MACHINE DIRECTION LAMINATE CURL CONTROL

by

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ABSTRACT

Machine Direction Curl is a phenomenon that develops sometime after a finished laminate is allowed to relax. The root causes of this eventual curl are due primarily to the recovering of strain, in either or both Strips A and B, which were stress induced prior to and during the laminating process.

This paper reviews the Laminating process parameters that effect the development of Machine Direction Curl. It then presents Soft Roll Drive configurations and empirical procedures to provide effective influence in correcting for Machine Direction Curl.

NOMENCLATURE

T	Strip Tension
Trq	Motor Torque
E	Young's Modulus
ϵ_x	Machine Direction Strain
σ_x	Machine Direction Stress
R	Roll Radius
F_s	Surface Force
F_N	Nip Force
GR	Gear / Speed Ratio – Motor to Roll

MACHINE DIRECTION LAMINATE CURL

Figure 1. represents a typical two (2) strip-to-one (1) strip laminating process. Strip A has been coated with adhesive, which is on its bottom side as it enters the Laminator nip.

Typically, the Laminator will be configured such that the Soft Roll is working on the non-adhesive side of the strip. Therefore, if Strip B were to break, the adhesive side of Strip A would become attached to the more easily cleaned Hard Roll, as opposed to the less resilient Soft Roll.

Strip C is the finished laminate, which is typically wound downstream on a continuously transferring turret winder.

Figures 2 and 3, represent the symptoms of Machine Direction Curl.

Figure 2, where Strip B is at the inside radius of the curl, represents the relaxed results of a laminating process that experienced either excess stain in Strip B, or excess compression in Strip A.

Figure 3, where Strip A is at the inside radius of the curl, represents the relaxed results of a laminating process that experienced either excess stain in Strip A, or excess compression in Strip B.

Strip Strain Prior To Laminating

Both Strips A and B enter the Laminator Nip under independent tensions (stress), the levels of which are a function of the Modulus of Elasticity of each strip and the respective upstream section's relative speed relationship to the Laminator Nip speed. The independent tension levels of Strips A and B may or may not be actively controlled, however they do exist, and some degree of stress induced strain is being realized in both strips as they enter the Laminator Nip.

Normally, particular strips are transported at tension levels that are either limited by, or are a function of, the web transport or tension control mechanisms of the preceding upstream section, or are set at levels which provide optimal strip transport behavior (abatement of sheet flutter, sheet wrinkles, web off-tracking etc.). As such, the narrow range of lead-in tension modification of either of the two (2) strips, in order to effect induced strain - although a possible mechanism - normally allows for relatively limited influence.

The amount of strain realized by either strip is directly a function of the strip tension (stress), and Young's Modulus for the respective strips.

$$\epsilon_x = (1/E)(\sigma_x) \quad \{1\}$$

ϵ_x = Machine Direction Strain
σ_x= Machine Direction Stress
E = Young's Modulus

Therefore, strips with a low Young's Modulus (relatively extensible webs) will have greater strain for a particular tension level, and would be the best candidates for experimenting with.

For example:

If Strip A had a low Young's Modulus, modifying its strip tension may have an influence on the Machine Direction Curl of the finished laminate per the following:

1. Decreasing the tension in Strip A would tend to decrease Curl where Strip A is at the inside radius.
2. Increasing the tension in Strip A would tend to decrease Curl where Strip B is at the inside radius.

Note that 2. is not normally recommended as it would utilize increased strain in Strip A to counteract other induced strains, and would not likely be a satisfactory long term solution.

The same relative cause and effect relationships would exist if tension were modified for Strip B.

Per the above, it is seen that reducing the lead-in tension of a strip, with a low Youngs Modulus, may reduce Machine Direction Curl, where that strip is at the inside radius of the curl in the finished laminate.

Strip Strain and Compression in the Laminating Nip

Depending on the distribution of force-related loads experienced by the combination of the two (2) Laminator Roll Drives , excess strain or compression can be realized by the laminate strips during their dwell in the Laminator Nip.

The surface forces being realized by the two (2) laminator rolls and the laminate strips, as well as the related distributed roll shaft torques of the two (2) laminator rolls can be analyzed as follows:

Roll Surface Forces As A Function Of Roll Torques.

$$Fs_{S(roll)} = [Trq_{(roll)} / R_{(roll)}] \qquad \{2\}$$

$$Fs_{S\,(HrdRoll)} = [Trq_{(HR)} / R_{(HR)}] \qquad \{3\}$$

$$Fs_{S\,(SftRoll)} = [Trq_{(SR)} / R_{(SR)}] \qquad \{4\}$$

Total Roll Torque as a function of Process Loads.

$$[Trq_{(HR)} / R_{(HR)}] + [Trq_{(SR)} / R_{(SR)}] = [T_1 + T_2] - [T_3] + [NpLss_{(SR)}] \qquad \{5\}$$

$NpLss_{(SR)}$ = Soft Roll Nip Losses

The above statement indicates that the sum total of the two (2) Laminator Rolls' surface forces supports the balance of Strip Tensions leading in and out of the Laminator, plus the surface force required to work (or extrude) the surface cover of the Soft Roll, also called Soft Roll Nip Losses ($NpLss_{(SR)}$). It is assumed that bearing losses are insignificant.

