Chapter 11
Welding Process under Fault Coverage Approach for Reliability and MTTF

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ABSTRACT
This chapter deals with the problems occur in the welding under the consideration of many causes of defects such as cracking, distortion, porosity, inclusion and undercutting. Welding is very useful for every industry. It is used as a fabrication and sculptural that joins the two parts of materials, generally metals or thermoplastic, through a restricted amalgamation from a suitable combination of temperature, pressure and metallurgical conditions. In this chapter, authors study that the welding process is how much reliable when many causes of defects taken account into this process and try to find out the reliability and mean time to failure of welding process with the help of Markov modelling and supplementary variable technique. They derived the generalised expression for the probability of each possible transition state, probability of upstate and downstate of welding, and also studied the sensitivity in reliability and MTTF of welding. Fault coverage technique has been developed to enhance the reliability of the welding process for practical utility in the industry.

INTRODUCTION
Reliability is a measure of performance of any system or process, particularly welding process; it decides that how well an operation will perform or success for a given time period under the specified operating conditions. There are many traditional techniques to analyse the reliability aspects of any process under the consideration of defects occur in it. Todays, many techniques are also available to enhance the

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reliability of process including the faults occur during process due to design, wrong selection, environmental conditions etc. Welding process is the core and important part for the manufacturing processes of the material engineering. So, the reliability of welding process is a key factor of manufacturing process because it directly influences the reliability of manufacturing of the system or sub-system. The reliability of welding process depends upon the failure rate of some main defects of welding such as cracking, porosity, under cutting, inclusion and distortion. So, maximize the reliability of the welding process through minimize the failure rates of defects is required for manufacturing process. Reliability work on welding process introduces two basic concepts that have central importance namely, modelling of the designed process and their transition state probability. Reliability of the welding process can be enhanced by detecting the number of faults and try to cover the maximum number of faults. The ratio of number of faults that can be covered to the number of total detected faults is called coverage factor (Arnold, 1973; Bouricius et al., 1969), i.e.

Coverage factor= faults that can be covered/total detected faults

The fault coverage that is used to measure the productivity of the system, is imperfect fault coverage because the validation of the system is depend on the efficiency of their fault mechanism (Powell et al., 1965) while a measure that is used to compute the degree of meticulousness of testing in a software is called software test coverage. Software test coverage and other coverage applications are also determined by many tools in various terms such as hunks, divisions, computation-use etc. (Malaiya et al., 2002; Ram et al., 2013; Ram & Manglik, 2014).

As far as we know that the reliability analysis of welding process with coverage factor has never been discussed in the literature while reliability theory has a wide history in the literature. A lot of researchers including Ascher (1986), Smith and Oren (1980), Singh and Jain (2000), Cempel et al. (2000), Singh et al. (2013), Ram et al. (2013) have analysed the reliability of systems. Ke et al. (2007) investigated the reliability and mean time to failure of a system with standby and unreliable server and also analysed the sensitivity and relative sensitivity of these measures under the consideration of exponential distribution for failure and repair rates of the system. They obtained the generalized expression for reliability, MTTF and its sensitivity and relative sensitivity. Gupta and Tewari (2009) proposed a probabilistic model of flue gas and air system. They formulated the model with Markov birth-death process and analyzed the system availability. Authors also discussed the maintenance priority for the sub-system contained in the flue gas and air system of the thermal power plant. Kumar et al. (2015) analyzed the reliability of the casting process and obtained the generalized expression using Markov process. Goyal et al. (2015) proposed a mathematical model of water cooling system and simulated the results using Markov process. They investigated the reliability measures of water cooling system and also seek the cost-benefit analysis in the maintenance of it.

Malaiya et al. (2002) derived the relation between reliability, software test coverage and time duration of testing. Xing (2007) developed an approach to analyse the reliability of a phased mission system with the common cause failure by introducing imperfect fault coverage. Myres (2007) studied the four different models of coverage namely, perfect fault coverage, element level coverage, fault level coverage and one-on-one level coverage and discussed the effects of coverage using two techniques, combinatorial and recursive and the method how it is obtained. Wang et al. (2013) examined the reliability and mean