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Surface texture specification, the more complete the better?

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Abstract

In this paper, three solutions are proposed to simplify the surface texture specification without significant information loss. The first solution is operating additional default values for simplification. The second solution is utilizing simple symbols in CAD systems but affiliated with complete specifications attribute data which can be transferred to other CAx systems or end users for reading and analyzing. The third solution is using both default values and CAD specifications attribute data. After the combination, the shortest specifications can be generated and also can be employed in both paper technical drawings and CAD systems.

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Keywords: surface texture; specification; ISO 1302:2002; CAD; XML

1. Introduction

In order to reduce specification uncertainty, the specification of surface texture has became increasingly detailed to provide engineers with optimal information about how to control the manufacturing process and carry out the subsequent measurement. ISO 1302:2002, the latest international standard for surface texture specification, gives the tools to control the surface texture by an unambiguous specification on technical drawings. This standard makes it possible for the designers to indicate unambiguously the intended surface texture with the least possible effort, also makes it possible for the reader of a given surface texture specification to understand, to implement or verify the requirement without mistakes [1]. This standard is nowadays applied globally in manufacturing. Most of the engineers are however yet employing its old versions since it is simple and save drawing space despite having significant specification uncertainty (up to 300%) [2]. As shown in Fig 1 and Table 1, the first two versions are short in both vertical and horizontal direction in drawing space; and the 2002 version is much longer in horizontal direction. When ISO 1302:2002 is applied, if there are multiple surface texture symbols with both upper and lower limit value, the surface texture symbols, geometric tolerance, dimension, etc., create a crowded and almost unreadable technical drawing. It is however with essential meaning if the designers are assigning complete surface texture specifications. Therefore, a dilemma is emerged. Is it the complete the better for the specification of surface texture? On the one side, in order to fulfill the function requirements and control manufacturing process precisely, the specification should be the complete the better. On the other side, if the technical drawing is full of specification symbols, it will turn into an unreadable and un-transferable technical drawing. This issue demonstrates a question that is it possible to simplify a complete surface texture symbol without information loss? In this paper, three solutions are proposed to answer this question. The first solution is utilizing more default values to simplify the symbol. The second solution is exploiting simple surface texture symbols in CAD (Computer-Aided Design) systems but affiliated with complete specifications attribute data. The proposal of third solution is to

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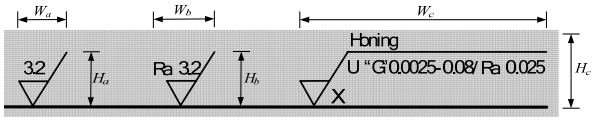

Fig. 1. Different versions of the surface texture symbols in technical drawing. (a) the 1971 version, (b) the 1992 version, (c) the 2002 version.

overcome the disadvantages of both first and second solutions.

2. First Solution - simplified surface texture specification

There are ten control elements which can be denoted as E_1, E_2, E_3, … E_{10} respectively in the surface texture specification defined in ISO 1302:2002, as shown in Fig 2. Each element has different number of options as listed in Table 2. As defined in ISO standards such as ISO 4288 [3], ISO 3274 [4] and ISO 12085 [5], element E_1, E_2, E_3, E_5 and E_6 have related ISO default values.

- The default value of E_1 is "U" which is defined in ISO 1302.
- The default value of E_2 is "Gaussian filter" which is defined in ISO 16610-21 [6].
- Defined in ISO 4288 and ISO 3274, the default value of E_3 is λc of 0.8mm, then related λs of 0.0025mm. For Motif parameters, the default value of A is 0.5mm, B is 2.5mm and λs is 0.008mm.
- The default value for E_5 of evaluation length as the number of sampling length is "5" which is defined in ISO 3274.
- The default value of E_6 is "16%-rule" which is defined in ISO 4288.

Table 1. Proportions of different symbols in technical drawing

No.	Standards version	H_a(*mm*)	W_a(*mm*)	*Height of letters* (*mm*)
a	ISO 1302:1971	27	27	8
b	ISO 1302:1992	27	32	8
c	ISO 1302:2002	38	134	8

Even when all default values are applied, the indication is however still not sufficiently short. In addition to the ISO default values, there are other elements which probably have national, company, institute or other non-ISO default values. For elements E_4 of profile parameter, there are few companies utilizing *Ra*, *Rz* or *RSm* as default parameters. Depend on the specialized function requirements, particular profile parameter can be assigned as a temporary default value. For E_8 of type of manufacturing process, there is no particular default type. However, for use in the written text, the textual indication for $E_{8\text{-}1}$, $E_{8\text{-}2}$ and $E_{8\text{-}3}$ is APA (any process allowed), MRR (material removal required) and NMR (no material removed) respectively. To avoid the necessity of repeating a complicated indication a number of times, or where space is limited, or if the same symbol is required on a large number of surfaces of a workpiece, a simplified reference indication may be invoked [1]. The simplified reference indication is with E_8 and a reference letter to refer the specification details. The element E_9 of surface texture lay cannot write by text, then it cannot be simplified except in the simplified reference indication.

