ROTOR CRACK DETECTION STRATEGIES – A REVIEW

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Number of crack related failures of rotors in the field are reported in published literature. Fatigue cracks get initiated in regions of stress concentration and they begin to propagate due to fluctuating stress conditions. If these propagating cracks remain undetected and reach their critical size, then a sudden structural failure occurs. Such a failure in a power plant rotor can be disastrous leading to considerable damage and loss due to downtime. Therefore it is essential that rotors are monitored online for cracks. The crack detection strategies should be reliable and fool proof.

In the present paper, cracks in the three rotor subsystems i.e., the shaft, the discs and the blades are considered. For the case of blades, crack is considered in the blade-form as well as in the blade root. The various diagnostic strategies primarily based on vibration signatures as reported in literature are discussed along with their limitations and advantages. The paper also suggests improvements in existing methodologies of crack detection in order to make them more reliable.

When a rotor with a transverse crack in the shaft coasts up or down, the sub-critical resonances at operating speeds of one half or one third of the rotor critical are observed. The sub-critical resonances at other speeds like 1/5 and 2/3 of rotor critical and super-critical resonance at twice the rotor critical are also reported in literature. The above described resonances could be present irrespective of the angular location of unbalance relative to the position of the crack. Minor differences in the response curve are reported when the unbalance is located on the side of the crack or opposite to it. It is however difficult to diagnose the crack reliably based on the above sub- and super- critical resonances because these resonances are also present due to other factors, for example the various non-linearities in the rotor. Moreover these resonances can be observed only when the rotor coasts up or down, which may not always be desirable.

Several studies are reported in literature, in which crack in the rotor shaft is diagnosed from the 2X component of vibration signature during steady operation of the rotor. The 2X component appears because of the asymmetric nature of cracked shaft. This is also not a reliable crack indicator because in real rotors there are several other geometrical features which introduce asymmetry. Moreover coupling misalignment, which is one of the common faults in rotors, gives higher order (2X, 3X etc.) harmonics in vibration signatures.

Some recent studies on crack detection in rotor shafts pertain to the phenomenon of coupling of lateral, axial and torsional vibrations of rotor. It is suggested that a mild harmonic axial excitation could be given to the rotor, which due to the coupling of vibrations will result in stronger lateral vibrations and this could be used as a reliable indicator for rotor shaft crack.

For the cracks in rotor blades and discs, to the best of author's knowledge, there is no reliable crack detection strategy reported in literature. The vibration signatures from the bearing housing or even from the shaft through proximity pickups are insensitive to cracks in blades and discs. Moreover a typical turbomachine has a large number of blades with widely varying characteristics, for example the HP and LP stage blades of a steam turbine. In the present paper it is suggested that the crack detection in blades could be best carried out through a set of proximity transducers mounted in the turbine casing, which could pickup complete or partial vibration at the blade tip. It is felt that variations in the blade tip deflections and the slight shift in blade natural frequencies due to crack, measured through the casing mounted pickups, could give a reliable indication of a crack in the blade-form as well as in the blade root.