Typically, the total roll surface force necessary to support the balance of tensions in and out of the Laminator ($[T_1 + T_2] - [T_3]$) is relatively low compared to the surface force necessary to support the Nip Losses of the Soft Roll. In any case, whatever the total surface force requirement, to support the balance of tensions, is (plus, minus or zero), it would be ideal if it were shared equally by each of the two (2) Laminator Roll Drives.

However, the usually more significant component, Soft Roll Nip Losses ($NpLss_{(SR)}$), ideally should be provided for solely by the Torque/Radius of the Soft Roll Drive $[Trq_{(SR)} / R_{(SR)}]$ itself.

To whatever degree the Soft Roll Nip Losses ($NpLss_{(SR)}$) component is not provided for by the Soft Roll Drive $[Tr_{(SR)} / rd_{(SR)}]$, it will automatically be delivered by the speed regulated Hard Roll Drive $[Tr_{(HR)} / rd_{(HR)}]$. With this operating condition, the Hard Roll Drive is providing a portion of the drive force required to support the Soft Roll Nip Losses, and the in-nip Laminate is engaged as the surface force transmission medium. This operating condition tends to induce additional strain or compression into the strips – which, when allowed to recover, may result in Machine Direction Curl.

Conversely, if the Soft Roll Drive delivers more Surface Force than is necessary to support the Soft Roll Nip Losses ($NpLss_{(SR)}$), the excess Soft Roll Surface Force will be transferred through the laminate to the Hard Roll surface, thereby reducing the Force and Torque contribution required from the Hard Roll Drive. As above, additional strain or compression is induced into the laminate strips – again potentially resulting in Machine Direction Curl.

Referring to figures 2 and 3, and the discussions relative to the influence of strain or compression on the direction of curl:

It should be noted that the unique nature of each laminating process, which includes the characteristics of the two (2) strips being laminated as well as the adhesive, will determine which strips are more likely to experience strain or compression relative to the direction of surface force transmission. It is not intended that this technical discussion address which laminate strips would likely experience strain or compression during particular laminating processes.

The intention of this technical discussion is to review the surface-to-surface force transmission issues presented above, and subsequently present a Laminator Drive Control Configuration and setup procedure which could neutralize the tendency to induce excess strip strain or compression while in the laminating nip.

DUAL IN-DRIVEN LAMINATOR DRIVE CONFIGURATION

LAMINATOR AS LEAD SECTION

Almost without exception, the Laminator Section should be the Lead Section (Master or Pacer) of the system. This is because the Laminator is the section where multiple webs are joined, and for any other section to function as the Lead Section would needlessly complicate the Tension Control system relative to establishing which machine sections should regulate respective upstream or downstream web spans.

HARD ROLL DRIVE

The Hard Roll Drive, with it's diameter being more stable under variable nip loading, should be configured as the Laminator Section's Speed Regulated Drive, with its speed reference developed as a direct function of the Master Line Surface Speed Reference. Refer to figure 4.

To reduce speed-loop-following-error, and thereby enhance up-steam and down-stream tension control during machine accelerations and decelerations, as well as to reduce the span of control for the drive's speed regulator and thereby improve speed loop bandwidth, Torque Feed-Forward should be incorporated for both inertia and friction compensation.

SOFT ROLL DRIVE

The reasons for applying a drive to the Soft Roll are twofold:

1. To relieve the laminate from having to provide the, otherwise required, surface-to-surface force necessary to drive the Soft Roll - if the Soft Roll were not driven by a dedicated in-drive.

2. To provide the ability to vary the torque distribution, required for laminating and roll-driving surface-to-surface forces, between the Hard Roll and Soft Roll, in order to effect machine-direction curl in the finished laminate.

Soft Roll Drive State Modes of Control

Laminator Nip Open. When the Laminator Nip is Open, the Soft Roll Drive must operate in the Speed Mode, and be surface speed matched with the Laminator Hard Roll, such that when the Nip is closed, the two (2) surface speeds are as closely matched as possible.

It is recommended that a moderate amount of Load Based Droop be introduced into the Soft Roll Drive. Therefore, if the recognition of the "Laminator Nip Closed" status is latent, relative to the actual nip closure, then the two (2) drives will not tend fight each other during this transition.

Laminator Nip Closed. With the Laminator Nip Closed, it is no longer practical to operate the Soft Roll Drive as a Speed Regulator. Once the Nip is Closed, both the Hard Roll and the Soft Roll should be considered as one, mechanically linked, laminating unit. Therefore there can be only one Speed Regulator for the Laminator Section and, as indicated above, that should be the function of the Hard Roll Drive.

With the Laminator Nip Closed and Loaded, there are a number of application issues that must be considered relative to establishing an appropriate control configuration for the Soft Roll Drive.

- Due to Laminator Nip Loading, both the radius and effective circumference of the Soft Roll are no longer stable or, to a practical extent, determinable. As such, the drive speed data, which is developed based on motor rotational-speed, is no longer valid data, relative to roll surface speed, for either control or analytical purposes.

