'Analysis of Motor Speed Effect on Winding Tension in the Wind Up Calendering Process

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***Abstract*—The winding process is widely used in manufacturing industries. For the high speed winding, the centre winding method is used. Irregular internal stresses at the centre of the roll result in major weaknesses such as buckling, spoking and cinching. Therefore, entanglement with the right tension is very important to get a stable wound package. It should be mentioned that winders usually operate based on the principle of precision winding. A typical characteristic of winders is increasing the surface speed as the diameter increases. This will cause the winding to increase which has the potential to cause damage. To overcome damage due to an increase in roll tension, the rolling motor speed must decrease so that the roll tension remains the same or even decreases. And because the rolling process uses additional media in the form of a liner fabric which is tension controlled with pneumatic disc brake, the pressure brake must also be made taper constructing both.**

Keywords: Winding, Diameter, Tension, Speed.

I. Introduction

The winding is the process used in manufacturing industries, especially in the material storage process. The centre winding roll is one of the most widely used storage for high-speed windings. But internal stresses in the middle roll produce large defects such as bumps, folding, and others. Therefore, entanglement with the right tension is very important to get a stable roll.

Winding must be done with a high level of precision. A typical characteristic of these rolls is the tension increases with increasing diameter. Increasing the surface speed will cause the velocity of windings to increase so that the tension in the roll increases.

To overcome this, the speed of the motor must be reduced as the package diameter increases. Because of that, usually in a scavenger machine like this is equipped with a spring roll to maintain if there is an increase in speed does not affect the tension on the roll. With the existence of this spring roll, it is expected that there will be no injuries or defects in the roll.

Rolling machines usually operate by passing many roll winding of different lengths. The tension acting on the treatment can be caused by the speed of the rolling motor or because of the winding roll in the process. Therefore, in this context the influence of tension and speed will be considered separately.

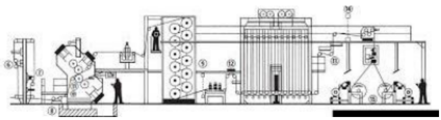

Fig. 1. Calendering Machine

II. Objectives

The objectives of the study comprising of:

- Analyze the relationship between speed and tension in the winding process.
- Analyze the causes of damage to treatment in the winding process.

III. Theoretical Perspectives

A. Wind up Calendering process

Wind up is one part of a machine that functions for the process of storing products produced by this machine. The process of storing wind up is by winding material with cores so that long material can be stored in the form of simple rollers. This machine has two wind up which aim to make the process complete and when waiting for loading, winding can be done on the other wind up. This is so that the process is more efficient and there is no delay too long when loading the stored material. This storage process is very important to control so that there is no material damage during the winding process. That is the material tension and tension liner layer used to coat the material. Because if the tension is not appropriate there will be a curve in the roll or slip that results in damaged material Sections, subsections and subsubsections

The process of winding the treatment material as shown in Figure 2. Treatment is rolled by a motor drive at the centre of the roll until the desired roll size is desired. In the process when rolling the material is coated with a liner cloth which is coiled along with the treatment. This is done so that the material is not sticky and makes it easier when the next process is done. The liner cloth is supplied from a cloth roll drawn by a rolling motor similar to the treatment rollers. The tension of the liner fabric is controlled by pneumatic brakes allowing the tension to be as expected.

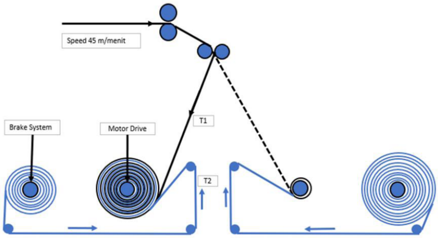

Fig. 2. Ilustration of stretching in the wind up.

To understand the relationship between diameter and speed, it is necessary to know the characteristics of the process and also the products made. The treatment material has a thickness of 0.001 m width of 1.200 m fed by a motor with a speed of 45 m/s then rolled on a roll with a diameter of 0.15 m. For this winding process, it must be coated with a liner fabric that has a thickness of 0.0007 m so that the material is not sticky during the next process.

This needs to be analysed in terms of the control of the winding. Namely on the approved liner cloth as a coating or when separator. How is this liner fabric controlled when coating the material during the rolling process. The controlled liner fabric uses brakes to rotate large diameters, the larger diameter it must be faster too.

What happens is that in-depth analysis of the brake is carried out on the liner layer, and it needs to be observed. From the results of the observations, it was found that the decrease in pressure brake data was not linearly adjusted from the start, that is, from the position of the 33-meter roll length. This happens because one method is that the initial roll of the liner is not solid so that it isn't too loose when lining it deliberately with the brake.

