A Case History for Assessing Power Requirements on Line-Shaft Driven Sections for the Purpose of Converting the Sections to Electrical Sections

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Abstract: - **A line-shaft drive paper machine was investigated while operating to determine the individual power requirement of each section. A step by step sequence of tests was developed to isolate the operating power requirements of each section. This paper documents the steps required for this power evaluation and generalizes the recommendations for other paper machines.**

Index Terms – Line-shaft, Drive Power, Drive Revamp.

I. Introduction:

When converting a line-shaft driven or a partially line-shaft driven paper machine to a sectional electric, it is important to determine the actual power requirements for each section. Due to the fact that line-shaft driven paper machines are older, the necessary original documentation defining the power requirements may not be available. Even if the original design power information is available, many mechanical or operational changes may have been made to the paper machine which will typically increase the power required for the sections.

Another means of estimating the power required for a section is to use the TAPPI recommended calculations. However, in the TAPPI calculations, many of the mechanical parameters of the section must be known which, may also be difficult to obtain for older machines. For these reasons and others, it is certainly reasonable to take data from the existing machine while it is operating and use this data to estimate the power requirements.

II. Machine Configuration:

The paper machine under study is of a tissue machine design. The original machine was designed and supplied in 1974. The details of the machine are tabulated in Appendix A.

The original machine consisted of the following:

Forming section with the Couch and Wire Turning rolls being driven. The Wire Turning is connected to and powered by the line-shaft drive. The Couch is an electrical helper drive.

The Press section with the Suction Pressure roll being powered by an electrical helper drive.

Yankee dryer section with the Yankee connected to and powered by the line-shaft drive.

The 1st Dryer section which is connected to and powered by the line-shaft drive.

The 2nd Dryer section which is connected to and powered by the line-shaft drive.

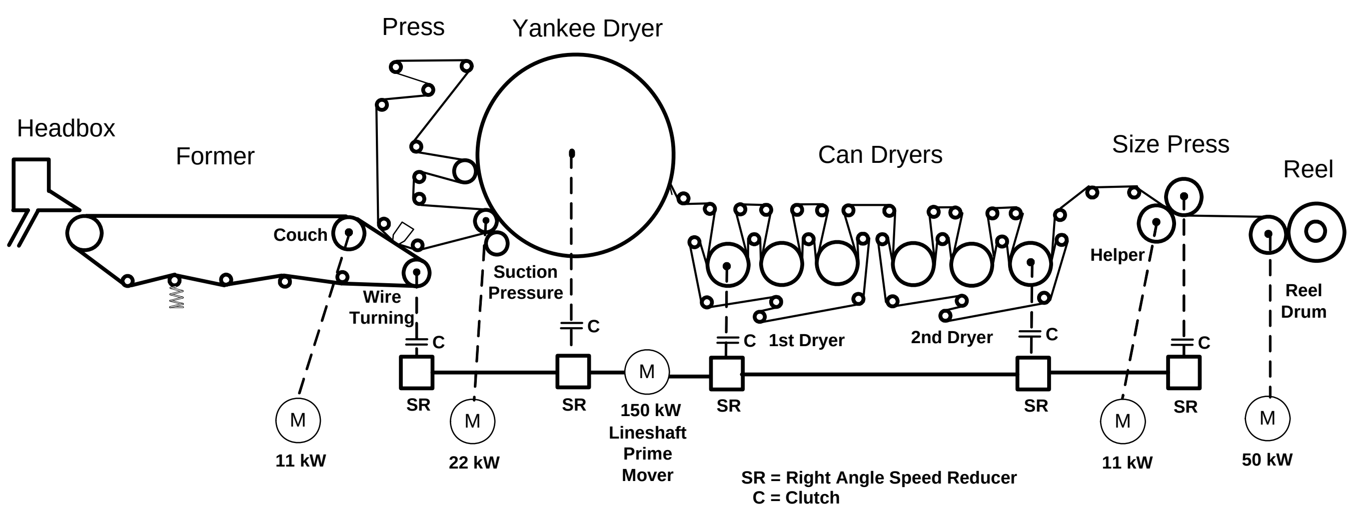

Fig. 1 Original Configuration

Size Press section with the Top and Bottom rolls being driven. The Top roll is connected to and powered by the line-shaft drive. The Bottom roll is an electrical helper drive. Drying of the sheet after the Size Press is accomplished by air dryers and no drives are involved.

