MODELING OF THE CONCEPTS IN ISO STANDARDS FOR PROFILE SURFACE TEXTURE

Q. Qi[1], X. Jiang[1], L. Blunt[1] and P. J. Scott[1,2]
[1] University of Huddersfield, Queensgate, Huddersfield HD1 3DH, UK
[2] Taylor Hobson Ltd., 2 New Star Road, Leicester LE4 9JQ, UK

ABSTRACT

The current concepts in surface texture international standards are considered to be too theoretical, complex and over-elaborate for industry. A functional approach that completely expresses the complicated surface texture knowledge for designers and engineers is often nonexistent on the shop floor. Based on Geometrical Product Specifications (GPS) philosophy, this paper proposes a modeling of connection between design, manufacture and measurement in surface texture. Explicit specification and verification processes are modeled base on the general GPS matrix and related ISO standards. The goal of the modeling is to bridge the knowledge gap between design, manufacture and measurement in the field of surface texture.

Keywords surface texture, ISO standards, Geometrical Product Specifications (GPS)

1 INTRODUCTION

Over the last several decades, surface texture information has been playing a significant role in controlling important operating characteristics of critical machine components. Hundreds of concepts in surface texture ISO standards have been proposed by researchers and national/international measurement institutes. Most of these concepts are considered to be too theoretical, complex and over-elaborate for industry. While key ISO documents (for instance, ISO 1302 [1], ISO 4288 [2] and ISO 4287 [3]) are widely known in the field of engineering, it is almost unknown that the relationships between these standards. In order to achieve better quality and lower costs in product design, designers has the great responsibility to complete an unambiguous surface texture specification providing manufacture and measurement information as shown in figure 1. As there are twelve ISO standards should be considered in a single surface texture design (see figure 3), a functional approach that can structure all of the concepts in these standards should be developed to help designers make accurate and unambiguous surface texture specifications, and help engineers and metrologists for manufacture plan and measurement strategy guidance.

Based on Geometrical Product Specifications (GPS) philosophy, this paper proposes a modeling of connection between design, manufacture and measurement in surface texture. Explicit specification and verification (measurement) processes are modeled base on the general GPS matrix [4] and related ISO standards. The ultimate goal is to bridging the collaboration between design, manufacture and measurement to reduce product development lead time and improve product quality and performance, thus providing a more timely and profitable solution for industry.

2 MODELING OF CONNECTION BETWEEN DESIGN, MANUFACTURE AND MEASUREMENT IN SURFACE TEXTURE

In principle, the modeling connection between design, manufacture and measurement in surface texture is similar to the quality management process which communicates with different part of product process. According to the ISO 9001 model which is based on a specific management philosophy called Shewhart/Deming Cycle is currently described as the plan-do-check-act (PDCA) cycle. This philosophy determines the structure, planning and implementation of the standard. It is the single most important element which is embedded within the standard. The modelling represented in figure 2 is the connection process cycle based on PDCA philosophy which pertains to the fundamental tasks in quality control. As shown in figure 2, the design process express customers needs and expectations in function specification and then make complete surface texture specifications considering manufacturing and measurement issues. The manufacture would be under considerable time pressure to complete its work and get the design into production, to meet a commitment or a bidding deadline that marketing required. According to the specified surface texture specification, the metrologist will decide the measurement strategy, carry out the measurement and report the result and advice for design improvement, then designers capture and analyse this feedback. Therefore, providing a timelier, profitable, quality assurance solution and learning effect solution for industry.