- Depending on the cover characteristics of the Soft Roll, the rotational speed, relative to the surface speed, may increase or decrease when the nip is loaded. Relative to surface speed, the rotational speed will tend to increase due to the nip-force induced reduction in the effective radius of the Soft Roll in the nip zone. As well, some covers will tend to be extruded to a degree that increases the effective circumference of the Soft Roll when it is nipped. This latter phenomenon will tend to develop a reduction in the Soft Roll's rotational speed relative to its surface speed. Both phenomena exist simultaneously.

  Therefore, with the Laminator Nip Closed and Loaded, it is recommended that the Speed Feedback data of the Soft Roll Drive be ignored relative to it representing roll surface speed. In this operational mode, it may be more valuable to use the Soft Roll Drive's Speed Feedback data to provide Soft Roll rotational speed (RPM) information only.

- With the Laminator Nip Closed and Loaded, the surface speeds of both Laminator rolls are controlled by the Hard Roll Drive. As well, the rotational speed of the Soft Roll Drive is no longer an effective means of establishing the surface speed of the Soft Roll in the Nip Zone.

Soft Roll Speed Control Issues

Some drive control solutions focus on Speed Trim configurations for the Soft Roll Drive to influence the physical conditions in the laminating nip. These configurations of course can provide for the influence of Machine Direction Curl, but are rarely effective long-term solutions. The potential problems with Speed Control configurations for the Soft Roll Drive are due to the following:

1. Because the rotational speed of the Soft Roll is a function of the surface speed of the Hard Roll and the effective radius or extruded circumference of the Soft Roll itself, establishing a consistently appropriate speed profile for the Soft Roll is problematic.

2. Due to the physically restrictive nature of the Laminating Nip, and the difficulty of establishing the appropriate rotational speed for the Soft Roll Drive, load based Droop would be required for the Soft Roll Drive. Droop is beneficial in reducing tendency for the Hard and Soft Roll Drives' Speed Controls to fight each other.

3. Once load based Droop is incorporated into the Soft Roll Drive, speed based analysis is no longer viable.

4. The root cause of the problem is the transfer of surface-to-surface forces, required to support Soft Roll Nip Losses [$NpLss_{(SR)}$], through the laminate strips. This is, most basically, a roll-surface-force balance issue – not a speed tracking issue. Force related control solutions are best effected by Torque control configurations.

Based on all of the above surface force related issues, configuring the Soft Roll Drive as some form of Load or Torque control, as opposed to Speed control, will provide a more manageable means of influencing Machine Direction Curl.

Soft Roll Torque Control with Load Based Droop

This configuration is attractive because of its simplicity and it is inherent safety. This form of control utilizes the drive's load related data, which is typically the drive's torque reference, and factors a percentage of that data as an inverse trim to the drive's primary speed reference. Also required, for this type of application, is a moderate amount of over-speed introduced into the primary speed reference to cause the Drive to develop a forward load tendency.

Advantages.

- Simplicity – no mode changes are required when transferring from Open Nip to Closed Nip.
- No unique control strategies are required to prevent over-speed conditions if the physical linkage between the Soft Roll Drive and the Laminator Hard Roll is lost (ie failed in-drive couplings, Laminator Nip not effectively made etc.)

Disadvantage.

- Load or Torque levels are not predictable or maintainable relative to the two (2) adjustable variables, primary over-speed and percent droop. The control requires frequent attention by the operator.

Torque Control via Min-Value Reference Selection

The control configuration depicted for the Soft Roll Drive represented by figures 5. and 6. is Torque Control via Min-Value Reference Selection. The appendix presents a detailed description of how the basic Torque Control via Min-Value Reference Selection effects safe and reliable Torque Control.

For a Laminator application, a number of unique control features should be incorporated:

Bumpless Transfer from Speed to Torque Control. This feature is incorporated when the Nip is Closed, and the Drive Transfers from Speed Control to Torque Control. It is effected by the Pre-Set Ramp function introduced between the Torque-Mode Torque Reference and the Min-Value Selector.

While in the Speed Mode (SM), the Final Torque Reference (FTR) for the Drive is the Speed Regulator Output (SRO). The SRO data is also provided to the Preset Ramp which, when in the Speed Mode, also links this data to the Torque Input of the Min-Value Selector (MVS). The primary input to the Ramp is, as always, the Torque Mode Torque Reference required for Laminating.

When the Soft Roll Drive is transferred from Speed Mode to Torque Mode, at the Laminator Nip Closure, the Torque Reference to the MVS is then ramped from the existing SRO level to the new Torque Mode Torque level, effecting a bumpless transfer.

Inertia Compensation. Two (2) methods of developing the Torque-Mode Torque Reference for the Soft Roll Drive will be discussed below – Load Sharing Torque Control, and Independent Torque Control.

If Load Sharing Torque Control is utilized, a separate Inertia Compensation is **not** required for the Soft Roll Drive.

If Independent Torque Control is utilized, then a separate Inertia Compensation is suggested, such that the Profiled Torque Reference is required to support only the Soft Roll Nip Losses [$NpLss_{(SR)}$].

