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CONTROL TECHNOLOGIES FOR WARP YARN TENSION ON WEAVING LOOMS

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Abstract

The precision of warp tension control has evolved dramatically with advancements in drive and control technology. This paper surveys the progression from traditional mechanical regulation to state-of-the-art electronic and adaptive control systems employed in modern weaving machines. We provide a comparative analysis of different control paradigms—mechanical, electronic servo, and AI-based adaptive systems—evaluating their performance, limitations, and economic impact. The findings indicate that while servo-controlled systems currently dominate the high-performance sector, adaptive systems represent the future frontier for ultra-fine fabric production and maximized efficiency.

Keywords: Tension Control, Servo Motor, Electronic Loom, Adaptive Control, Weaving Automation.

I. Introduction

The weaving loom is a machine of constant acceleration and deceleration, creating a dynamic environment where maintaining constant warp tension is a significant engineering challenge. The control system responsible for this task has a direct bearing on the operational limits of the machine and the quality of its output. This paper explores the technological evolution of warp tension control systems, highlighting how innovations in motor and control theory have transformed weaving from a craft-dependent operation to a precision engineering process.

II. Traditional Tension Control Systems

A. Mechanical Regulators: Early looms used a weight-and-lever system, often connected to a friction brake on the weaver's beam. The weight provided a constant resistive torque, while the back rest acted as a tension-sensing and damping element.
B. Weight-Based Systems: These were simple and reliable but suffered from inertia and friction, leading to sluggish response. Tension would inevitably drop as the beam diameter decreased, requiring manual intervention.

III. Modern Electronic Control Systems

This paradigm shift replaced mechanical feedback with electronic sensing and actuation.
A. Servo-Motor Control: The weaver's beam is driven by a servo-motor. Instead of a passive brake, the motor actively provides a controlled torque to maintain tension.
B. Sensors and Transducers: A tension roller, equipped with a strain gauge or piezoelectric sensor, provides continuous real-time feedback on the actual warp tension to the central controller (see Fig.1).

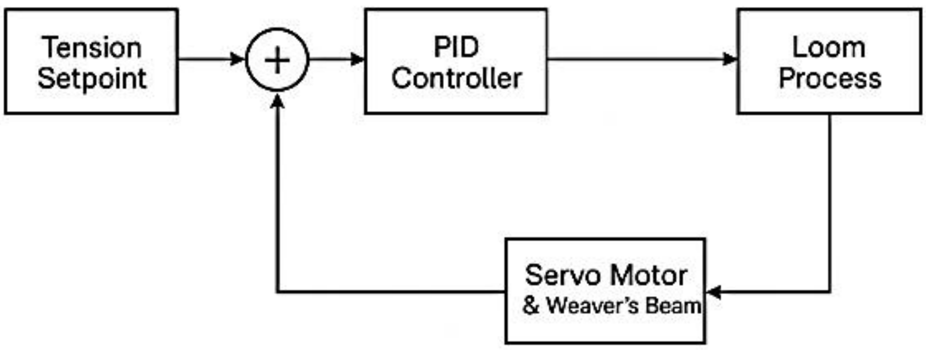

Figure 1. A block diagram of a closed-loop warp tension control system.

C. Microprocessor Control: A PLC or dedicated motion controller runs a Proportional-Integral-Derivative (PID) algorithm. It compares the measured tension to the setpoint and sends a corrective signal to the servo-motor, creating a closed-loop control system that is fast, accurate, and programmable.

IV. Adaptive Tension Control Systems

The next generation of control incorporates intelligence and foresight.
A. AI-Based Solutions: Machine learning algorithms can analyze historical and real-time data to predict tension disturbances before they occur—for instance, compensating for the tension spike caused by the beat-up motion.
B. Real-Time Adaptability: These systems can automatically adjust the tension setpoint based on the specific yarn batch properties or the evolving fabric style, moving from a "one-setting-fits-all" approach to a dynamic, self-optimizing process.

V. Comparative Analysis and Conclusion

A comparison reveals a clear trade-off between cost and capability. Mechanical systems are low-cost but low-performance. Electronic servo-systems offer high precision at a higher investment. Adaptive systems promise the highest quality and efficiency but are currently at the premium end of the market. The choice of technology depends on the product portfolio and economic strategy of the manufacturer. The undeniable trend is towards greater automation and intelligence, with future systems likely to be fully integrated into the Industrial Internet of Things (IIoT) ecosystem of the smart factory.

REFERENCES

1. Borkowski, D. (2017). Automation in Weaving: The Role of Control Systems. Springer International Publishing.
2. Koc, E., & Çinçik, E. (2010). Analysis of the effects of warp let-off system on fabric quality. Textile Research Journal, 80(8), 717-729.
3. Miao, M., & Xin, J. H. (2012). Advanced Weaving Technologies. Woodhead Publishing.

4. Sengupta, A., et al. (2018). Design and development of an adaptive control system for warp tension in air-jet weaving. Indian Journal of Fibre & Textile Research, 43(3), 287-294.
5. Zhou, J., & Chen, X. (2021). Intelligent control of warp tension in high-speed weaving machines using neural networks. Journal of Engineered Fibers and Fabrics, 16.