3 MODELING OF SPECIFICATION AND VERIFICATION PROCESSES IN SURFACE TEXTURE

According to the principle of GPS which is based on metrology and uncertainty, GPS aims to ensure product function through unambiguous, explicit and complete specifications for design, manufacture and verification of product geometric characteristics. Aimed at collecting and harmonizing existing standards for the specification and verification of geometrical characteristics of workpiece, ISO/TC 213 determined the so-called GPS matrix as presented in ISO/TR 14638 [4]. In the GPS matrix model the concept of chain of standards is applied. Referring to a specified geometrical characteristic, each chain collects all the related standards, which can be used in the various steps of the production process. Each single standard in the chain affects the other standards, which must necessarily be known to be understood and applied correctly. Figure 3 shows the schematic diagram of the general GPS matrix model in profile surface texture. In the general GPS matrix model, the concept of chain links refers to a specified geometrical characteristic. In figure 3, chain links 1-3 describe the requirements for specification and verification is defined in chain links 4-6, see [4] for details. The reference to the complementary GPS Matrix considers the items relating to manufacture.

According to the general GPS matrix, the expression of surface texture can incorporate two processes: specification and verification processes. The surface texture specification process is the design step where the field of permissible deviations of a set of control elements of surface texture is stated, accommodating the required functional performance of the workpiece. ISO 1302:2002 version (see figure 1) gives ten different control elements which include profile parameter, limit value, filter type, transmission band, evaluation length, comparison rule, manufacture process and surface texture lay. The purpose of the specification process is to establish those control elements associated with the design requirements of parts and their functional surfaces commensurate with production capabilities for the use of design and engineering drawings.

The modelling of specification process of profile surface texture is shown in figure 4. The desired function requirements and other advance information will be used for experiential specification control elements inference. After the inference procedure, all of the inferred control elements such as parameter, parameter value, filter type, transmission band, manufacturing process and surface texture lay can be combined to a complete profile surface texture specification. Then the specification can be generated to an indication in engineering drawing and saved to specification data.

The surface texture verification process takes place after the specification process. It is the manufacturing step at which a metrologist determines whether the real surface of a workpiece conforms to the field of permissible deviations specified. The definition of this geometrical deviation will be used to adjust the manufacturing process. It assists manufacturing and inspection areas in the interpretation of drawing information and method of assessment, and explains to them the terms, symbols and values shown on drawings. It defines how surface texture specification data will be interpreted, and how a metrologist determines whether the surface of a workpiece conforms to the specification.

Standard GPS rules and definitions for verification define theoretically perfect means for determining conformance of a workpiece to a GPS specification. However, verification is always accomplished imperfectly. Because verification involves the realization of the GPS specification in actual measuring equipment, which can never be made perfect, verification will always include implementation uncertainty.

In this paper, the modelling of verification process of profile surface texture is provided. As shown in figure 5, when a specification of a workpiece is verified, the metrologist begins by reading the specification, translating the specification to a measurement specification, then deciding the measurement strategy which includes measurement distribution, measurement area, measurement times and speed. While particular surfaces may require very different measurement techniques, individual steps in the measurement plan are developed from specification that consistent with desired function. After the surface texture measurement, the collected data will be treated by different steps. The numerical parameter measurement values can be calculated after the filtration. Finally, an uncertainty evaluation should be carried out in order to make a decision for conformance or non-conformance. In addition, the comparison results will be feed back to design process for the design improvement.

4 CONCLUSIONS

This paper proposes a modeling of connection between design, manufacture and measurement in profile surface texture based on GPS philosophy. Explicit specification and verification processes are modeled base on the general GPS matrix and related ISO standards. This paper concentrates on profile surface texture because the areal surface texture standards are still in progress. The modeling of concepts in areal surface texture standards will be developed in future work. This work is a foundation to bridge the collaboration gap between design, manufacture and measurement in surface texture to reduce product development lead time and improve product quality and performance, thus providing a more timely and profitable solution for industry.

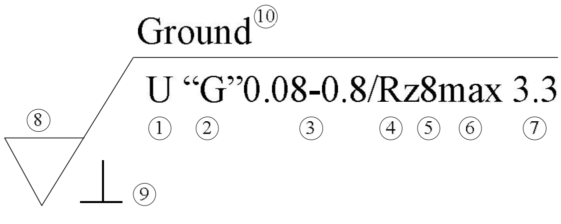
REFERENCES

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION. (2002), *ISO 1302:2002 Geometrical Product Specification (GPS) – Indication of surface texture in technical product documentation*.

