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DYNAMIC THRESOLD DETECTION BASED ABORT SCHEME FOR SAFEGAURDING CRYOGENIC TURBO PUMPS DURING CAVITATION

Abstract

Timely detection and response to the malfunction of cryogenic propulsion system during testing is critical to safeguard test system and its associated facility.To achieve the impeccable detection of the failure and for controlling the process, the Programmable Logic Controllers (PLCs) are designed and opted. Due to the robust performance, wide range of operating conditions and functional simplicity PLC's are deployed for testing complex cryogenic systems.The critical parameters are monitored by PLC and subsequently employed for controlling the process.In the case of any abnormality, the operations have to be terminated immediately.The process termination can be done either by manual or automatic operations. But manual termination which involves human decision takes more time and may lead to severe damage of the test system. Therefore the natural choice is "Automatic Termination" and coined as "Auto Abort". The threshold for the abort parameters can be fixed by using static or dynamic method.The static threshold limit is fixed prior to the test and may lead to unwarranted abort. Hence, for safeguarding the cryogenic turbopumps, an Auto-Abort Scheme with dynamic threshold estimation is essential.

A novel Abort Scheme has been designed and embedded in the PLC based control system to estimate threshold dynamically, detect the fault and abort the process safely. The threshold level for the abort parameters can be estimated online by various techniques like statistical analysis, averaging etc. The cumulative moving average scheme is realized for threshold estimation. The implemented scheme has following advantages

1.Abort limit estimation when thresholds are not well-known, ambiguities not having prior experience.

2.Estimating uprated/de-rated margins of pumps.

The verification and validation test plan was designed with various abort cases and simulated. The developed algorithm is verified at the block level and finally integrated with the system. The implemented software was successfully inducted for actual testing of cryogenic pumps under cavitation condition. The abort system performed appropriately when it was called upon with guaranteed safety and has shut down the process within 190 milli second. The implemented abort scheme and its algorithms gives enhancement over static threshold abort scheme by avoiding false abort with increased reliability.The critical Net

Positive Suction Head (NPSH) required for the Cryogenic pump with actual propellants Liquid hydrogen (LH2) and liquid oxygen (LOX) is predicted based on the test data and sufficient margin of tank pressures was ensured during actual flight.