Chapter 17

Prognostics and Health Management of Industrial Equipment

E. Zio
Ecole Centrale Paris, France & Politecnico di Milano, Italy

ABSTRACT

Prognostics and health management (PHM) is a field of research and application which aims at making use of past, present, and future information on the environmental, operational, and usage conditions of an equipment in order to detect its degradation, diagnose its faults, and predict and proactively manage its failures. This chapter reviews the state of knowledge on the methods for PHM, placing these in context with the different information and data which may be available for performing the task and identifying the current challenges and open issues which must be addressed for achieving reliable deployment in practice. The focus is predominantly on the prognostic part of PHM, which addresses the prediction of equipment failure occurrence and associated residual useful life (RUL).

INTRODUCTION

In human health care, a medical analysis is made, based on the measurements of some parameters related to health conditions; the examination of the collected measurements aims at detecting anomalies, diagnosing illnesses and predicting their evolution. By analogy, technical procedures of health management are used to capture the functional state of industrial equipment from historical recordings of measurable parameters (Vachtsevanos, Lewis, Roemer, Hess & Wu, 2006). With the term ‘equipment’, from now on we shall intend a System, Structure or Component (SSC).
The knowledge of the state of equipment and the prediction of its future evolution are at the basis of condition-based maintenance strategies (Jarrell, Sisk & Bond, 2004): according to these strategies, maintenance actions are carried out when a measurable equipment condition shows the need for corrective repair or preventive replacement. From the point of view of production performance, by identifying the problems in the equipment at their early stages of development, it is possible to allow the equipment to run as long as it is healthy and to opportune schedule the maintenance interventions for the most convenient and inexpensive times. The driving objectives are maximum availability, minimum unscheduled shutdowns of production, economic maintenance (Jardine, Lin & Banjevic, 2006).

The condition of the equipment is usually monitored at a regular interval and once the reading of the monitored signal exceeds a threshold level, a warning is triggered and maintenance actions may be planned based on the prediction of the future evolution of the degradation process. The monitoring interval influences the equipment overall cost and performance: a shorter interval may increase the cost of monitoring, whereas a longer one increases the risk of failure. The monitoring system should be reliable in order to avoid false alarms. A decision must be taken every time an alarm is indicated; to ignore an alarm may give rise to serious consequences. A first option is to make further investigation of the alarm, without stopping the equipment; an alternative option is to stop the equipment for an overhaul. In the first option, a false alarm would result in extra cost due to the time and manpower necessary to make the diagnosis; the second option could result in greater losses, where lost production and manpower costs occur simultaneously. The greatest losses will occur when ignoring the alarm, in case of accidents with damages and loss of assets.

The dynamic scheduling of condition-based maintenance represents a challenging task, which requires the prediction of the evolution of the monitored variables representing the equipment condition. Upon detection of failure precursors, prognostics becomes a fundamental task; this entails predicting the reliability or the probability of failure of the equipment at future times, and the residual useful life (RUL), i.e. the amount of time the equipment will continue to perform its function according to design specifications. This prediction/forecasting/extrapolation process needs to account for the current state assessment and the expected future operational conditions. The ‘fortune teller’ of such prognostic task is the intelligent integration of the information and data available into accurate models solved by efficient computational algorithms.

Equipment state knowledge and prediction are also central to the management of abnormal events in process plants (Venkatasubramanian, Rengaswamy, Yin & Kavuri, 2003). A single abnormal event may give rise to a catastrophic accident with significant economic, safety and environmental impacts (the accident at the Kuwait petrochemical refinery in 2000 led to an estimated 100 million dollars in damages (Venkatasubramanian et al.)). On the other hand, minor accidents occur relatively frequently and may cumulate to numerous occupational injuries and illnesses, and relevant costs to the industry (estimates of these costs in the US and UK range in the order of 20 billion dollars per year (Nimmo, 1995; Laser, 2000)). This explains the great interest in, and attention paid to the development of effective methods and procedures for abnormal event management.

Successful abnormal event management requires the timely detection of the abnormal conditions, diagnosis of the causal fault, prognosis of the process evolution; these elements feed the procedure of correction of the equipment fault and of plant control to safe conditions. From the point of view of safety, the recognition of the state of equipment (diagnostics) and prediction of its future evolution (prognostics) enable safer and more reliable operation, under a proactive approach to operations and maintenance which
Related Content

Activity Theory
www.igi-global.com/chapter/activity-theory/39672?camid=4v1a

Dynamical Disequilibrium, Transformation, and the Evolution and Development of Sustainable Worldviews
www.igi-global.com/chapter/dynamical-disequilibrium-transformation-evolution-development/69457?camid=4v1a

Modelling the Impacts of Inter-City Connectivity on City Specialisation
www.igi-global.com/article/modelling-the-impacts-of-inter-city-connectivity-on-city-specialisation/225095?camid=4v1a

Association Rules Evaluation by a Hybrid Multiple Criteria Decision Method
www.igi-global.com/article/association-rules-evaluation-hybrid-multiple/58367?camid=4v1a