The last section is a Reel section and is powered by an electrical sectional drive.

The Line-shaft is powered by a 150 kW dc motor. All of the electrical helper drives are powered by dc motors. Refer to Fig. 1 Original Configuration.

A discussion of the different sections is worthwhile at this point to set the stage for the data acquisition. An understanding of the driven points and the regulation configurations is important as well

The Forming section consists of the Breast roll and dewatering elements such as vacuum boxes and foils, Couch roll, Wire Turning roll and Wire Return rolls. The Couch roll has an internal vacuum box for dewatering and it is driven by an electrical helper drive. The Wire Turning roll is powered by the line-shaft. The speed of the Former is determined by the line-shaft as it drives the Wire Turning roll with a mechanical draw adjustment. The electric drive of the Couch roll is a torque helper providing a fixed amount of torque based on the operator adjustment.

The Press section is driven by the electric drive of the Suction Press roll when the press is not nipped to the Yankee. During normal operation the Suction Press roll is nipped against the Yankee dryer. In this manner the Yankee dryer will determine the speed of the press felt and the Suction Press roll is a torque helper to the Yankee with an adjustment by the operator.

The Yankee Dryer is powered by the line-shaft and is the master speed regulated drive (i.e. no draw control) of the machine.

The 1st Dryer section is powered by the line-shaft and is therefore speed regulated with draw control.

The 2nd Dryer section is powered by the line-shaft and is therefore speed regulated with draw control.

The Size Press section consists of two rolls. The Top roll is powered by the line-shaft and is thus speed regulated with draw. The Bottom roll is an electrical helper drive and is a torque helper to the Top roll providing a fixed amount of torque based on the operator adjustment.

The Reel section is an electrical sectional drive powering the Reel Drum. The drive is a speed follower to the line-shaft with draw control.

The Line-shaft drive is the master speed controller for the entire machine. The Yankee dryer normally has no draw with respect to the Line-shaft. All other sections have draw control with respect to the Line-shaft speed.

III. Steady State Data Gathering

In order to minimize the interruption of production it was recommended to take the data in steps as the machine was being shut down for maintenance. Also, it was recommended to take the sheet off of the machine starting with the Reel section and working back towards the Forming section. Multiple sets of readings should be taken at different speeds to insure the entire range of products is taken into account.

Step 1 – Prepare a spreadsheet listing all of the machine sections, with relevant entries to enable calculation of the power requirements for each section.

Step 2 - With the sheet on the Reel, take data from the Reel Drum drive. The data is to consist of the drive voltage, current, speed and field current. All of the existing drive motors are dc motors. Calculate the power requirement of the Reel Drum drive for consistency.

Step 3 - Take the sheet off the Reel so that the Reel drive does not affect the Size Press power. This is very important on a paper machine where the Reel can affect the power and tension at the incoming to the Size Press. On a tissue machine tension is not normally transmitted through the sheet so the Reel would have no affect on the Size Press. Record the data for line-shaft drive and the Size Press helper drive.

Step 4 - Break the sheet after the 2nd Dryer and open the Size Press. Record the data for the line-shaft drive and the Size Press helper. The difference between the power calculated in Step 3 minus the power calculated in Step 4 is the process load of the Size Press on each of the rolls. The power recorded for the Size Press helper at this step is the power required just to rotate the roll with no process (sheet) requirements.

