Electronic Line Shafting-Control for Paper Machine Drives

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Abstract - This paper deals with the performance analysis of the paper manufacturing process through synchronized motion control system. The current synchronized motion control method used in paper machine drives are not designed to posses the inter-shaft stiffness properties which were responsible for the coordinating force inherent in classical, mechanically coupled paper machines. Consequently, these controllers cannot easily maintain coordination for all operating condition. This paper presents the application of an "Electronic line-shafting" control technique which serves to replicate and even improve on the mechanical line-shafted properties.

Keywords-Electronic line shafting, Drive system.

1 Introduction

The objective of choosing this work is, in some of the paper industry is still using synchronized motion control method. Currently used synchronized motion control is not sufficient to synchronized speed of the entire rolling cylinder. Due to speed synchronization in paper machine, lots of problem is arrive like paper breaking, paper thickness is not maintain constant , quality if the paper. To synchronize speed of rolling cylinder electro mechanical control system needs to use.

In Nagpur region most of the paper industry is use synchronize motion control system,one of paper mill from Bazargaon MIDC was identified, which use motion control system. Bazargaon paper mill is located in Bazargaon village. 35 Km away from Nagpur, on Nagpur-Amravati road, plant is having capacity 100TPD currently Bazargaon paper mill is operating on mechanical line shaft drive system. The systemconsists of a speed controlled motor driving a long shaft all the way along the different mechanical section. Each section is coupled to the line shaft through a gear box, conical pulleys, and the section connecting shaft. This mechanical arrangement assures that the entire system shaft will remain rigidly locked to each other through the common line shaft, even in the presence of disturbances on individual section. The only steady-state relative motion is due to torsional windup of shafts transmitting the driving torque.

2. Papermaking Process

Fig.1 shows the schematic diagram of paper making process, the papermaking process is to dilute and disperse the prepared material, or paper stock, spray the paper stock on wire cloth to form a paper sheet, and drain water from the sheet and dry it. A paper machine consists of a paper machine mainframe and auxiliary equipment. The paper machine mainframe consists of a stock inlet, wire part; press part, dryer part, size press, calender, and reel along the flow of materials. The auxiliary equipment consists of a driving unit, approach pipes that supply raw materials and circulate white water, a vacuum system that drains water from the wire part and press part, a drainage system that supplies and recycles steam for the dryer bank, an air system that circulates and uses air for drying and recovers waste heat, etc. Papermaking machines are roughly classified into the Fourdrinier machine and the cylinder machine according to the type of wire part, and the multiple cylinders dryer and the Yankee dryer according to the type of dryer part. [1]

3. Line Shaft Drive System

Early paper machine drives were constructed with mechanical interconnection components that produced motion with respect to a common line-shaft input. The mechanical power was produced by a single motor driving a line shaft to which all of the in-shafts were attached.

Fig.2 shows a simplified arrangement of a line-shaft drive. It consists of a speed-controlled motor driving a long shaft all the way along the different mechanical sections. Each section is coupled to the line shaft through a gear box, conical pulleys, and the section connecting shaft. Conical pulleys allow draws to be set in the different mechanical sections. Assuming no belt slip in the conical pulleys, this mechanical arrangement assures that all the system shafts will remain rigidly locked to each other through the common line shaft, even in the presence of disturbances on individual sections. The only steady-state relative motion is due to torsional windup of shafts transmitting the driving torque. [2]

