A review of chemical and physical factors influencing Yankee dryer coatings

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SUMMARY: Various chemical additives are utilized to provide thin adhesive coatings on Yankee dryers during the production of creped tissue papers. These coatings aid in imparting the desired degree of crepe to the tissue sheet. The creping process is a delicate balance between adhesive and release forces, which has a dominating influence on the physical and tactile properties of the final tissue sheet. Yankee coatings also play a pivotal role with regard to machine runnability, strongly impacting wear rates of the Yankee surface and of the creping blades. Like many areas of tissue technology, much of the information which is available regarding Yankee coatings is kept proprietary by tissue manufacturers.

This paper reviews some of the chemical and physical properties of Yankee coating materials which appear to have an impact on performance. A list of Yankee coating materials, derived mainly from the patent literature, is presented and classified according to chemical type. Properties of the coatings provided by these materials are then considered. These include coating uniformity and stability, adhesion, polymer material properties (glass transition temperature and modulus), and moisture properties. Literature information is supplemented by experimental results in the areas of adhesion, glass transition temperatures, and moisture uptake capacity.

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Typically in the manufacture of lightweight tissue papers a single large diameter, steam-heated cylinder and its associated hood are used to dry the sheet. The cylinder is termed a "Yankee" dryer and can range in diameter from 3 to 6 meters. The Yankee is of cast iron construction, and is polished to a smooth surface finish. The smooth finish is desirable to increase the contact between the tissue web and the dryer surface, thereby, promoting more efficient heat transfer to the sheet. The smooth finish also promotes even coating and lower crepe blade wear. A schematic of the dry end of a tissue machine is shown in ***fig.*** **1.** Here the Yankee is shown in relation to other machine components of interest.

In the manufacturing process, the wet sheet travels to the Yankee by means of a felt and is transferred to the Yankee surface at the pressure roll nip. A second pressure roll may also be present, but is not shown in this diagram. At this point the sheet is typically at 35-40% consistency. The surface temperature of the Yankee is normally close to 100°C and machine speeds are in the 900 to 2000 m/min range. The sheet is dried as it contacts the dryer, and is then removed by the creping doctor. As its name implies, this blade imparts a crepe to the tissue, after which the sheet is wound up on the reel. For 'dry creping,' the sheet contains approximately 5% moisture when creped.

Creping. Creping compacts the tissue sheet in the machine direction creating a folded or ridged structure. The degree of crepe, or crepe ratio, is defined as the difference in speed between the Yankee and the reel, divided by the Yankee speed. The crepe ratio generally falls within the 10-25% range (Hollmark 1983). The mechanical action imparted by the creping blade breaks a large number of fiber bonds. A large reduction in the strength properties of the sheet, as for example tensile strength, occurs concurrently with increases in bulk, stretch, absorbency, and softness. These latter properties are the ones characteristic of tissue and which differentiate it from flat grades of paper.

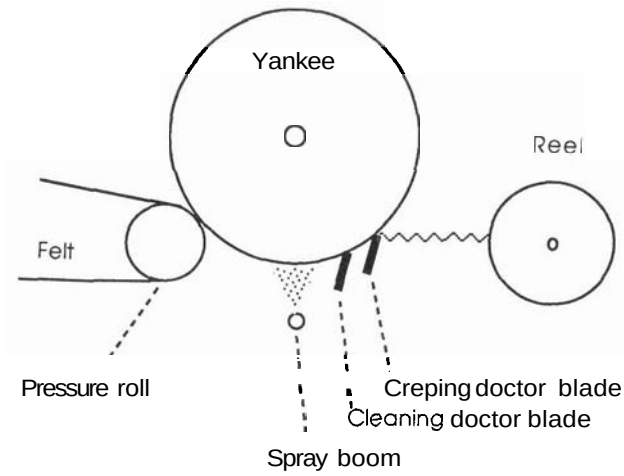

Fig. *1. Schematic of tissue machine dry end.*

The effectiveness of the creping action may be evaluated by analysis of the new structure imparted to the sheet, both in terms of the frequency and amplitude of the folds. Frequency is the most easily handled of these two measurements and may be expressed as the number of crepe folds or ridges per unit length of tissue. A crepe of higher frequency is described as "finer" and is usually desirable because it produces softer tissue products.

Coating. The ability to crepe the sheet in the desired manner is strongly influenced by the chemistry and properties of the coating which is present on the Yankee surface. The coating is a thin layer of organic and inorganic material deposited on the dryer as the process water flashes off. The occurrence of this natural coating may be supplemented by the addition of synthetic materials to the wet end of the tissue machine, or by materials sprayed directly on the Yankee surface. Besides the important function of providing the proper amount of adhesion, the coating also serves in a protective role, shielding the dryer and creping blade surfaces from excessive wear.

Prior to the use of specific additives as creping aids, tissue makers relied upon the natural components within a papermaking furnish to provide the required dryer coatings. This natural coating is a tacky organic layer originating from the hemicellulose component of the fibers. Analysis of this layer has shown it to be mainly composed of hemicellulose in association with smaller amounts of lignin, cellulose, and extractives (Fuxelius 1967). This layer also contains embedded fibrillar material, fines, and fibers pulled out from the tissue web @