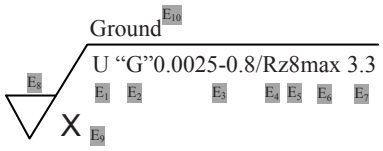

Fig. 2. Control elements in indication of surface texture requirements on engineering drawings

Table 2. Details of ten control elements in ISO 1302:2002

No.	Control elements	Value	Default value in ISO standards	Suggested default value
E_1	Indication of upper(U) or lower(L) specification limit	$E_{1\text{-}1}$=U, $E_{1\text{-}2}$=L	$E_{1\text{-}1}$=U	
E_2	Filter type	$E_{2\text{-}1}$=FPLG, $E_{2\text{-}2}$=FPLS, $E_{2\text{-}3}$ =FPLW... $E_{2\text{-}13}$=F2RC	$E_{2\text{-}1}$=FPLG	
E_3	Transmission band	$E_{3\text{-}1}$=0.0025-0.08, $E_{3\text{-}2}$=0.0025-0.25 ...$E_{3\text{-}5}$=0.025-8	$E_{3\text{-}3}$=0.0025-0.8	
E_4	Profile parameter	$E_{4\text{-}1}$=Ra, $E_{4\text{-}2}$=Rq, $E_{4\text{-}3}$=Rz … $E_{4\text{-}n}$, n≥62	None	Company default parameter
E_5	Evaluation length as the number of sampling length	$E_{5\text{-}1}$=3, $E_{5\text{-}2}$=4, $E_{5\text{-}3}$=5…$E_{5\text{-}6}$=8	$E_{5\text{-}3}$=5	
E_6	Comparison rule	$E_{6\text{-}1}$=16%-rule, $E_{6\text{-}2}$=max-rule	$E_{6\text{-}1}$=16%-rule	
E_7	Limit value in micrometers	$E_{7\text{-}1}$=0.025, $E_{7\text{-}2}$=0.05, $E_{7\text{-}3}$=0.1...$E_{7\text{-}m}$, m≥12	None	
E_8	Type of manufacturing process	$E_{8\text{-}1}$="✓", $E_{8\text{-}2}$="∀", $E_{8\text{-}3}$="∀✓"	None	In the written text is APA, MRR and NMR
E_9	Surface texture lay	$E_{9\text{-}1}$="⊥", $E_{9\text{-}2}$= "=", $E_{9\text{-}3}$= "X"...$E_{9\text{-}7}$= "P"	None	
E_{10}	Manufacturing process	$E_{10\text{-}1}$=Milling, $E_{10\text{-}2}$=Honing...$E_{10\text{-}i}$, i≥9	None	

Fig 3 gives the flow chart of the simplified procedure for a complete surface texture specification. The procedure is as follows:

- adjudge whether the element E_1 is the default value. If yes, goes to the next default judgment, otherwise the default value is $E_{1\text{-}2}$, then goes to the next default judgment;
- adjudge whether the parameter is $E_{4\text{-}1}$. If yes, goes to the next default judgment, otherwise adjudge if the parameter is other default parameter such as company default one. If yes, goes to the next default judgment, otherwise it is other non-default parameter;
- adjudge whether E_2, E_3, E_5 and E_6 are default values. If yes, omit all default values, otherwise they are non-default values;
- account the number (n) of repeat time for the same indication;
- adjudge $n \geqslant i$ (i is a constant positive integer which is assigned by the designers depend on the drawing space or other information). If yes, using graphical symbols with or without letter (simplified reference indication), otherwise, goes to simplified specification generation procedure. The simplified specification then will be generated.