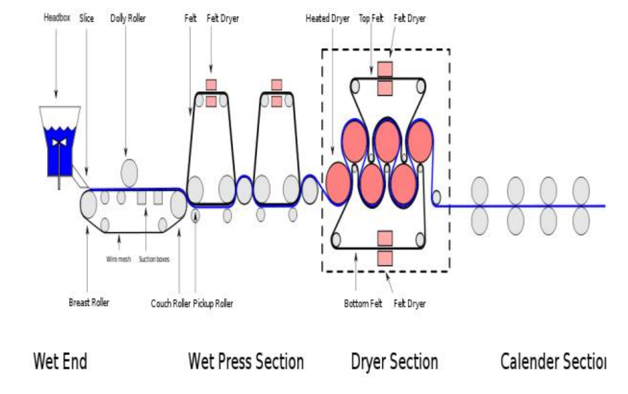

Fig. 1– SCHEMATIC DIAGRAM OF FOURDRINIER MACHINE SECTIONS

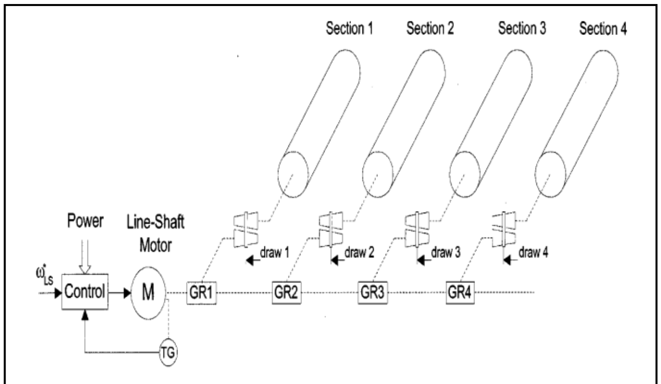

Fig. 2 – LINE SHAFT DRIVE SYSTEM

3.1 Sectional Drive System

As advances in power electronics and high-performance drives became available, the line-shaft structure evolved into modern, individual dc and ac sectional drives, which allow an increase in the operating speed and sectional power of paper machines. Fig.3 shows a simplified arrangement of a sectional drive. Each mechanical section is driven by a fully controlled drive (some sections might have more than one). All the sectional drives are "electronically synchronized" through the master reference command and the draws are set adding an auxiliary signal to the master reference. During a load disturbance in such a system, the speed in the disturbed section will decrease momentarily until the drive control is able to restore it to the reference speed. During this transient period, the loss of synchronization might cause a web break.

Therefore, although the increased power and flexibility allowed by sectional drives provided enormous strides in paper manufacturing, it lost the inter-shaft state feedback inherent to the line-shafted drives which was the driving force for the coordination of the multiple mechanical sections. Its properties are not achieved by the sectional drive control topology currently in use [2]

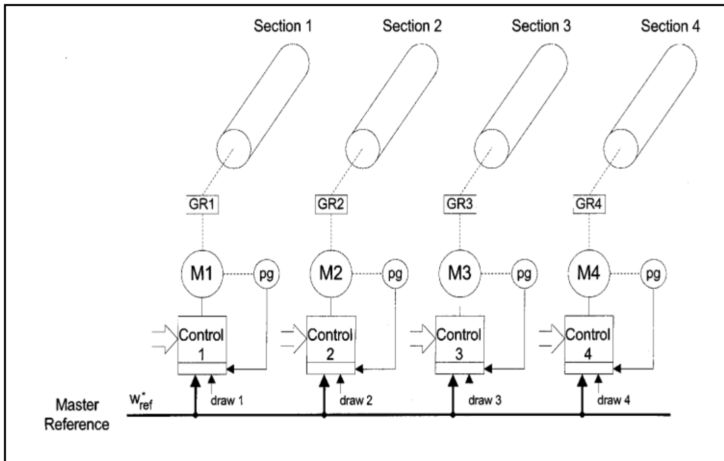

Fig. 3 – SECTIONAL DRIVE SYSTEM

3.2 Proposed Control System

Fig. 4 shows the block diagram of the proposed control structure. This control structure replicates the mechanical line shaft machine of Fig. 3. It contains "a virtual line-shaft drive," "virtual in-shafts," and "virtual gear-box conical pulleys" combinations to replicate ideal physical elements. In order to obtain the simplest model, the line shaft has been assumed perfectly stiff, and only the in-shafts' stiffness and damping attributes are considered.

The physical line-shaft drive can be described as a virtual master reference that sets the instantaneous position (θ_v) and velocity (ω_v) references to the sectional drives. Since the virtual line-shaft drive (master reference) is not physical, the values of J_v and b_{av} are relatively unconstrained control variables that are set to accomplish the desired dynamic performance with feasible trajectories to the follower drives.

The virtual compliant connecting in-shafts establish the basic relative state feedback needed to force the master reference to slow down or to speed up according to the load changes in the mechanical sections. Thus, these virtual in-shafts provide the coordination needed for relative motion control during load disturbances. A critical difference between the mechanical line-shafted system and the proposed electronic line-shafting

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control for sectional drives arises from different physical limits. The synchronization limit of the mechanical line-shafted system is the torque capacity of the line shaft and in-shafts (or slip of the conical pulleys). The torque capacity of the mechanical shafts was generally far in excess of the torque needed for even worst case loading scenarios. By comparison, the distributed sectional drives are limited by torque and/or velocity limits of the drives. Peak torque limits of modern drives are generally only a factor of 2 above the rated torque. This rather low limit makes sustained operation in torque limits a very important issue.

