TIP 0402-34

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Paper machine reel spool journals: guidelines for the in-service inspection to detect cracking and repair/replacement considerations

Scope

These guidelines have been developed by a TAPPI Task Group to provide information regarding nondestructive testing (NDT) of reel spool journals. They provide background information about reel spool failures, inspection, and design/re-design as well as considerations for repair/replacement.

Reel spool journal failures have been a concern in the paper industry for many years. Although they are infrequent, the consequences of failure can be severe and include: significant physical damage to equipment and injury or death to personnel. This is due to a high level of kinetic energy reel spools have while rotating and they are very heavy when loaded.

This document provides information to assist owners in establishing an inspection program to detect cracking and prevent reel spool journal failures. It contains information on failure location, failure mechanism, inspection frequency, nondestructive testing (NDT) methods and techniques, journal materials, etc. It should be applicable to reel spool journals of all sizes and the general concepts may be applicable to other journals and shafts.

Safety precautions

Reel spools are heavy when empty and very heavy when fully loaded. Care should be exercised when working around them to ensure they are stable and properly supported/secured. Appropriate precautions should be taken to avoid an unsafe situation where an individual could be struck or become trapped by the rolls, caught in a pinch point or injured by other equipment. Proper safety equipment should be worn when working in or around the paper machine, rereeler or in a machine shop, repair facility et cetera where rotating equipment is running, loads are being moved or lifted. The safety requirements of the facility where testing is performed should be reviewed before any work is performed and followed at all times. If any loads are applied to the reel spool as part of the testing, appropriately sized equipment should be used to apply these loads and procedures used to ensure the reel spool is stable under all conditions. Also, contingencies should be made for problems that might occur while load testing.

This TIP may require the use and disposal of chemicals that may present serious health hazards to humans. Procedures for the handling of such substances are set forth on Material Safety Data Sheets (MSDS), which must be developed by all manufacturers and importers of potentially hazardous chemicals and maintained by all distributors of potentially hazardous chemicals. Prior to the use of this technical information paper, the user should determine whether any of the chemicals to be used or disposed are potentially hazardous, and if so, strictly follow the procedures specified by both the manufacturer as well as the local, state and federal authorities to insure safe use and disposal of these materials.

immediately next to the drive/brake hub and at keyways, but journal failures outboard of the bearings generally pose less severe consequences.

Failure causes

Fatigue failure initiated by weaknesses in design configuration, operation, maintenance or repair is the most common cause of reel spool journal fracture. Production changes like increasing the weight of paper on the reel or speeding up the machine may significantly affect the journal stress and promote fatigue failure. Also, bent journals, brinelled radiuses, machining grooves and other localized surface conditions can greatly affect stresses or cause localized stress risers, which increase the probability of crack initiation. Replacement journals composed of material with lower material strength or toughness may also be more susceptible to failure.

Fatigue characteristics and mechanism

Fatigue cracks are typically very straight and tight. There are three distinct stages in fatigue failure. First is the initiation phase, where changes occur on a submicroscopic scale at the highest stressed sites, leading to initiation of microscopic cracks. Next, in the propagation stage the microscopic crack grows progressively with an increasing number of stress cycles. The third stage is the final/overload, which occurs because the remaining cross-section area becomes too small to support the service stresses.

Inspection

Locations to inspect

A bearing or other piece of hardware obscures most crack locations. This makes it virtually impossible to detect these cracks with surface tests like penetrant or magnetic particle testing (PT and MT), without disassembly. Conversely, volumetric nondestructive testing (NDT) such as ultrasonic or acoustic emission testing (UT or AET) is possible without removing the bearing.

Inspection frequency

The frequency of inspections will vary as each mill and machine has different operation conditions. Some things to be considered when setting up a frequency for inspection are the journals age, history, method of rotation/number of cycles the reel spools experience, and the loading/stress on each spool/journal. As a minimum and unless inspection trending indicates otherwise journals should be inspected every three years; inspection frequency should be adjusted (usually more often) if operating conditions become more severe.

Inspection methods

The methods discussed here all have been used successfully, either alone or in combination, throughout the paper industry. Section 7.0 and Appendix B review the different methods.

Personnel qualifications

As a minimum all personnel performing non-destructive testing must have training, experience and be certified in accordance with ASNT TC-1A. As a minimum, technician training and experience must be as equivalent to a Level II for reel spool testing. Actual experience in journal inspection is important.

Testing methods

Four different methods of nondestructive inspection are typically used to locate cracking and other defects in reel spool journals. The main inspection methods are magnetic particle, ultrasonic and acoustic emission testing (MT, UT and AET). The typical types of defects that are looked for are: cracking from keyways, cracking from drilled holes, cracking at the head to journal interface, and cracking below journals and dumbbells.

Replacement

Manufacture of a replacement reel spool journal requires great care. The original blueprint used to manufacture the journals, should provide specifications for material, heat treatment and appropriate dimensions. In many situations operational demands and load/fatigue requirements have increased since the journals were originally designed.

To design or redesign a reel spool journal stress and fatigue life calculations must be performed and then the appropriate material and heat treatment chosen. Careful engineering evaluation of the current operating parameters the spool experiences is important to design or redesign. An original equipment reel spool manufacturer or a qualified engineering company should do the evaluation. Failure to design a journal for the current operating conditions or hastily repairing journals has led to rapid failures.

Keywords

Paper machines, Reels, Spools, Bearings, Shafts, Inspection, Nondestructive tests, Testing

Additional information

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Other information

This TIP was created in response to a request from a mill that had a reel spool failure. Initially, the information for this TIP was presented at a panel presentation for the December 2001 TAPPI Engineering Conference.