Load Sharing – Figure 5

This method of control should be utilized when it is desired to have the Load, or Torque, of the Soft Roll Drive always at a particular percentage of the Hard Roll Drive. This method of control is moderately successful when the desired relative load of the Soft Roll is not particularly high compared to the Hard Roll Drive.

Because, for a particular total Laminator Section Load, it should be noted that as the Torque contribution from the Soft Roll Drive is increased, the Torque required by the Hard Roll Drive will decrease. With this situation, the Torque Reference data of the Hard Roll Drive, which with Load Share Control is also the base data for the Soft Roll Torque Reference, will reduce proportionately.

Total Laminator Torque is equal to the sum of the Hard and Soft Rolls' Torques:

$$Trq_{(Ttl)} = [Trq_{(HR)}] + [Trq_{(SR)}] \qquad \{6\}$$

The Soft Roll Torque is the Product of the Hard Roll Torque and the Load Share Factor:

$$Trq_{(SR)} = [LS] \times [Trq_{(HR)}] \qquad \{7\}$$

Therefore: $Trq_{(Ttl)} = [Trq_{(HR)}] + [LS]\,[Trq_{(HR)}]$ {8}

$[Trq_{(HR)}] = [Trq_{(Ttl)}] / [1 + LS]$ {9}

This phenomenon will disallow Soft Roll Torque levels that approach or exceed 100% of the total torque required for the Laminator.

The Load Share factor can be negative, if it is desired that the Soft Roll Drive provide reverse (regenerative) torque. However if a negative Load Share factor is allowed for the Soft Roll Drive (resulting in regeneration), then it is necessary for the control to include a check for reverse rotation of the Soft Roll Drive, and initiate a drive shut down if it would occur. This feature is necessary to prevent a reverse rotation over-speed if the Soft Roll Drive were to loose mechanical linkage with the Laminator Section, while being commanded to deliver reverse torque.

Advantages.
- Torque Regulated as opposed to Speed Regulated.
- Loads related to Strip Tension differential are automatically compensated for.
- Only one Inertia Compensation is required

Disadvantages.
- The span of Soft Roll Torque contribution is limited.
- Cannot profile Soft Roll Torque relative to Soft Roll Nip Losses [$NpLss_{(SR)}$].

Independent Torque Profiling – Figure 6

Because, as indicated in the **"Strip Strain in the Laminating Process"** portion of this discussion, typically the largest portion of the Surface Force related torque required for the Laminator Section is to support the Soft Roll Nip Losses [$NpLss_{(SR)}$]. Therefore, for the Torque Control of the Soft Roll Drive to provide the optimum control of the Laminating Nip surface-to-surface forces that influence Machine Direction Curl, it is best that the Torque Reference for the Soft Roll Drive be independently profiled.

The torque contribution by the Soft Roll Drive can be set greater than the total torque required for the Laminator Section, thereby requiring the Hard Roll Drive to operate in the regenerative mode.

As with the Load Share configuration, if the Independent Torque control allows for a negative Profiled Torque Reference, the control must include a check for reverse rotation, and drive shut down if it were to occur.

Advantages.
- Torque Regulated as opposed to Speed Regulated.
- Soft Roll Torque can be independently profiled relative Nip Losses, process speed, or any other operational parameters.
- Broad span of Soft Roll torque contribution.

Disadvantage.
- Requires independent inertia compensation.

ESTABLISHING SOFT ROLL DRIVE PROFILED TORQUE LEVELS

Because the Soft Roll Torque level, associated with the Soft Roll Nip Losses, is the primary relationship to be established for the optimum Torque Reference Profile for the Soft Roll Drive, the following experiment is suggested.

1. With the Laminator Nip open, operate the Hard Roll Drive throughout the normal laminating speed range. Record the per-unit torque data of the Hard Roll Drive relative to laminating speed.

2. Translate the Per-Unit Hard Roll Drive Torque data, relative to laminating speed, to Equivalent Soft Roll Drive Per-Unit Torque, based on the Soft Roll-to-Hard Roll ratios of drive: Rated Torque, Roll Radii and Speed Reducers, per the following equation:

$$Trq_{(PU\text{-}SR)} = [Trq_{(PU\text{-}HR)}] \times \frac{[(Trq_{(rtd\text{-}HR)})\ (GR_{(HR)})]}{[(Trq_{(rtd\text{-}SR)})\ (GR_{(SR)})]} \times \frac{[R_{(SR)}]}{[R_{(HR)}]} \qquad \{10\}$$

3. Uncouple the Hard Roll in-drive, at the Hard Roll, such that the Hard Roll is free of the in-drive system.

4. With the Laminator Nip closed and loaded, operate the Soft Roll Drive throughout the normal laminating speed range. Record a family of Per-Unit Torque data of the Soft Roll Drive, based on incremental Laminator Nip Loading relative to the same laminating speed points of item 1. above.

5. Subtract, from these torque data, the Equivalent Soft Roll Drive Per-Unit Torque values calculated in item 2. above.

6. This final set of data represents the per-unit torque of the Soft Roll Drive, required to support Soft Roll Nip and In-Drive Losses, relative to a combination of Nip Loadings and Laminating Speeds. This data can be utilized as operator reference material, or to develop an automated Profiled Torque Reference Control for the Soft Roll Drive.