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION. (1996), *ISO 4288:1996 Geometrical Product Specification (GPS) – Surface texture: Profile method – Rules and procedures for the assessment of surface texture*.

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION. (1997), *ISO 4287:1997 Geometrical Product Specifications (GPS) -- Surface texture: Profile method -- Terms, definitions and surface texture parameters.*

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION. (1995), *ISO 14638:1995 Geometrical Product Specification (GPS) – Masterplan*.



① Indication of upper (U) or lower (L) specification limit
② Filter type
③ Transmission band
④ Profile parameter
⑤ Evaluation length as the number of sampling length
⑥ Comparison rule
⑦ Limit value in micrometres
⑧ Type of manufacturing process
⑨ Surface texture lay
⑩ Manufacturing process

Figure 1: Control elements in indication of profile surface texture requirements on engineering drawings

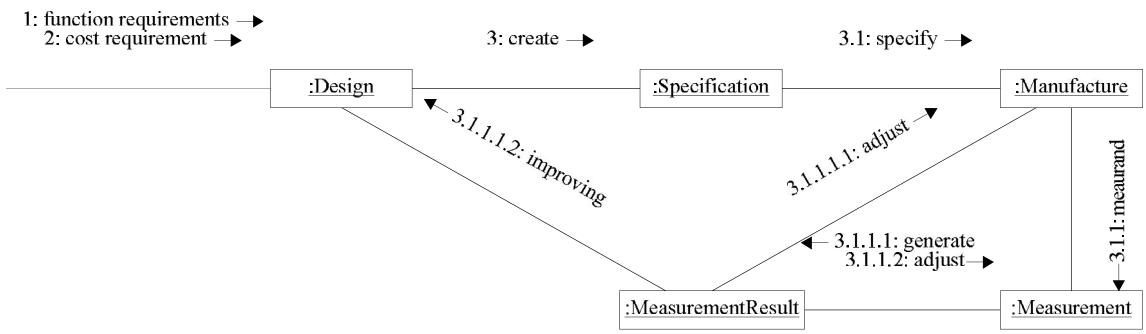


Figure 2. The UML communication diagram of the connection process between design, manufacture and measurement in surface texture

Chain link No.	1	2	3	4	5	6
Geometrical characteristic of feature	Product documentation indication-Codification	Definition of tolerances - Theoretical definition and values	Definitions for actual feature - characteristic or parameter	Assessment of the deviations of the workpiece - Comparison with tolerance limits	Measurement equipment requirements	Calibration requirements - Measurements standards
Roughness	ISO 1302	ISO 4287, 11562,12085, 13565-1,13565-2, 13565-3	ISO 4287, 11562, 12085, 13565-2	ISO 4288,12085	ISO 3274, 11562	ISO 5436-1, 5436-2,12179
Waviness	ISO 1302	ISO 4287,11562, 12085	ISO 11562, 12085	ISO 4288, 12085	ISO 3274, 11562	ISO 5436-1, 5436-2,12179
Primary	ISO 1302	ISO 4287,11562	ISO 4288		ISO 3274, 11562	