B. Motion Speed

If compare the rotation of two different wheels, we will find that the length of the track in one rotation between the two wheels will be different. This is because the circumference of the circle is different, while the rotation of one wheel has the same path length as the circumference of the circle of wheels. To understand this difference, we need to understand the concept of angular velocity and linear velocity in ordinary circular motions.

The definition of angular velocity is the magnitude of the curing angle of a circle formed by a point path that moves circularly per unit time. The angular velocity unit is rad/sec. Other units that can be used for example rotation per minute (rpm). Angle speed is the angle of travel divided by the time of travel. The formula for determining the angular velocity (angular velocity) of a circular moving object is as follows.

$$v = \frac{s}{t} = \frac{r\theta}{t}; \frac{\theta}{t} = \omega \qquad (1)$$

$$v = \omega r \qquad (2)$$

where: ω: angular velocity (rad/second), r: radius of circle (m), v: linear speed (m/second), and t: period (second).

Period (t) is the time it takes for an object to complete a full rotation. The period of objects that rotate n times as long as t.

C. Mathematical Models for Winding

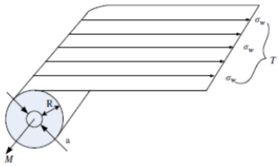

Fig. 3. Schematic of a center-wound roll.

Figure 3 shows as from the T tension geometry that works on nets and scroll coils. Whereas a is the core radius, R is the ratio of the control radius, M is the torque, and σ_w is the taper stress profile. In general, a typical tidal stress profile is applied to the winding process; they can be represented as Eq. 3 and 4, where σ_0 is the initial tension of the web, acute is a decrease of taper stress, and r is the dimension with a smaller ratio of roll radius (i.e., the roll radius is currently divided by the core radius) . In Eq. 3 and 4, σ_{w-L} and σ_{w-H} are linear taper profiles and hyperbolic taper profiles, respectively

$$\sigma_{w-L}(r) = \sigma_0[1 - (\frac{taper}{100})\frac{(r-1)}{(R-1)}] \qquad (3)$$

$$\sigma_{w-H}(r) = \sigma_0[1 - (\frac{taper}{100})\frac{(r-1)}{(r)}] \qquad (4)$$

where: $Taper$: Decrease value (0-100), σ_0: initial stress (N/m^2), σ_w: web stress (N/m^2), σ_{w-L}: web stress with linear tension profile (N/m^2), σ_{w-H}: web stress with hyperbolic tension profile (N/m^2), r: winding radius ratio, dimensionless (i.e., the radius divided by the core radius), R: outer roll radius ratio, dimensionless (i.e., the max radius divided by the core radius).

IV. Result

A. Speed motor winding

With the circle mathematical formula (Eq.1—2), we can know the roll diameter and treatment length of each layer. Then from the diameter can also be seen the rotation speed of the rolling motor so that it is equal to the feed motor speed. The results of the formulation above obtained a roll table, diameter, treatment length and rolling motor speed, shown in Figure 4.

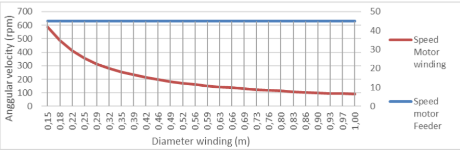

Fig. 4. Angular velocity treatment and diameter roll.

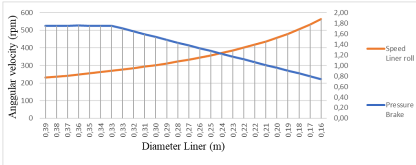

Fig. 6. Chart Speed and pressure brake for liner roll.

B. Evaluation taper tension

Two existing taper tension profiles have advantages and disadvantages of each area of the changed radius. Numerical studies show that telescoping defects are initial windings, where radial stress distribution is important to prevent starring defect. Therefore, to reduce these defects, more advanced tapered stress profiles are presented by defining hybrid alpha factors, as shown in Eq.5.

$$\sigma_w = \sigma_0[1 - (\frac{taper}{100})\frac{(r-1)}{(r + \alpha(r)(Rr1))}] \quad (5)$$

With a core radius 0,08 m, maximal radius 1 m, taper 40% and initial stress 200 N/m^2, so by entering these value in Equation 3—5 we get chart shown in Figure 5.

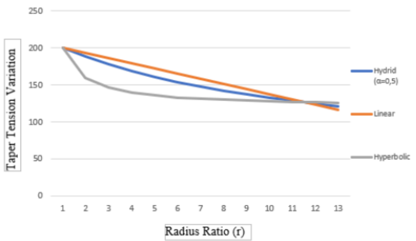

Fig. 5. Taper tension profiles in a winding process.