CONCLUSIONS

- Because Laminator Nip Induced Machine Direction Curl is a symptom which develops due to the transmission of surface-to-surface forces through the laminate strips, configuring the Soft Roll Drive as an adjustable Torque Controller provides the most effective method of controlling these forces.

- Independent Profiled Torque Control (figure 6) is the most effective configuration for implementing the appropriate torque based surface-to-surface force distribution between the Soft and Hard Rolls.

- By implementing the drive torque monitoring procedure, outlined under **ESTABLISHING SOFT ROLL DRIVE PROFILED TORQUE LEVELS**, a set of data can be developed which can provide the basis for establishing the required Soft Roll Drive Torque Profile, required to neutralize Machine Direction Curl.

APPENDIX

TORQUE CONTROL VIA MINIMUM VALUE SELECT

The primary requirement to effect Torque control is that the speed of the driven equipment must be regulated, or limited, by the mechanical system.

The second practical requirement for effective Torque Control is to provide a method of limiting the speed of the drive if the linkage to the mechanical system is lost or compromised. This would occur if there was a drive train failure (belts or couplings) or, in the case of the driven assembly becoming unlinked from the primary mechanical system, without the control-logic-knowledge of that status.

Referring to figure 5 or 6 of this paper, the speed reference for the drive is biased to a level above the physical speed of the mechanical equipment to which it is linked. For most applications, a percent and a fixed over-speed should be introduced. The fixed over-speed is to ensure proper control action near zero (0) speed, and the percent factor is to satisfy conditions at or approaching maximum speed.

Assuming that the physical speed of the Drive is limited by the mechanical system, and therefore its speed feedback is less than the biased speed reference to the drive's speed regulator, then the speed regulator output will slew to its maximum forward (positive) torque level (often referred to as "saturated").

The "Min Value Select" will compare this saturated Speed Regulator Output data to the lesser "Profiled Torque Reference", resulting in the latter being utilized as the Torque Reference for the drive.

If the physical linkage between the Drive and the mechanical system can not absorb the torque delivered, its physical speed will tend to increase towards the above indicated biased over-speed level. If the over-speed level is reached, the speed regulator will then begin to modulate. The MIN Value Select will then compare this modulated Speed Regulator Output data to the higher "Profiled Torque Reference" - with the former being selected as the Torque Reference for the drive, resulting in a "Speed Regulated Drive".

With this Min-Value configuration, torque control with speed limitation is achieved.