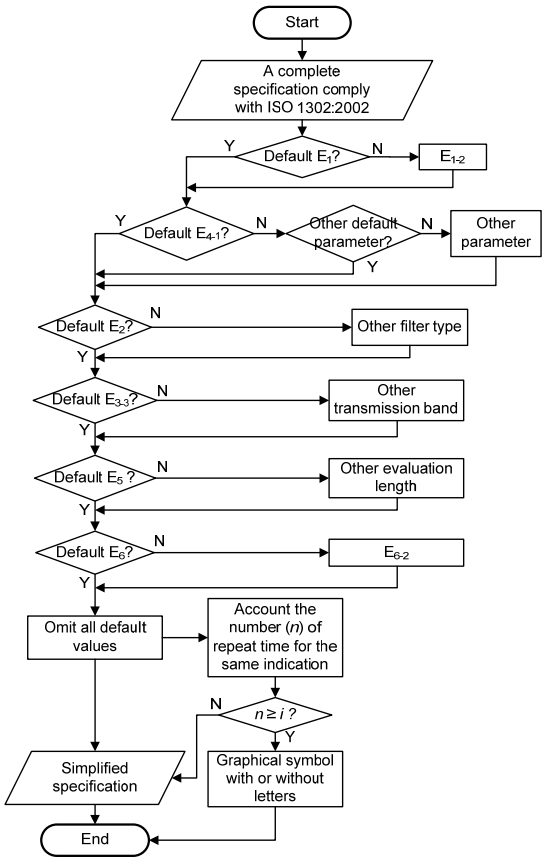

Fig. 3. Flow chart of the simplified procedure for surface texture specification

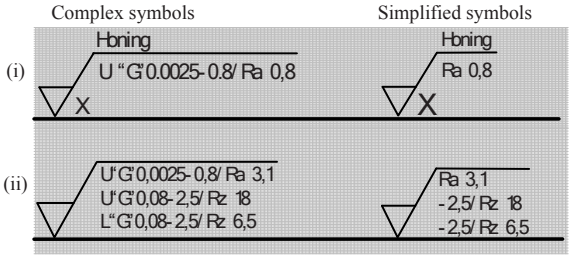

Fig. 4. Examples for complex and simplified symbols a complete surface texture specification

This solution is complies with the ISO and company standards; specifications are shorter, and easy for paper technical drawings. Fig 4 gives two examples before and after the simplified procedure. For case (i), the specification is simplified about 60%. For complex specifications with both upper and lower specifications with different kind of parameters and limit value (case (ii) in Fig 4), there is no practicable approach to shorten the specification over 50%.

3. Second Solution

The second solution is utilizing simple surface texture symbols in CAD systems and affiliating with complete specifications attribute data which can be transfer to other CAx (Computer-Aided Technologies) systems or end users for reading and analyzing. In this solution, a XML (Extensible Markup Language) based surface texture specifications attribute schema is established.

3.1. XML Schema

Conscious of the difficulty in data exchange among various engineering information systems, the series of ISO 10303 (commonly known as STEP) is for the computer-interpretable representation and data exchange between engineering information systems (especially CAx systems). With the increasing popularity of XML on the distributed environment, mapping geometrical specification data into XML seems a logical way to make specifications more accessible and exchangeable [7, 8]. According to the properties of XML Schema and requirements to represent surface texture, this section shows how to represent surface texture specification by using XML Schema to meet different application domains' requirements. Based on the XML Schema file, users can construct an appropriate XML instance data file to meet requirements. After an XML instance file been constructed by the developers, its validity can be pre-checked with the schema before it is passed to another system. Such an XML instance file can apply to CAx systems, make it more easier to transfer data between different stages of production.

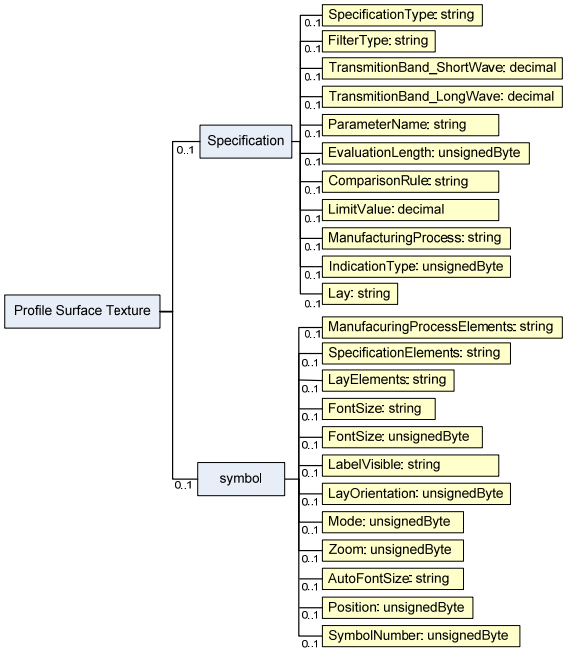

Fig. 5. XML schema for surface texture specification

The XML schema for a simplified surface texture indication with a complete specification reference is indicated in Fig 5. For profile surface texture, the first level is the Specification which includes the complete ten elements defined in ISO 1302:2002, the second level is the Symbol which is the simplified surface texture symbol comply with old ISO 1302 version or simplified symbol from first solution.

