

Handling Non-Normal Data in Individual
and Moving Range Control Charts:
An Application to Raw Rubber
Manufacturing Process Data

by

Manage Prabhashrini Dhanushika

Handling Non-Normal Data in Individual and Moving Range
Control Charts: An Application to Raw Rubber Manufacturing

Process Data

The work described in this thesis was carried out by me under the supervision of Prof. D. M. S. G. Banneheka and Dr. Keminda Herath and a report on this has not been submitted in whole or in part to any university or any other institution for another Degree/Diploma. I certify that all the recommendations and suggestions have been incorporated in the thesis in accordance with the suggestions of the examiners.



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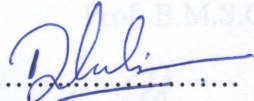
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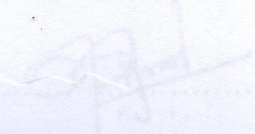
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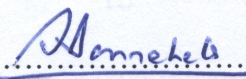


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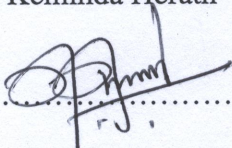
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“Where I am Today, That’s Because of You All”

Affectionately Dedicated

To

All My Respectable Teachers,

My Beloved Grandparents, Parents and Sister

My Dearest Husband

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LIST OF ABBREVIATIONS

AD	-	Anderson-Darling
ARL	-	Average Run Length
CL	-	Center Line
CM	-	Cramer-von Mises
CUSUM	-	Cumulative Sum
DMAIC	-	Define, Measure, Analyze, Improve and Control
EWMA	-	Exponentially Weighted Moving Average
HDD	-	Hard Disk Drive
I- chart	-	Individual chart
I-MR	-	Individual and Moving Range
ISO	-	International Organization for Standardization
KS	-	Kolmogorov-Smirnov
LCL	-	Lower Control Limit
LF	-	Lilliefors
MCUSUM	-	Multivariate Cumulative Sum
MEWMA	-	Multivariate Exponentially Weighted Moving Average
MR-chart	-	Moving Range chart
OC	-	Operating Characteristics
OCP	-	Out of Control Points
PC	-	Pearson chi-square
Q-Q	-	Quantile - Quantile
RRISL	-	Rubber Research Institute of Sri Lanka
RSS	-	Ribbed Smoked Sheet
Rwui	-	R Web User Interface
SF	-	Shapiro-Francia
SPC	-	Statistical Process Control
SW	-	Shapiro-Wilk
TSR	-	Technically Specified Rubbers
UCL	-	Upper Control Limit

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Manage Prabhashrini Dhanushika

ABSTRACT

This research focused on control charting for quality assurance of crepe rubber manufacturing process in Sri Lanka. There is lack of interest in applying quality tools for process monitoring in crepe rubber industry due to the crude nature of this process. However, some researchers have identified individual and moving range (I-MR) control charts as a suitable statistical process control (SPC) technique for rubber data. When applying control charting in SPC, normality assumption of data should be considered since performances of the control charts are very much sensitive to departures from normality. Rubber data also show a significant deviation from normal assumption. No comprehensive study has been done to establish a proper practice for laymen to use I-MR charts in crepe rubber industry when data are non-normal. Therefore, the main objective of this research was to find a solution for non-normality issue of data on I-MR control charting and hence to introduce a feasible way to apply I-MR charts for process improvement in crepe rubber manufacturing industry.

We have identified Johnson transformation as a suitable method to handle non-normality issue of data; other simple transformations and distribution fitting did not work for rubber data. By incorporating Johnson transformation, a feasible way to use I-MR charts was developed. Evaluation of the method was based on Monte Carlo simulation and probability of type I error, average run length and the power of control charts were estimated under the simulation study. We have evaluated the performances of I-MR charts for non normal data generated from different non normal distributions.

In the case of factory (rubber) data, data were generated from the empirical distribution of factory data in order to evaluate the performance of I-MR charts with respect to the practical situation. In this research, data were collected from two sites where the crepe rubber manufacturing process runs; Dartonfield rubber factory and Payagala rubber factory. Data collected during the period of two years commencing from year 2004 at Dartonfield factory and data collected during the period from September 2010 to August 2011 at Payagala factory were used.

The results of simulation study clearly indicate the high sensitivity of I-MR charts to non-normality. I chart developed for Johnson transformed data produces relatively low values for probability of type I error. Small values of average run length when the process is actually in control (ARL_0) for original data strongly show the bad impact of not addressing non normality issue for control charting in SPC. Same figures which are shown for I chart, can be seen for MR chart also, but comparatively MR chart gets lower values for ARL_0 for Johnson transformed data than I chart obtains. It indicates the low effectiveness of MR chart for process monitoring when compared to the effectiveness of I chart. Further, I chart developed for Johnson transformed data produces a power curve which is aligned with the theoretically accepted power curve of standard 3-sigma I chart. Therefore, the method of applying I-MR charts by incorporating Johnson transformation can be recommended for non normal data in any industry.

Finally, a user friendly web application that can be used by any industry person to develop I-MR charts for process monitoring task when the process generates non normal data has been created by using Rwebi (R web user interface) which is a web application which can be used to create user friendly web interfaces for R scripts.