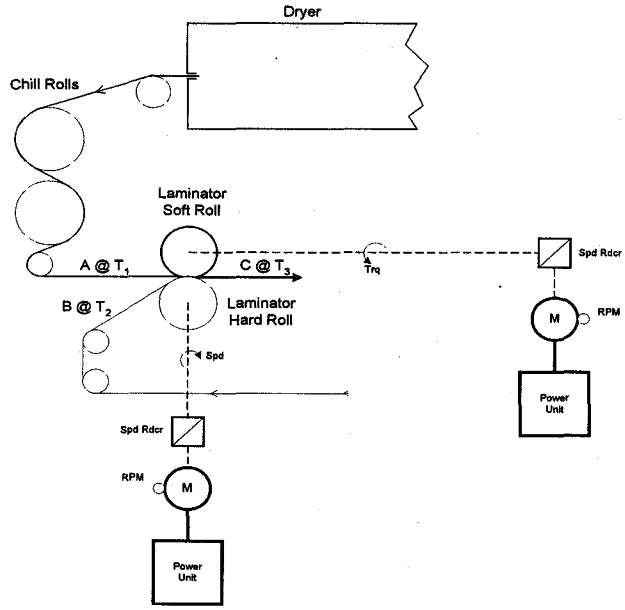

Figure 1

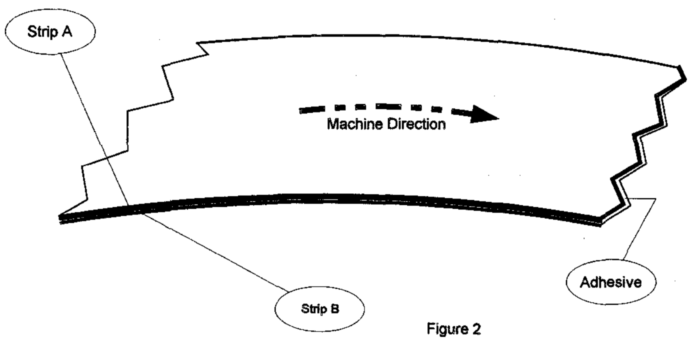

Figure 2

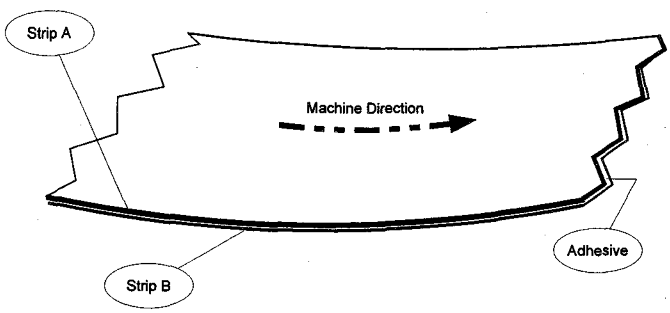

Figure 3

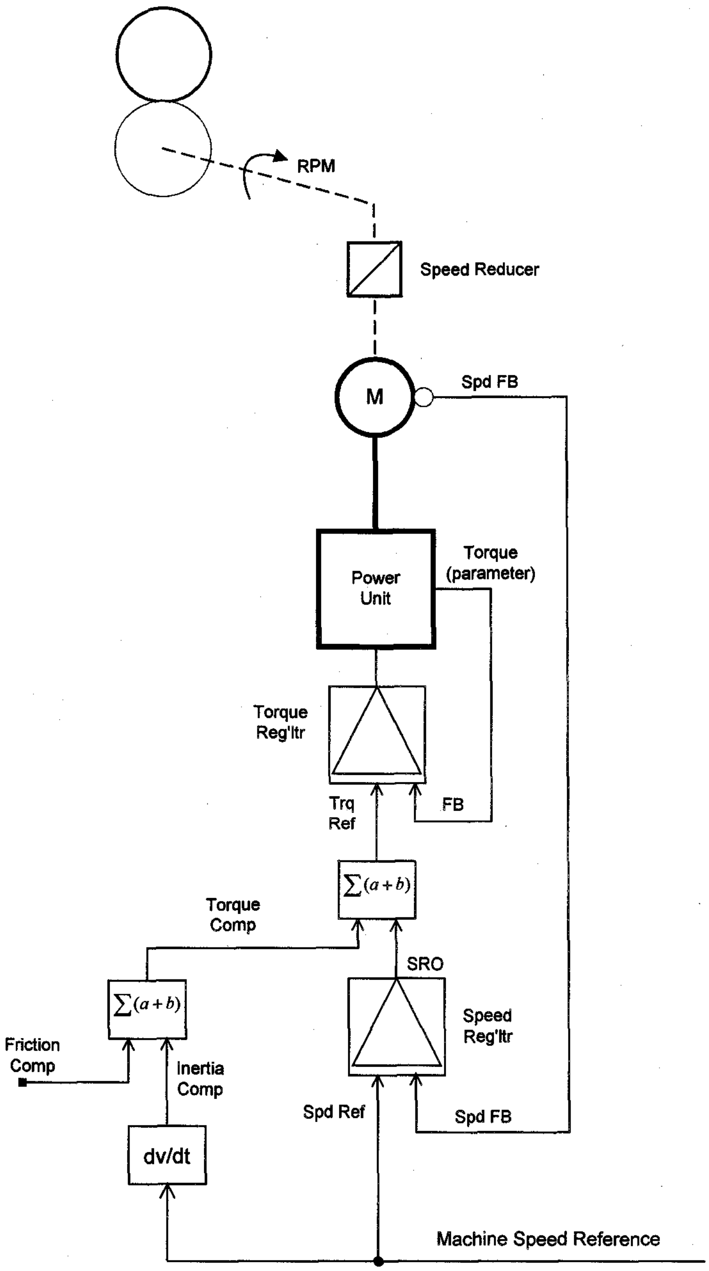

Fig. 4 Speed Regulated Hard Roll Drive

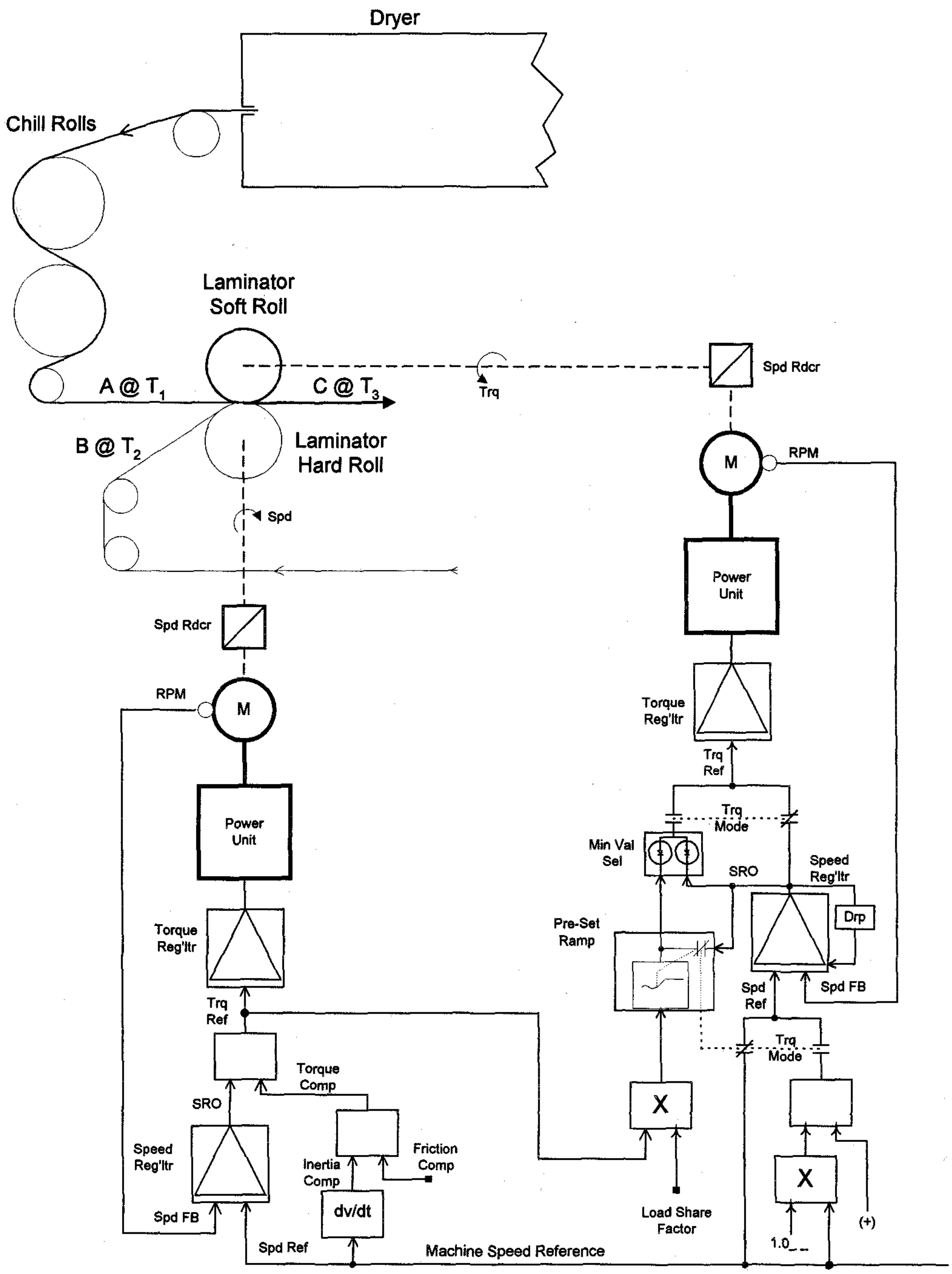

Fig. 5 Load Share Torque Controlled Soft Roll Drive

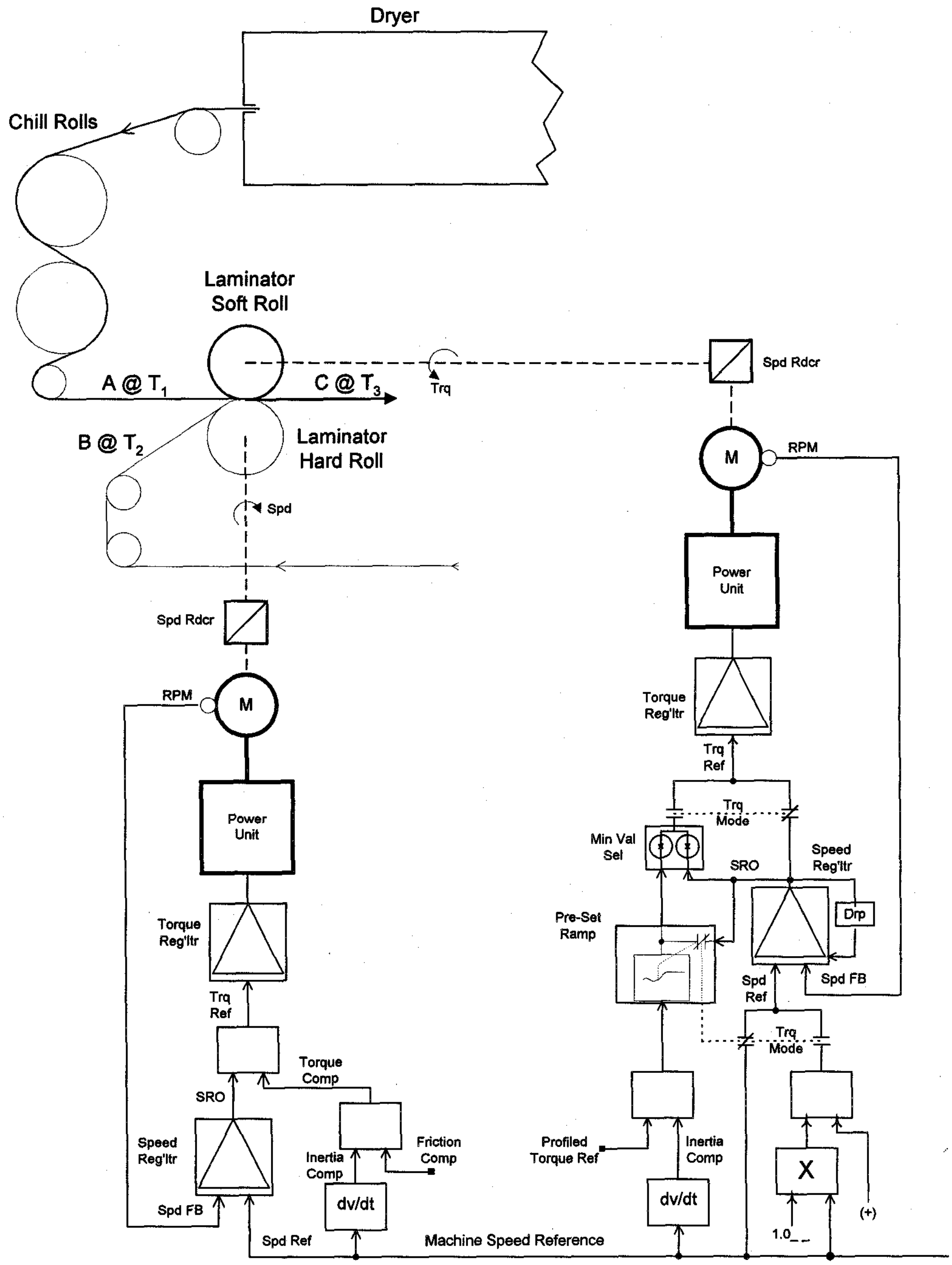

Fig. 6 Independent Torque Profiling Soft Roll Drive

P. Werner
Machine Direction Laminate Curl Control
6/8/99 Session 2 12:45 - 1:10 p.m.

Question - Duane Smith, Black Clawson Co.
Once you've established this torque at different speeds then I'm assuming that if you got a curl in the reverse direction or positive direction you would go back and correct this chart for the profile curl that your looking for. Is that correct?

Answer – Pete Werner, Rockwell Corporation
That is correct. Most people do it much more empirically. They look at the result of rolls being used downstream and then make a correction, without necessarily going back and having the discipline of updating their curve. Your suggestion would be the ideal thing to do.

Questions:
That would be the way to take care of a curl problem, because curls are always a problem with us and they keep wanting to blame it on the winder and we have to look downstream at the laminator. But with an independent torque drive, which is not a load share and not a speed regulator, is it okay to go ahead and get your curl by using this torque limit?

Answer - Pete Werner, Rockwell Corporation
What torque control and independent torque give you is you can now isolate that as an independent variable. You are correct with regard in how to deal with curl.

Questions - David Pfeiffer, JDP Innovations
