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Ed Lightbourn

Energy Importance of Improved Heater Roller Temperature Control

Heated rollers are used to dry moist paper webs, dry wet inks and set the temperature of plastic webs. A new technology developed by American Roller Company in Union Grove, WI offers greatly improved control of web heating parameters. Improved regulation results in a higher quality product and reduced scrap. This project leads to a better understanding of the contact resistance and the thermal interactions between heated webs and rollers, and a more effective adoption of the new roller technology.

The environmental and economic impact of rollers in the state of Wisconsin and the U.S. in general is substantial. Rollers are used in the converting process in the forest product, printing and plastics industry to convert raw feed stock to a finished product. In 1985 Paper drying was estimated to consume 3.95×10^{14} kJ of energy. The printing industry has also become increasingly important to the Wisconsin economy, with companies like Quad/Graphics alone printing more than 100 million magazines a month. In addition, the plastics used in this study; polyester, polyethylene, polypropylene and polyvinyl chloride account for 70% of the U.S. polymer production. Temperature control is a vitally important parameter in the processes of all three industries, and improvement in its control will offer substantial energy efficiency gains.

Rollers have been traditionally heated using internal convection with steam or hot oil. The hot fluid is passed through the roll by a rotating union through the bearing on each side of the roll and the heat then conducts outward to the surface of the roll. There are several inadequacies in using internally heated rollers. From a process control viewpoint, they are inherently difficult to regulate. They have long start up times, requiring a boiler or other heat source, and their long thermal time constant hampers tight control of temperature.

The new technology patented by American Roller Co. uses a thin coating of electrically conductive material applied to the surface of a hollow steel core. A voltage is applied across the ends of the conductive layer, and the flowing current generates heat through ohmic dissipation in the conductive layer. The ceramic heater advantages are their relatively quick startup time and their ability to have their temperature regulated very closely.

Due to the difficulty in measuring the moving web temperature, the roll temperature is usually used as the process control variable. The temperature of the web must be inferred from the process parameters such as speed, web material and the contact resistance. This project seeks to accurately measure the contact resistance for commonly encountered web processing conditions. Once this is known, the advantages of the new energy efficient technology can be realized.

Generally the heater (or cooler) rollers are controlled by keeping the surface of the roller at a constant temperature method. A simple feedback control law is often used with a P.I.D. controller used to regulate the heat supply to the roller based on whether the roller is above or below the desired temperature. Typically a non-contact infrared sensor is calibrated to give a correct measurement based on the roll covering.

However rollers exist to heat webs, and the relation between the roll temperature and the web temperature is complex. The thermal capacity of the web moving over the roller is important, as is the wrap angle of the web on the roller and surface characteristics of the roller. The single most important parameter in controlling the heat transfer between the roller and the web is the thermal contact resistance.

The shortcomings of traditional web heating have been even more apparent with plastics processing. The thin webs have low heat capacity and they can be easily overheated and undesirably stretched. Much processing is done at close to their transition temperatures where temperature control is most critical.

This study examines the effect of contact resistance on the heating of plastics, specifically polyester, embossed polyethylene and polypropylene.

Process rollers create value. They are used to convert the bulk web material in successive steps to the finished product. They number of steps and the exact nature of the steps vary with both the raw material and the desired finished product. Heaters rollers are often used to both soften the web or pre-set the web to a certain temperature for the next finishing operation. Web temperature is especially critical in plastic due to their low transition temperatures, and the fine line that must be kept between softening the plastics and avoiding a catastrophic tear in the web.