Step 5 – Stop the Size Press main roll by opening the clutch which is interlocked to stop the Size Press helper also. Record the line-shaft data. The difference in the line-shaft power requirements between Step 4 and 5 is the power required just to rotate the main Size Press roll.

Step 6 – Break the sheet after the Yankee Dryer and stop the 1st and 2nd Dryers. Record the line-shaft data and calculate the line-shaft power. The difference in the line-shaft power between steps 5 and 6 is the Normal Running Load of the two dryers. The two dryers are identical so the power requirements can be split between the two dryers. Record the Suction Pressure data and calculate the power.

Step 7 – Break the sheet after the Former and take the sheet into the Couch pit. Un-nip the Suction Pressure from the Yankee dryer and stop the Yankee dryer. Record the line-shaft data and calculate the line-shaft power. Record the Couch and Suction Pressure data and calculate the power. The difference between step 6 and step 7 of the line-shaft power plus the Suction Pressure roll power is the Normal Running Load power required by the Yankee dryer and the Suction Pressure roll. This total power would be split between the Yankee dryer and the Suction Pressure roll. The power required by the Suction Pressure roll when it is not nipped is the least amount of power required by the Suction Pressure roll.

Step 8 – The total of the power of the line-shaft and the Couch in Step 7 would be the total power required by the Former. This total power would be split between the Couch and the Wire Turning rolls. A normal split would be 40% of the power by the Couch and 60% of the power by the Wire Turning.

On this machine the Line-shaft prime mover is a dc motor from which data can be gathered readily for the power calculations. Many Line-shafts are driven by steam turbines. In the case of steam turbines the pressures and the flow of steam must be used to develop the power calculations including the efficiency of the turbine in order to arrive at real power.

Once the data has been collected and the calculations have been done, it would be reasonable to compare the results with the TAPPI recommendations. Appendix B contains a form that can be used to collect data and tabulate the results. The latest information for sizing drives per TAPPI is contained in the “Paper Machine Drives – Short Course”.

IV. Acceleration Data Gathering:

When using a line-shaft drive to accelerate a section of a paper machine, it should be remembered that practically all of the line-shaft-power can be used to accelerate the section. This can yield relatively short acceleration times which may not be as practical when the section is powered by a smaller sectional drive.

For a fixed inertia the acceleration time of a section is dependent on the power available from the line-shaft prime mover and the power transmitting ability of the clutch which in turn is dependent on the clutch air pressure. In general, the short acceleration times that can be obtained with a line-shaft prime mover are not considered required when using sectional drives. A normal acceleration rate usually is in the range of 22 f/min/sec (6.7 m/min/sec).

Deceleration of the sections is different with a line-shaft drive system. Deceleration consists of opening the clutch and the mechanical drive will coast to a stop. This is normally acceptable on the wet end of the machine where the friction loads on the mechanical drives is significant. On the dry end of the machine where the inertia of the mechanical load is consider large and the friction load is low, the deceleration by coasting can require considerable time. A mechanical brake can be added at some cost. Some machines may have “creep” drives which sometimes are used to brake the sections. A sectional drive will normally be able to stop the mechanical drive by regeneration to the electrical mains by converting the kinetic energy into electrical energy. This provides a much shorter stopping time.

The means of determining the acceleration requirements is accomplished by clutching in each section individually and recording the line-shaft motor data along with the times of acceleration. Appendix B contains a form that can be used to collect the acceleration data and tabulate the results. Based on the resulting power calculations, the sectional drive can be selected considering the acceleration power requirements and the steady state operational power requirements.

V. Conclusion:

The methodology of data taking on a line-shaft tissue machine for normal running and acceleration/deceleration conditions has been presented. This method can be used for all machines but with caution. As mentioned earlier, once the sheet can transmit tension, the power requirements can be affected by the following drive sections. By using a step by step procedure, the data is accumulated in the most efficient manner and can be used to determine the experienced power. The power that is experienced can be used with logical means such as TAPPI guidelines to recommend the power requirements of each section.

