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JAIPUR – 302017 (RAJASTHAN), INDIA

CERTIFICATE

This is to certify that the dissertation entitled **" An accelerated degradation test planning using inverse Gaussian process for reliability prediction"** being submitted by Areesha Nafees (2013PIE5141) is a bonafide work carried out by her under my supervision and guidance, and hence approved for submission to the **Department of Mechanical Engineering, Malaviya National Institute of Technology Jaipur** in fulfillment of the requirements for the award of the degree of **Master of Technology (M.Tech.)** in **Industrial Engineering**. The matter embodied in this dissertation report has not been submitted anywhere else for award of any other degree or diploma.

Prof. Rakesh Jain
Professor,
Department of Mechanical Engineering,
MNIT Jaipur
Place: Jaipur
Dated: June 2015

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CANDIDATE'S DECLARATION

I hereby declare that the work which is being presented in this dissertation entitled **"An accelerated degradation test planning using inverse Gaussian process for reliability prediction"** in partial fulfilment of the requirements for the award of the degree of **Master of Technology (M.Tech.)** in **Industrial Engineering**, and submitted to the **Department of Mechanical Engineering, Malaviya National Institute of Technology Jaipur** is an authentic record of my own work carried out by me during a period of one year from July 2014 to June 2015 under the guidance and supervision of **Prof. Rakesh Jain** of the Department of Mechanical Engineering, Malaviya National Institute of Technology Jaipur.

The matter presented in this dissertation embodies the results of my own work and has not been submitted anywhere else for award of any other degree or diploma.

Areesha Nafees
(2013PIE5141)

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

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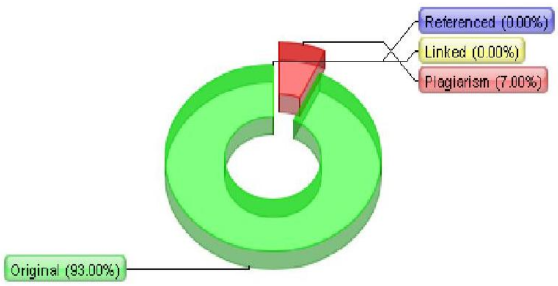

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Areesha Nafees

ABSTRACT

Throughout the history of modern engineering, failures of systems have been observed in every field of engineering .Due to increasing complexity of modern engineering systems, the concept of reliability has gained importance in overall system design. Reliability of a system or component is not achieved accidentally it is to be incorporated into the system or component. It needs to be addressed at all stages of the product or system development including design, manufacturing, testing and maintenance phases. In order to express the reliability of a system in quantitative terms, it is necessary to develop model of the overall system and components and realize its performance under real operating conditions. .

Different models and methods have developed for the reliability analysis of a system or diagnosis of a fault. It includes various statistical methods for data analysis as well as reliability analysis such as diagram-based models, analytical methods, physics-of-failure and fuzzy logic-based reliability tools and techniques that have molded the emergence of the reliability engineering discipline.

The degradation models are getting increasing importance for highly reliable products where generating failure data through life testing is time consuming and incurs high cost. Further, the increasing pressure to reduce development time and cost does not permit reliability tests to go on continuously. Therefore, these models are based on the premise that a system performance characteristic is satisfactory if and only if its tolerance remain within the requirement level (i.e. failure occurs when something is normally working but not well enough). If failure is defined in terms of a specified level of degradation, a degradation model defines a particular time-to-failure distribution. Interestingly, many failure mechanisms can be traced through an underlying degradation process. When it is possible to measure degradation, such measures often provide more reliable information than failure-time data for the purpose of assessing and improving reliability of a product.

Therefore, for some very highly reliable products, due to time constraint, one can resort to an accelerated (or elevated stress) degradation process to gather the required information about degradation behavior. The IG process models have been shown to be an important family in degradation analysis.

In this study we have worked upon optimal constant-stress accelerated degradation tests (ADTs) planning when the underlying degradation follows the inverse Gaussian (IG) process. We considered ADT planning for the IG process with random effects. Asymptotic variance of the estimate of a lower quantile was derived, and the objective of the planning was to minimize the variance by properly choosing the testing stresses as the accelerated parameter, and the number of samples allocated to each stress. We then applied the IG process to fit the stress relaxation data of a component, and use the developed methods to help with the optimal ADT design.

CONTENT

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

ADT	Accelerated degradation testing
SSADT	Step stress accelerated degradation testing
ARDMT	Accelerated Repeated degradation Measure Test
PSADT	Progressive Stress Accelerated Degradation Tests
ADDT	Accelerated destructive degradation measure tests
PDF	Probability density function
CDF	Cumulative distribution function
IG	Inverse Gaussian
MLE	Maximum Likelihood Estimate
EM	Expected maximization
ALT	Accelerated Life Tests
ABT	Accelerated Binary Test
MTTF	Mean time-to-failure
MSE	Mean Square Error

NOTATIONS

$Y(t)$	Product degradation path
T_D	Product lifetime
D	Degradation threshold
$IG(a,b)$	The inverse Gaussian distribution
θ	The true parameter
ξ_p	p-quantile of the failure time under use condition
N	Sample size
J	Number of stress level
K_j	Number of measurement under the j-th stress level
τ_j	Measurement time interval under the j-th stress level
$\mathrm{I}(\theta)$	Fisher information matrix
$\Phi(.)$, $\phi(.)$	Standard normal CDF and PDF
Avar(.)	Asymptotic variance
$x_j, j =$ 1,…..,J	Stress value of the j-th stress level
N_j, j=	Number of units allocated to x_j