Have you dealt with a situation where the top layer of the laminator is a soft polyethylene and the base sheet is very inextensible Mylar or polyester type of material and the laminator is kind of gooey?

Answer - Pete Werner, Rockwell Corporation
Could you give me an example of a product like that?

Questions - David Pfeiffer, JDP Innovations
I'm not disclosing a particular product, but I know its a real problem when the tensile modulus of the two materials, the top laminate and the bottom one are wildly different. You have a softly modulus on top and straining is difficult.

Answer - Pete Werner, Rockwell Corporation
If you move to a laminating process where you don't have the rubber roll captured by the mechanical system, then torque control isn't viable. It is important in any torque application that that the torque regulated drive is limited by the physical speed of whatever it's linked to. I don't know what kind of laminating process you had there, but it is likely that there are processes where you can't deal with a force applying system.

Questions:
Have you looked at the shear wave that is in the rubber back up of the roll itself? Because there is that speed difference due to the rubber flowing through the nip that requires the rubber to accelerate into the nip and that makes a shear transmission at the surface.

Answer - Pete Werner, Rockwell Corporation
I haven't. Again my discipline is not that much into the characteristics of the surface; it's in the mechanism to be able to provide speed or torque. No I don't have any particular experience with that.

Questions:
A similar problem exists in rotor rearview printing that uses a rubber back up roll and it tends to smear the ink if the torque's aren't matched up there, and Bob Uppenhimer (TGA graphics) published a paper on that in the 60's. Its a commonly encountered problem that the shear and the rubber backup roll will cause you curl inducement or problems which you could probably get out of with torque adjustment.

Answer - Pete Werner, Rockwell Corporation
But again, torque control would be the proper way to control that rubber roll opposed to speed control. The big point in this discussion is that people still often try to deal with the rubber roll as a speed regulator because they feel as they increase and decrease the speed they can do something; and indeed they will effect or influence curl, its just not manageable. You can't put numbers on it as well as with this approach.

Question -David Roisum
Would you recommend using regenerative drives on both those positions so you can extend the range with what you can do with the strain balance?

A- Pete Werner, Rockwell Corporation
There are people who want to go to the extreme of having one drive overhaul the other. And that's obviously to the point where they are starting to induce strain with the drive that, maybe either the tension leading into it can not be modified enough, so they modify the other strip. But yes, it is not uncommon that they will have the rubber overhaul the steel, or steel overhaul the rubber. In that case both drives need to be regenerative; at least the one that's overhauling. Its a good idea in any web handling system, particularly when you are dealing with three strips, is to have the ability to maintain tension balance. You may have a high downstream tension, downstream of the laminator, and it is also important to have the two strips leading into the laminator as low as you can get them, and still transport the sheet because you don't want to preinduce strain. Its not uncommon to have low tensions coming in as low as can transport the sheet and downstream of the laminator with higher tension. So generative drives are required for that.