VI. References:

R.P. Derrick and T.O. Trueb, “Application of Drive Systems”, *TAPPI Paper Machine Drives – Short Course*.

A. Lowe, “Paper machine Drive Control Strategies”, *TAPPI Paper Machine Drives – Short Course*.

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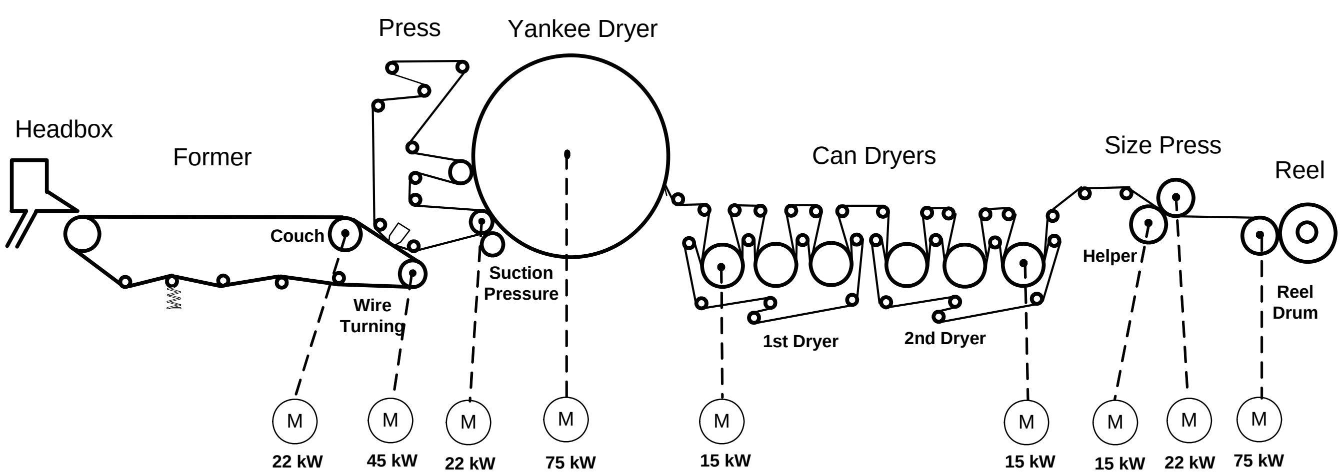

Fig 2 Configuration After the Revamp

Appendix A:

Machine Data

Production speed:	152 m/min (500 f/min)
Line-shaft speed:	500 r/min
Suction Couch diameter:	620 mm
Suction Pressure roll diameter:	750 mm
Wire Turning roll diameter:	600 mm
Wire Turning roll face:	3.95 m
Yankee Dryer diameter:	5 m
Yankee Dryer face:	4.11 m
Can Dryers diameter:	1.25 m
Size Press rolls diameter:	600 mm
Size Press rolls face:	3.76 m
Wire width:	3.86 m
Suction Pressure roll:	70 N/mm (400 PLI)
Size Press rolls:	35 N/mm (200 PLI)

Appendix B:

Data Gathering Formats

COMPANY:______________________, LOCATION:__________________
MACHINE:______________________,

DATE OF READINGS:__________, BY:_______________,
MACHINE SPEED:_____________, BASIS WEIGHT:________

DRIVE SECTION	MOTOR VOLTS	MOTOR AMPS	SPEED (f/min)	MOTOR FIELD AMPS	CALCULATED RESULTS HORSE-POWER	CALCULATED RESULTS HP/ 100f/min
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

COMPANY:______________________, LOCATION:__________________
MACHINE:______________________,

DATE OF READINGS:__________, BY:_______________,
MACHINE SPEED:_____________, BASIS WEIGHT:________

DRIVE SECTION	MOTOR VOLTS	MOTOR AMPS	SPEED (f/min)	MOTOR FIELD AMPS	ACCEL/ DECEL TIME	CALCULATED RESULTS HORSE-POWER
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						