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Selection criteria for wet end ceramics

Scope

The choice of ceramic materials for paper machine wet ends is a difficult. This TIP is intended to introduce and explain the important factors affecting paper machine performance that should be considered when making a material choice. The characteristics of the ceramic products currently available are also discussed.

Safety precautions

All applicable safety procedures for working around the wet end of a paper machine must be followed. These include the standard safety precautions for working around moving equipment as well as specific safety regulations required by the mill where the work is performed. Manufacturer's recommendations for safe handling, installation, and repair of ceramic components should be followed. Extra precaution should be taken when working with fine grain ceramics like Zirconia as they can develop very sharp dangerous cutting edges.

Important ceramic characteristics

Wear resistance

A material's wear resistance determines how long it will maintain its correct papermaking shape such as their doctoring edges and foil angles. The ability to last a long time justifies the high initial cost and provides consistent machine operation. There is no standard method for rating wear resistance and different suppliers each have their own wear resistance rating or test method. In order to evaluate materials already in common use, on-machine performance is the best guide to wear resistance. However, actual guaranteed or expected material life will always be machine and application dependent.

If stock is particularly abrasive as demonstrated by the frequent wearing out of machine surfaces, a ceramic with high abrasion resistance is essential. If the stock is not abrasive, then any qualified ceramic is acceptable and the material choice will be made on other requirements.

In some cases wear resistance must be sacrificed over other criteria such as thermal shock resistance or toughness. Ceramic surfaces should be checked regularly on machines with high abrasion. In the case of very abrasive applications this should be as often as every schedules forming fabric change.

Forming fabric wear

Ceramics are very hard wear resistant materials that are commonly used to wear away other softer materials as typified by their common application as grinding stones. It is therefore important that ceramic surfaces selected for wet end use are specifically formulated for low forming fabric abrasion. It is critical that sharp edges and abrasive surfaces be avoided and adequate lubrication provided. Again with no standard fabric abrasion rating

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method, material performance references are very important and should be checked for similar or harsher machine loads, speeds, and fillers.

Surface finish

Surface finish and edge sharpness are important, but their effect on fabric life is a function of the exact grade of ceramic material being used and the particular machine application. There are no established standards for edge sharpness. Most suppliers specify a minimum radius of 0.010 to 0.025 in. (0.25 to 0.64 mm) on new elements to avoid sharp edges. Radius should be increased as vacuum level increases. Covers used in high vacuum applications can require radii as high as 0.060 in. (1.52 mm). Applications that have higher than normal fabric wrap angles over ceramic edges require larger radii. Some forming section ceramic blades require different radius standards for papermaking reasons. Worn components can be honed to original radius to eliminate sharp edges that create a personnel safety risk or provide potential to reduce fabric life.

The monitoring of surface finish and edge sharpness is strongly recommended in conjunction with forming fabric wear rates to establish acceptable levels for each machine application. Surface finish measurements need to be interpreted carefully. Surfaces often become highly polished at or close to edges due to higher wear and rougher in large flat areas where wear is lower; therefore measurements should be taken at both locations. Any material selected should be smooth, fissure free, and have no internal pores that when exposed by wear can act as sharp fabric wearing edges and trap or slow down abrasive particles traveling over the surfaces.

Some companies offer regrinding service so worn or rough ceramic surfaces and doctoring edges can be refurbished and reground to original surface finish values.

Toughness

Applications subject to mechanical stress caused by impact or rough handling can benefit from a stronger material. Ceramics are known to be sensitive to cracks and flaws within their microstructures that will propagate under sufficient mechanical stress. There are two preferred methods of evaluating the ultimate strength of ceramic materials to help draw conclusions about resistance to load or impact. A “toughness” K_{1C} or “Notched Beam Test” is a measurement of energy required to propagate a crack in a deliberately flawed or notched sample. A “Flexural Strength Test” ASTM F417-78 refers to a four-point bending test to determine the modulus of rupture of a non-notched sample. If the elements will be handled frequently or breakage frequently occurs, a tougher material should be considered. All ceramic elements must be handled FLAT without bending. Some machine positions require tougher materials due to mechanical loads and stress. Tougher materials will resist damage much better than others, but all ceramics are inherently fragile and none are totally immune from damage. In some cases toughness must be sacrificed over other criteria such as wear or thermal shock resistance.

Thermal shock resistance

This is the largest rapid decrease in temperature that the material will tolerate without developing visible cracks. This number is usually given in degrees Celsius (or Kelvin) for a simple shaped sample of the material. Resistance will be less for complex shapes since thermal stresses will be higher. If sudden large temperature changes such as cold water wash-ups or lube showers on hot machines or low stock temperature on dry positions cannot be avoided, ceramics with high thermal shock resistance must be considered. Machine speed, vacuum level, dryness level and ceramic geometry are other influencing factors that can require higher thermal shock resistance. Since materials with higher thermal shock resistance are still not immune to damage, it is best to change operating procedures to eliminate risk of thermal shock and/or provide adequate lubrication

Frictional heat stress

Stresses that may cause ceramic cracking can develop if elements are heated too fast or are heated to excessive temperature. A potential source of heat stress is friction in areas of poor lubrication and/or high vacuum where the ceramic temperature can increase rapidly. Dependent on element geometry, construction and ceramic material properties it is possible to cause a failure as differential thermal expansion creates internal tensile stresses or high surface tensile stresses. Ceramic materials with higher tensile or toughness properties generally have improved resistance.

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