of which offers pros and cons:

• Electric:
  – Cons:
    • takes significant time to change temperature
    • system can be high in maintenance
ACCUMULATORS

Overview

• Accumulators are provided in web processing lines where there is a need to store in process web.
**ACCUMULATOR**

**Uses**

*Immediately after an unwind* – to allow for a zero speed splice while the process continues to run

*Immediately prior to a winder* – to allow for a zero speed transfers while the process continues to run

*In the middle of the process* – where certain operations need to be performed on an intermittent basis
ACCUMULATORS

Design Considerations and Features

Several factors that need to be considered in the design of the accumulator:

• how much storage is required to allow for the zero speed operation to occur
• how many rolls and how much travel is required to meet the storage
  – typically determined by the space available for the accumulator to be installed
ACCUMULATORS

Design Considerations and Features

Several factors that need to be considered in the design of the accumulator:

• will the moving rolls pass through the fixed rolls, allowing for straight through threading
  – this design allows for the empty accumulator to be run without the web contacting all of the rolls
ACCUMULATORS
Web Handling and Tension Control

The handling of the web in the accumulator is of extreme importance. It must be kept under controlled tension not only when it is full but also during filling and emptying. The same system that is used to control the tension is used to move the traveling rolls up and down.
ACCUMULATORS
Web Handling and Tension Control

There are several methods available for controlling the tension in the accumulator as well as move the carriage, each of which offers pros and cons:

• Mechanically counterweighted:
  – Pros:
    • least expensive
  – Cons:
    • poor tension control
    • no ability to automatically change tension
There are several methods available for controlling the tension in the accumulator as well as move the carriage, each of which offers pros and cons:

• Pneumatic cylinders:
  – Pros:
    • allows for automatic tension control
ACCUMULATORS

Web Handling and Tension Control

There are several methods available for controlling the tension in the accumulator as well as move the carriage, each of which offers pros and cons:

• Pneumatic cylinders:
  – Cons:
    • inaccurate tension control from cylinder stiction and pneumatic hysteresis
There are several methods available for controlling the tension in the accumulator as well as move the carriage, each of which offers pros and cons:

• Motor driven screws:
  – Pros:
    • allows for automatic, closed loop tension control
ACCUMULATORS
*Web Handling and Tension Control*

There are several methods available for controlling the tension in the accumulator as well as move the carriage, each of which offers pros and cons:

- **Motor driven screws:**
  - **Cons:**
    - costly
WEB TURNS AND WEB FLIPS

Overview

• Often is the case that a web needs to be turned at 90° to the process line or it needs to be inverted (turned over).

• In order to perform this a web turn or web flip assembly is required.
WEB TURNS AND WEB FLIPS

Uses

Web Turns:

• where the web line is too long to fit in a building

• where additional webs are being introduced to or removed from the primary web path and there is not a convenient location to incorporate the unwind or winder
WEB TURNS AND WEB FLIPS

Uses

Web Flips:

- in a processing line with two coating heads, where certain processes require both coatings on the same side of the web and others require one coating applied to each side of the web
- where a machine is on two levels with the web running in opposite directions on each level and where the same side needs to be facing up on each level
WEB TURNS AND WEB FLIPS

*Design Requirements and Features*

In the web turn a single bar is positioned at a 45° angle to the entry and exit web paths, which are at 90° to each other. As the web enters the section it wraps the bar 180° and exits it.
A web flip is in essence two (2) web turns positioned at 90° to each other, forming an “X”. The web enters the assembly at a 45° angle to the first bar that it contacts, wraps each bar 180° (as well as several intermediate idler rolls) and exits parallel to the incoming web path, in the same direction with the opposite side facing up.
WEB TURNS AND WEB FLIPS
Design Requirements and Features
WEB TURNS AND WEB FLIPS

*Design Requirements and Features*

A major design consideration in the use of a turn bar is the speed of the web with respect to the surface of the roll:

- as the web wraps the bar from entry to exit its angle with respect to the bar’s center axis changes from 45° to 90° and back to 45°
A major design consideration in the use of a turn bar is the speed of the web with respect to the surface of the roll:

- as the angle changes so to does the velocity of the web with respect to the surface of the roll in the rolling direction
A major design consideration in the use of a turn bar is the speed of the web with respect to the surface of the roll:

- therefore, there is no speed at which the bar can rotate that will satisfy the web’s speed with respect to it
WEB TURNS AND WEB FLIPS

Design Requirements and Features

There are three different approaches that can be employed to address this, each of which offers pros and cons:

• Non-rotating bar:
  – Pros:
    • least expensive
  – Cons:
    • the web drags over the surface which can result in a significant tension increase and significant web scratching
WEB TURNS AND WEB FLIPS

Design Requirements and Features

There are three different approaches that can be employed to address this, each of which offers pros and cons:

• Rotating bar/roll:
  – Pros:
    • relatively in-expensive
  – Cons:
    • the web still drags over the surface which can result in a tension increase and web scratching
WEB TURNS AND WEB FLIPS

Design Requirements and Features

There are three different approaches that can be employed to address this, each of which offers pros and cons:

• Air Greased or Air Floatation Bar:
  – Pros:
    • minimal to no contact between bar and web
    • no increase in tension
    • no web scratching


There are three different approaches that can be employed to address this, each of which offers pros and cons:

• Air Greased or Air Floatation Bar:
  – Cons:
    • expensive to purchase and operate
    • noisy
    • can result in cross bar web drift
WEB TURNS AND WEB FLIPS

*Design of “Air Greased” and “Air Float” Bars*

- the bars feature a hole pattern in their surface through which air is passed
- the air forms a boundary layer between the web and the bar
- as the pressure of the air is increased, the height of the boundary layer increases
- float height of the web over the bar can be calculated based on the air pressure and web tension
WEB TURNS AND WEB FLIPS

*Design of “Air Greased” and “Air Float” Bars*

- an automatic guider can be added to the last bar to address an drift in the web that occurs
CONCLUSION

As illustrated, there are several equipment sections in addition to the unwinding, winding, coating, drying, laminating and embossing equipment that need to be considered in the specifying, designing, building and operating of a web processing line. There are many items that need to be considered when integrating these sections into the processing line.
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