Statistics in Materials Engineering
– Design and Lifing Perspective

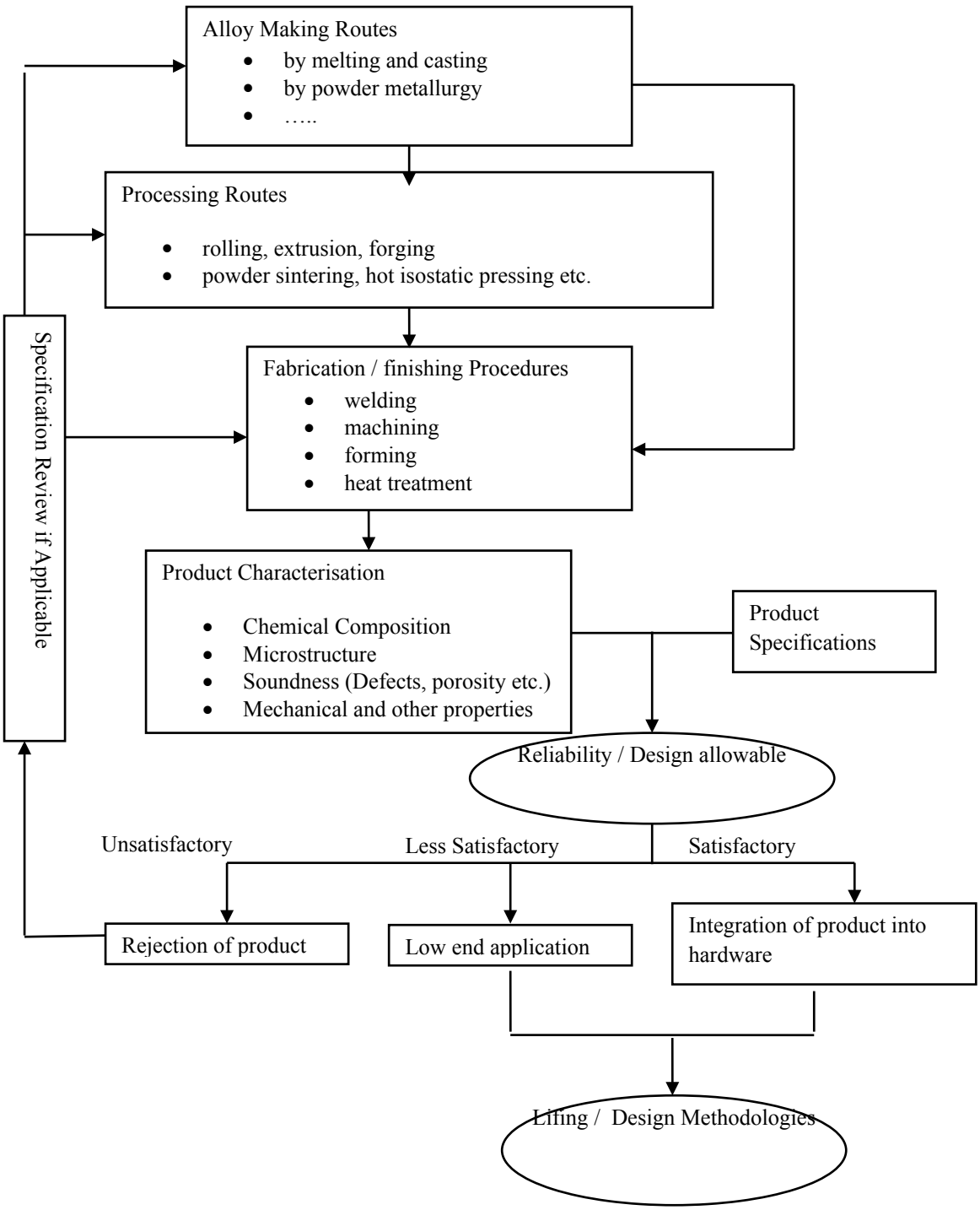
Dr. Hina Gokhale
Former DG(HR), DRDO, New Delhi & VC, DIAT, Pune

INTRODUCTION

Material science and engineering comprises of broadly three areas: Materials Development, Materials Processing and Materials Characterization. Figure below shows the flow chart of a general materials development program for an intended application. Role of statistics (shown in oval shape in the flow chart) in harnessing the uncertainties in arriving at materials trustworthiness, in terms of quality of production and property reliability, has been perhaps the oldest application of statistics, and still remains one of the primary areas of application today. Such reliability estimates of materials and components also contribute towards establishment of specifications to the designers of the hardware comprising of these materials and components. Using these estimates or design allowables the reliability of hardware is estimated. However, these estimates are based on laboratory tests which represent idealized service conditions. The real time operating conditions undergo considerable variation, some of which are stochastic in nature. Therefore, assessing the remaining life of a component requires statistical treatment of laboratory test data to make it applicable to real life service conditions.

The damage caused to a component of hardware due to the real time operating conditions can be quantified in terms of defects generated, specially cracks, its growth rate and sizes. The number, spatial distribution and orientation of cracks also have bearing on the accumulated damage. All of the above mentioned parameters are stochastic in nature. The technology that enables prediction of the remaining life of a hardware based on material science concepts and the uncertainties associated with the stochastic nature of defects generated is known as lifing technology. Such a treatment, it is hoped, will reduce the possibilities of overdesign and increase service span of the materials. The present talk looks at the role of statistics in life estimation of engineering materials subjected to fatigue loading. Example covers simulation of minimum fatigue life of a steel Gun Barrel.

The talk will also cover other examples of applications of statistics such as DoE and Analysis by Artificial Neural Networks and Genetic Algorithms etc.


Alloy Making Routes
by melting and casting
by powder metallurgy
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Processing Routes
rolling, extrusion, forging
powder sintering, hot isostatic pressing etc.
Fabrication / finishing Procedures
welding
machining
forming
heat treatment
Specification Review if Applicable
Product Characterisation
Chemical Composition
Microstructure
Soundness (Defects, porosity etc.)
Mechanical and other properties
Product Specifications
Reliability / Design allowable
Unsatisfactory
Less Satisfactory
Satisfactory
Rejection of product
Low end application
Integration of product into hardware
Lifing / Design Methodologies