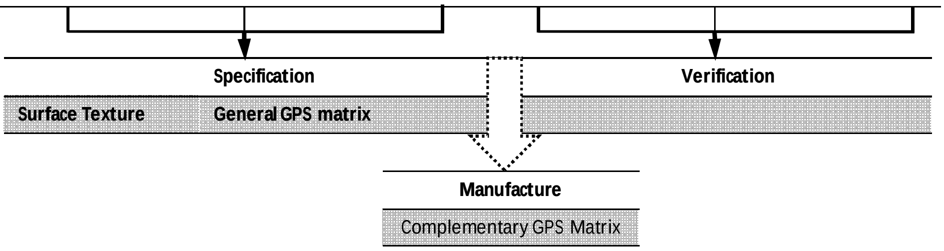


Figure 3: Scheme of GPS matrix model in profile surface texture

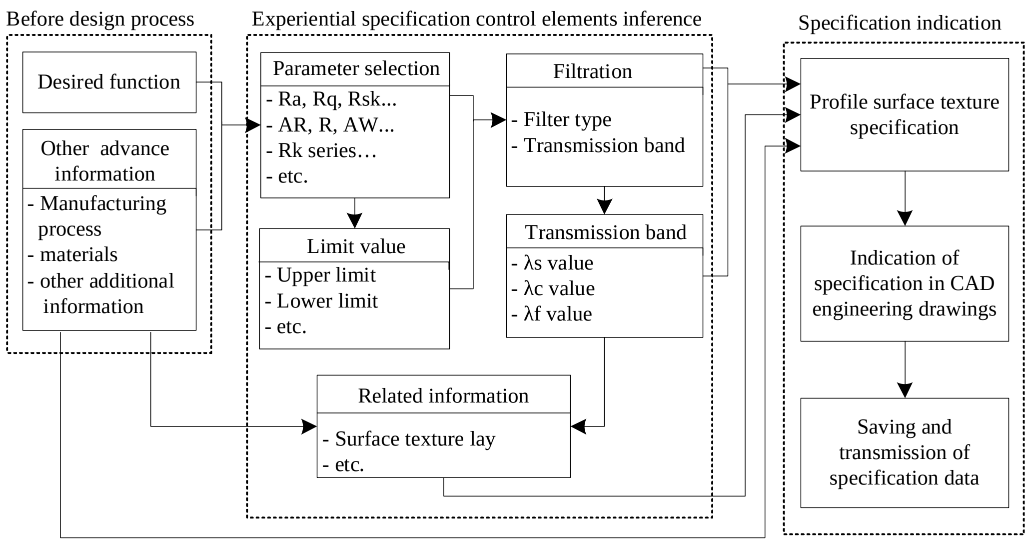


Figure 4. Modeling of specification process of profile surface texture

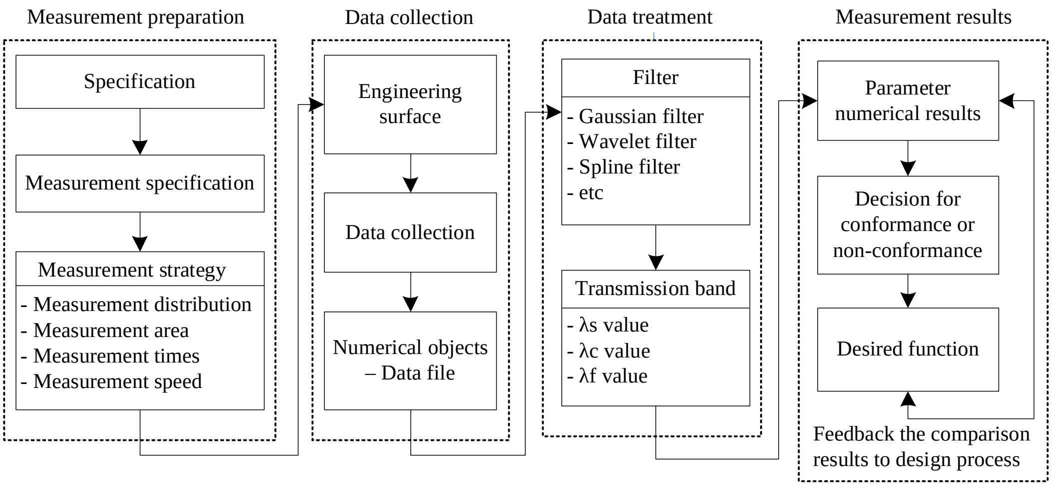


Figure 5. Modeling of verification process of profile surface texture