UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF A FUZZY LOSS-BASED PROCESS CAPABILITY INDEX

MOHAMMAD ABDOLSHAH

DEVELOPMENT OF A FUZZY LOSS-BASED PROCESS CAPABILITY INDEX

By

MOHAMMAD ABDOLSHAH

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree Doctor of Philosophy

December 2010

Abstract of Thesis Presented to the Senate of University Putra Malaysia in Fulfilment of the Requirement for the degree of Doctor of Philosophy

DEVELOPMENT OF A FUZZY LOSS-BASED PROCESS CAPABILITY INDEX

By

MOHAMMAD ABDOLSHAH

December 2010

Chairman: Rosnah bt. Mohd. Yusuff, PhD

Faculty: Engineering

Process capability indices are appropriate tools in order to measure the inherent capability of process, but most of these indices cannot take into account the losses of a process such as rejects, while in today's competitive business environment, it is becoming more and more important for companies to evaluate and minimize their losses. Since most of process capability indices do not consider the losses, the process capability indices based on losses can help manufacturers to understand the real capability of their processes in order to improve them.

Literature review showed two main gaps in loss-based process capability indices. The first gap is that there is not a loss-based process capability index, which has more features such as reject based, asymmetric, bounded, and target based. In order to overcome this problem, an appropriate loss function (asymmetric inverted normal loss function) was employed to propose a new loss-based process capability index.

The methodology is to compare the standard loss for a capable process with other cases. The proposed process capability index is bounded, asymmetric and it is able to provide a more realistic metric to evaluate and predict the performance of processes.

The second gap in literature review is that among all loss-based process capability indices, just C_{pm} has been fuzzificated, while literature review showed that the index C_{pm} is not an appropriate process capability index. Then fuzzy logic and operation research model were employed to fuzzificate the new proposed loss-based process capability index. The α-cuts of the fuzzy observation was the method employed to find the fuzzy membership function of the new loss-based process capability indices.

The result of this study is a new loss-based index with more specifications such as mean-based, target- based, variation-based, bounded, and loss-based compared with other process capability indices. The new process capability index was fuzzificated using α-cut method. Therefore a fuzzy loss-based process capability index was developed that is useful for vague data. In order to validate the new loss-based method, the sensitivity of this index to process specifications was studied. Sensitivity analysis showed that this index is sensitive to the mean, variation, and target of data. The new index has 99.6% relationship with the loss especially asymmetric inverted normal loss function. This relationship with loss is the highest relationship compared with other process capability indices. Moreover a regression analysis showed that the new index has the most relationship with the value of loss compared with other process capability indices.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
Sebagai memenuhi keperluan untuk ijazah Doctor of Philosophy

PENGEMBANGAN PROSES SEBUAH INDEKS RUGI FUZZY BERBASIS KEMAMPUAN

Oleh

MOHAMMAD ABDOLSHAH

Disember 2010

Pengerusi: Rosnah bt. Mohd. Yusuff, PhD

Fakulti: Kejuruteraan

Indeks keupayaan proses adalah alat yang tepat untuk mengukur kemampuan yang melekat pada proses, tetapi kebanyakan mereka tidak mengira kerugian dari sebuah proses, sementara di lingkungan perniagaan yang kompetitif saat ini, hal ini menjadi semakin penting bagi syarikat untuk menilai dan meminimumkan kerugian mereka. Kerana sebahagian besar indeks kapabilitas proses tidak mempertimbangkan kerugian yang terang nyata, kemampuan proses berdasarkan indeks kerugian dapat membantu pengeluar untuk memahami kemampuan nyata dari proses mereka dalam rangka untuk memperbaiki mereka.

Sastera ulasan menunjukkan dua jurang utama dalam proses indeks rugi berasaskan kemampuan. Perbezaan pertama ialah bahawa tidak ada proses kehilangan kemampuan berasaskan indeks, yang mempunyai lebih banyak ciri unggul seperti menolak berasaskan, asimetris, melompat, dan target berasaskan. Untuk mengatasi masalah ini, asimetris terbalik fungsi kerugian muzik dikembangkan untuk

mengajukan kerugian indeks kapabilitas proses berasaskan. Metodologi ini adalah untuk membandingkan kerugian standard untuk proses mampu dengan kes lain. Indeks ini proses baru kemampuan terhad, asimetris dan mampu memberikan lebih realistik metrik untuk menilai dan memprediksi prestasi proses.