C. Evaluation taper brake on liner

The treatment storage process, which is rolled on a roll with a liner so that the material is not sticky. Because the treatment is made of rubber, so if it is sticky it will be difficult to do the next process. So, the liner tension also affects the defects in the roll, the tension of the liner fabric is regulated using pneumatic disc brakes. Ideally the liner tension must be less than the maintenance tension (T2 $<$ T1), if it is greater than the maintenance tension, it will worsen the defects that occur in the roll.

When performing a taper tension test, the condition of the brakes is not evaluated and abnormal conditions occur after being examined. The results of checking the pressure brakes are shown in Figure 6.

It can be seen there is no change pressure brake to a diameter of 0.33 m after which there is a decrease to the end. Meanwhile, the acceleration of work done during braking is done. After allowing a new looseness there is an increase in tension which occurs a defect occurs. Then the brake pressure reduction is done to prevent it from rising. From Figure 3 because the pressure brake is not linear it can be described:

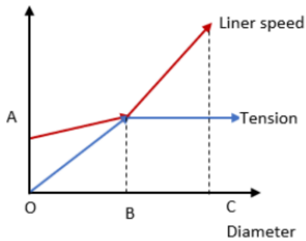

Fig. 7. Relationship between speed and tension liner.

From Figure 7 the equation:
Speed: $K \times D$, D: diameter (m), K: OA/(OC-OB), K: K after being reduce.

It can be explained that when constant speed tension increases with increasing diameter show in equation 2 and 4, when speed rises with constant K, the tension will be constant. In order for the tension to be constant, the pressure brake is made to decrease from the beginning of the roll. Pressure settings can be done by using a laser sensor that detects the diameter to be used as a feed back to control the decrease in pressure brake.

When we mark a roll that has been completed during the entanglement process, that is by giving a straight line from the midpoint to the outside of the roll, here marks what happens in the next process. After the roll treatment is placed on the Cutting Bias machine, the line is broken on the roll treatment. This occurs because of the release of tension on the roll, indicating that there is excessive tension on the roll.

This prototype will represent the control of the work process of wind up on the calender machine, the motor supplying the encoder material to calculate the number of turns that will calculate the length of the material. Encoder as input to control motor winding. From the length of material obtained the winding motor rotational speed is obtained so that the stress on the material does not increase.

V. Conclusions

The larger the roll diameter will increase the tension on the web, so that the tension does not increase there must be a decrease in speed of motor drive. From the analysis of the roll liner rotational speed has an effect on the increase in tension. The liner layer speed continues to increase at the start of the roll to a diameter of 0.33 m even though a fixed brake is carried out. This happens because the roll liner layer is not solid or loosened so that the speed continues to increase. After the liner rolls tight, the tension will increase significantly. To overcome this, a release pressure brake is carried out to keep the tension constant.

VI. Recommendations

From the observation results, the tension of the liner fabric is controlled by a pneumatic disc brake. To reduce the liner tension, the pressure brake must be lowered as the roll liner shrinks. From the graph in Figure 3 the decrease in pressure does not start from the beginning so that this causes an increase in liner tension, which affects the slip on the treatment. A decrease in pressure starts at a 0.34-meter roll diameter triggered by a photocell sensor. To overcome this, the pressure drop must start from the beginning and be linear to the end.

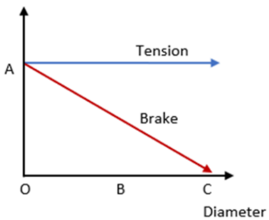

Fig. 8. Control brake linear

Figure 9 illustrates if the brake pressure is controlled from the start of the winding, so if the brakes are lowered linearly from the start, the tension will be maintained so there is no damage to the material. The tool used to control the brakes can use a laser sensor that measures the diameter of a roll or photocell that is mounted closer so that diameter measurements are more accurate and real time. This sensor will provide input to reduce brake pressure to make it better. This sensor design can be seen in Figure 8.

Of course, this will cause additional work and there is more cost to do it, but this can be calculated mathematically more favourably between allowing the scrap to occur or doing so. It is greater to pay for damaged material to be disposed of or pay an additional fee because of the liner layer compaction process before being used to coat the winding. This must be calculated and become a consideration to determine which choice will be taken later so as not to cause harm to the company.

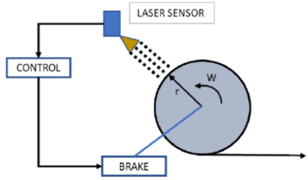

Fig. 9. Diameter measurement with laser to control brake

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