3.2. CAD attribute data

The complete surface texture specification should be assigned by the designer and a XML file will be generated according to the XML schema in the last section. A proposed example of result for second solution applied in AutoCAD 2011 is shown in Fig 6. Here, the indication example is a simplified specification from ISO 1302:2002, the complete specification is shown elements by elements in the block reference of the symbol. Part of the related XML file is shown as below:

```
<?xml version="1.0" encoding="utf-8"?>
<!--IconRoughness XML file-->
<root>
  <Specification>
    <SpecificationType>U</SpecificationType>
    <FilterType>Gaussian</FilterType>
    <ManufacturingProcess>Turning</ManufacturingProcess>
    <TransmitionBand_ShortWave>0.0025</TransmitionBand_ShortWave>
    <TransmitionBand_LongWave>0.8</TransmitionBand_LongWave>
    <ParameterName>Ra</ParameterName>
    <EvaluationLength>5</EvaluationLength>
```

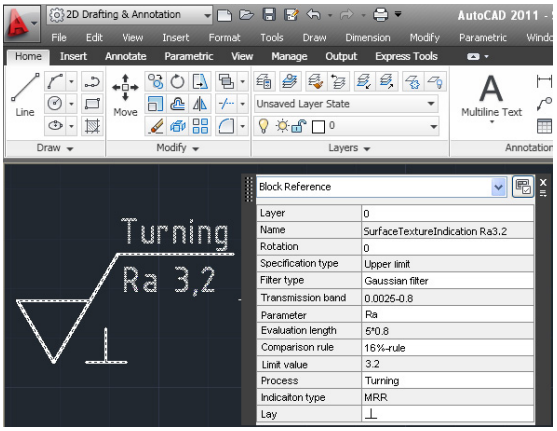

Fig. 6. A case study of second solution applied in AutoCAD

```
    <ComparisonRule>16%</ComparisonRule>
    <Limitvalue>3.2</Limitvalue>
    <IndicationType>1</IndicationType>
    <Lay>⊥</Lay>
  </Specification>
  <Symbol>
    <ManufacturingProcessElements>Turning</ManufacturingProcessElements>
    <SpecificationElements>”Gaussian” 0.0025-0.8/Ra 3.2</SpecificationElements>
    <FontSize>11</FontSize>
```

The second solution is easy to transfer and translate by software systems. The procedure is from simplified specification to complete specification, just to the contrary of the first solution. However it can only be applied in CAx systems, not suitable for paper technical drawings.

4. Third Solution

As both two solutions have advantages and disadvantages, in order to overcome the disadvantages of both solutions, the third solution is using both default values and CAD specifications attributes data. As shown in fig 7, if the symbol will be draw in CAD system, the assigned complete specification will be simplified firstly by utilizing the first solution. The simplified indication then will be draw in CAD system and original complete specification elements will be added to the indication attribute dada. If it is for a paper technical drawing, the simplified specification will be generated by the first solution, the symbol can be draw with list numbers, and the detailed specification elements can be attached in the spare space or attached documents.

After the combination, the possible shortest specifications can be generated and also can be employed in both paper technical drawing and CAD systems. However, when applied the approach to paper technical drawing, it may not very convenient when all the detailed requirements are showed and there are

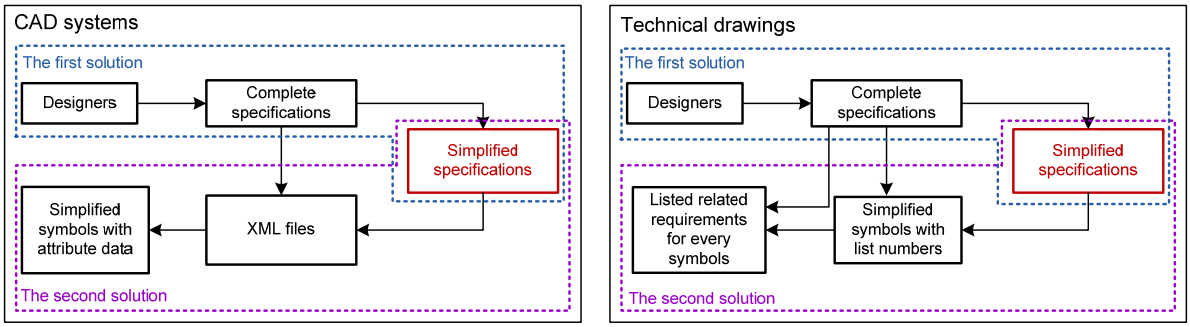

Fig. 7. The third solution applied in CAD systems and technical drawings

limited space. The simplified reference indication can be suggested to apply in this situation.

5. Conclusion

This paper proposed three solutions to simplify surface texture specifications without significant information losses. The proposed three solutions are basic images during surface texture specification assignment considering uncertainty issues.

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