Kesenjangan kedua dalam tinjauan literatur adalah bahawa di antara semua proses kerugian indeks berasaskan kemampuan, hanya C_{pm} telah fuzzificated, sementara kajian literatur menunjukkan bahawa indeks C_{pm} bukan merupakan indeks keupayaan proses yang sesuai. Dalam bahagian ini logik fuzzy digunakan untuk fuzzificate proses indeks dicadangkan baru kerugian berasaskan kemampuan. The α-potongan pemerhatian fuzzy kaedah yang digunakan untuk mencari fungsi keahlian fuzzy terhadap proses baru kerugian indeks berasaskan kemampuan. Akhirnya, pada setiap bahagian dengan satu contoh, penggunaan indeks kapabilitas proses baru digambarkan.

Hasil keputusan kajian ini adalah suatu indeks baru berasaskan rugi dengan lebih banyak spesifikasi, seperti berasaskan purata, berasaskan sasaran, berasaskan variasi, terbatas dan berasaskan rugi berbanding dengan indeks keupayaan proses yang lain. Indeks keupayaan proses yang baru ini adalah disamarkan menggunakan kaedah α-cut. Oleh kerana itu indeks keupayaan proses samar yang berasaskan rugi telah dibangunkan yang berguna untuk data samar. Untuk mengesahkan kaedah bera saskan rugi yang baru_ini,_kepekaan indeks ini_untuk spesifikasi_proses telah_dis elidiki. Analisis_sensitiviti_menunjukkan bahawa indeks ini sensitif terhadap purata, variasi, dan data sasaran. Indeks yang baru mempunyai hubungan 99.6% dengan kerugian terutama asimetris terbalik fungsi kerugian biasa. Hubungan dengan

kerugian adalah yang tertinggi berbanding dengan indeks keupayaan proses yang lain. Selain itu_analisis regresi menunjukkan bahawa indeks baru ini mempunyai paling besar hubungan dengan nilai kerugian berbanding dengan indeks keupayaan proses yang lain.

ACKNOWLEDGEMENTS

This research effort represents a culmination of advice and great support of many people to whom I am deeply grateful. I wish to express my utmost appreciation and deepest gratitude to the following individuals:

I am indebted to my father and mother for their loving support. I owe my loving thanks to my wife. Without her encouragement and understanding, it would have been impossible for me to finish this work.

I would like to express enormous gratitude to my supervisor Assoc. Prof Dr. Rosnah bt. Mohd. Yusuff. This thesis would not have been completed without her patience, support and guidance. I also want to thank my committee members, Assoc. Prof Dr. Tang Sai Hong and Prof Dr. Yusof for their helpful comments and suggestions.

I would also like to thank everyone who contributed directly or indirectly to this study. The final acknowledgment is reserved for Universiti Putra Malaysia.

I certify that an Examination Committee has met on June 2010 to conduct the final examination of MOHAMMAD ABDOLSHAH on his Doctor of Philosophy thesis entitled "Development Of A Fuzzy Loss-Based Process Capability Index" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The committee recommends that the student be awarded the relevant degree.
Members of the Examination Committee were as follows:

Napsiah Ismail, PhD
Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Shamsuddin Bin Sulaiman, PhD
Professor
Faculty of Engineering
Universiti Putra Malaysia
(Member)

Aidy Bin Ali, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Member)

Professor Min Xie, PhD
Department of Industrial & Systems Engineering
National University of Singapore
(External examiner)

BUJANG KIM HUAT,PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

Rosnah Mohd. Yusuff, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Tang Sai Hong, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Member)

Md.Yusof Ismail, PhD
Professor
Faculty of Manufacturing Engineering and Technology Management
University Malaysia Pahang
(Member)

HASANAH MOHD GHAZALI,PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

TABLE OF CONTENTS