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Applications of statistical and related methods to new technology and product development process — Robust parameter design (RPD)

Application de méthodologies statistiques et connexes pour le développement de nouvelles technologies et de nouveaux produits — Modèle paramétrique robuste

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Foreword

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 69, *Applications of statistical methods*, Subcommittee SC 8, *Application of statistical and related methodology for new technology and product development*.

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Introduction

Robust parameter design, also called parameter design, can be applied in product design stage to identify the optimum nominal values of design parameters based on the assessment of robustness of its function. Robustness assessment is performed as a consideration of overall loss during the product's life cycle. The overall loss is composed of costs and losses at each stage of the product's life. It includes all the costs incurred during not only its production stage, but also its disposal stages.

When a product is not robust, the product causes many environmental and social economic losses (including losses to the manufacturer and the users) due to its poor quality caused by functional variability throughout its usable lifetime from shipping to final disposal. Product suppliers have responsibilities and obligations to supply robust products to the market to avert losses and damages resulting from defects in the products.

The aim of applying parameter design in product design is to prevent defects, failures, and quality problems that can occur during the usage of the product. A robust product, an output of parameter design, is a product which is designed in such a way as to minimize user's quality losses caused by defects, failures, and quality problems. Note that defects, failures, and quality problems are caused by functional variability of a non-robust product. In parameter design, optimum nominal values of a product's design parameters can be selected by treating a product's design parameters as control factors and by assessing robustness under noise factors. The use of parameter design at development and design stages makes it possible to determine the optimum product design and specification so that the product is robust in the market.

At manufacturing stage, the product suppliers manufacture their products that meet the product specifications. One can optimize manufacturing processes to produce the products that meet the specifications. However, robustness against customer's environment and products' aging can be addressed only by product design.

Robust parameter design methodology provides effective methods for achieving robustness through its design of specification determination, and it is a preventive countermeasure against various losses in the market.

In practice, many product's defects and failures occur due to the product's response that deviates from or varies around the designed target values by the change in usage environment and deterioration, i.e. noise conditions. The variability of product's response due to noises can be used as a measure of robustness, because market losses increase in proportion to the magnitude of variability of product's response. SN ratio, corresponding to the inverse of the variability measure, is used as a measure of goodness in robustness. In other words, the higher the SN ratio is, the less the market losses are.

For the experimental plan of parameter design, direct product of inner array and outer arrays is proposed. Control factors are assigned to the inner array, and signal and noise factors are assigned to the outer array. By using a direct product plan, all the first level interactions between control factors and noise factors can be assessed and can be utilized to select the optimum level of control factors from the point of view of robustness.

Assessing robustness through SN ratio is a key of parameter design. The outer array is for evaluating SN ratio, robustness, for each combination of levels of control factors indicated by the inner array. The inner array is for comparing SN ratios and selecting the optimum combination of system's design parameters. As for the inner array, an orthogonal array L_{18}, is recommended as an efficient plan, and then only the applications of an orthogonal array L_{18} are discussed in this International Standard. Applications of experimental layout other than orthogonal array L_{18} can be found in the examples in references in the Bibliography. More detailed discussions on inner array and orthogonal arrays can be found in the references.

Robust parameter design (RPD), and thus this International Standard, is directly targeted at the losses incurred at the usage stage. Where possible, losses at other stages are also investigated so that the results of parameter design can be applied to perform the optimum product design for the whole stages of the product's life cycle.

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Applications of statistical and related methods to new technology and product development process — Robust parameter design (RPD)

1 Scope

This International Standard gives guidelines for applying the optimization method of robust parameter design, also called as parameter design, an effective methodology for optimization based on Taguchi Methods, to achieve robust products.

This International Standard prescribes signal-to-noise ratio (hereafter SN ratio) as a measure of robustness, and the procedures of parameter design to design robust products utilizing this measure. The word "robust" in this International Standard means minimized variability of product's function under various noise conditions, that is, insensitivity of the product's function to the changes in the levels of noises. For robust products, their responses are sensitive to signal and insensitive to noises.

The approach of this International Standard can be applied to any products that are designed and manufactured, including machines, chemical products, electronics, foods, consumer goods, software, new materials, and services. Manufacturing technologies are also regarded as products that are used by manufacturing processes.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3534-1, *Statistics — Vocabulary and symbols — Part 1: General statistical terms and terms used in probability*

ISO 3534-3, *Statistics — Vocabulary and symbols — Part 3: Design of experiments*

3 Terms and definitions and symbols

3.1 Term and definitions

For the purposes of this document, the terms and definitions given in ISO 3534-1 and ISO 3534-3, and the following apply.

3.1.1
function
work which a system performs in order to fulfil its objective

Note 1 to entry: A function can be expressed by the mathematical form of input-output relation.

3.1.2
robustness
degree of smallness in variability of a system's function under various noise conditions

Note 1 to entry: System's performance can be assessed by robustness. SN ratio is a quantitative measure of robustness.

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