If a sectional drive hits a torque limit and begins to fall behind the line-shaft reference, the electronic line-shafted system automatically increases the torque reflected back to the virtual line shaft. This torque feedback causes the line shaft to decelerate, which, in turn, causes all drives to decelerate to keep synchronized to the limited drive. [1]

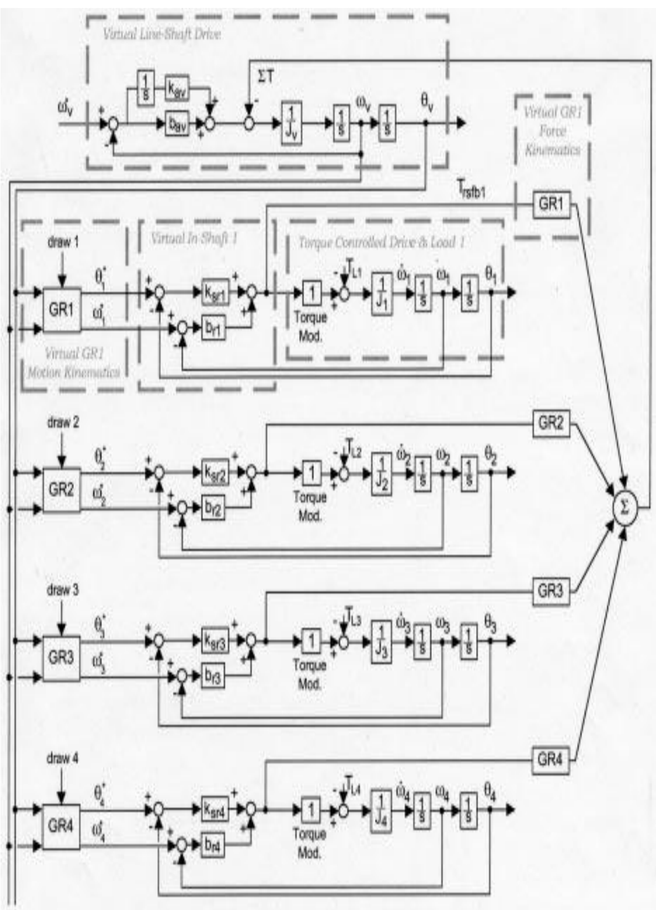

Fig.4 – LINE-SHAFT DRIVE SYSTEM

4 CONCLUCIONS

- Electronic line-shafting control has been developed to emulate the inter-shaft stiffness inherent to classical line-shaft drives.
- It is inherently capable of maintaining synchronization between the axes during startup and shutdown and even during extreme or abnormal load conditions.
- Its mechanical counterparts, electronic line-shaft control allows the designer to effectively apply well-damped "electronic" shafts which do not cause resonance problems in the system and inherently provide well-damped section-to-section dynamics.
- This feature provides a very attractive secondary benefit. It is quite well known in machine controls that "soft," i.e., low-bandwidth, servo control tends to provide smoother machine operation than "hard," i.e., high-bandwidth servo control.
- By providing well-behaved section-to-section dynamics, electronic line-shafting diminishes the need for individual drive hard servo control.
- In paper machine drives, this control topology allows the drive system to handle torque and speed limits in any sectional drive, and load disturbances in any section.
- In addition to the well-behaved disturbance-handling properties that can be achieved, electronic line-shafting control also demonstrates fast response to loads due to its inherently direct "torque-controlled" operation.
- The results demonstrate that this control can effectively handle sectional drive current (torque) limits and load disturbances in any sectional drive, maintaining synchronized motion between the different mechanical sections.
- Use of electronic line-shafting control in paper machine drives could provide significant strides to the machine capabilities, comparable to those obtained when the sectional drive replaced the mechanical line-shaft system.
- This approach will make the machine less sensitive to mismatched controller tuning since the electronic relative stiffness and damping will dominate the dynamics. Electronic line shafting will make the machine less sensitive. To improper ramp rate settings or draw signals. Startup and shutdown synchronization can, thus, be maintained. As a consequence, web breaks could be greatly reduced while allowing full utilization of the machine drive capabilities.

REFERENCES

1. PRTR estimation manual, Japan Paper association, Jan 2001 revised Mar 2002
2. M Anibal Valenzuela and Robert D Lorenz, *"EletroLine shafting control for paper machine drives" in Conf Rec. IEEE-IAS Annual meeting, 2001*
3. R. D. Lorenz and P. B. Schmidt, "*Synchronized motion for process automation"* in *Conf Rec. IEEE-IAS Annual meeting, 1989, pp-1693- 1699*.
4. R. G. Anderson, A. J. Meyer. A. Valenzuela, and R. D. Lorenz,*"Web machine coordinated motion control via electronic line-Shafting*,"*in Conf. Rec. IEEE-IAS Annual Meeting, 1999, pp. 300–306*.
5. A. J. Meyers, *"Design and implementation of a multiprocontrol system for a multi-axis, cross coupled machine control,"*M.S. thesis, Dept. Elect. Computer Eng., Univ. Wisconsin, Madison, Dec. 1994.
6. R. D. Lorenz and K. Van Patten, *"High resolution velocity estimation for all digital, AC servo drives,"*IEEE Trans. Ind. Application., vol. 27, pp 701–705, July/Aug. 1991.