AN APPROACH TO THE IDENTIFICATION OF MACHINED COMPONENTS USING SURFACE PROFILE ANALYSIS

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ABSTRACT

Computer based production design, planning and control systems have come a long since the late fifties when manufacturing companies started to use computers for wide range of applications. The problem of identification and classification of machine components has grown rapidly in recent years, A great deal of knowledge and experience is needed for machined components identification. Manufacturers do not supply documentation concerning the machining conditions for machined components. Surface structure plays a vital role in the time and function of some products e.g. Journal bearings and spindles. This work presents a coding system for surface texture pattern with respect to different machining processes for the purpose of classifying manufactured surface. A knowledge based system approach outlined the possibility of components identification using surface geometry analysis and pre-stored information. Simulation of surface batches in data base representing the texture lay pattern of nominal surface produced by different machining processes are collected and stored. Different machined components with known working conditions were prepared and measured for surface geometry evaluation to prove the capabilities of the proposed system. Parameters such as total roughness (Rt) for surface finish and machining feed rate are proposed for such manufactured product. A comparison between the know working condition and the proposed output condition was made to ensure the capability of the system. Final report of surface identification is then established including appropriate coding description of the surfaces and anticipated machining conditions.

NOMENCLATURE

R_t Roughness Total Value
R_s Roughness Average Value
R_z Roughness Zone Value
R_{max} Roughness Maximum value

INTRODUCTION

Most of Engineering surface are produced by variety of machining processes. The performance of any machining process is assessed by the dimensional error and the surface texture of its product. he importance of surface texture role in the life time and in the function of mechanical components should not be neglected. Interest in measuring surface texture has been on the increase during the last decades using different techniques.

In most cases researches [1-6] studied the ability to predict the process output by understanding how the process respond to change in its inputs in order to optimize the performance of the process ahead of the cut by both off-line process planning and on line predictive control.

This objective motivated the development of models to describe the relations between inputs and outputs of the process. [7].

Having produced spare parts with the required surface texture they are then assembled and delivered to consumers. By experience, manufactures do not considered detailed documentation for machined components in order to remanufacture or reproduce such parts.

This work presents an approach outlining the possibility of components identification using surface geometry analysis and pre-stored processing information.

The new approach in this work is implemented as a computer simulation of a coding system for surface texture pattern with respect to different machining processes.

The proposed system produced an identification report including appropriate coding, description of the surfaces and anticipated machining conditions, and is likely to assure increasing importance with the progressive shift to CAD/CAM system in industry.

SURFACE PATTERN AND MACHINING PROCESS

Surfaces could be produced with cutting tools of defined geometries such as in turning, shaping & mailing or undefined geometries such as in grinding & polishing. A chip particle of the metal is detached by the cutting action between the cutting tool and the workpiece, leaving on the workpiece surface a scratch mask generally called microgeometrical irregularities (hatches). The pattern of these hatches are dependent upon the geometry of the cutting tool point the nature of the engagement between the tool and workpiece, relative motion between them (feed) and cutting condition used.

Tool marks and field direction generate what is called the "lay" which characterize the surface irregularities direction. Figure (1) summarized some of lays symbols for surface texture designation [8]. Surface roughness measurements take place across and along the lay in order to obtain the most significant characteristics of the surface irregularities and different assessment parameters such as Rt, Ra Rz,... etc).

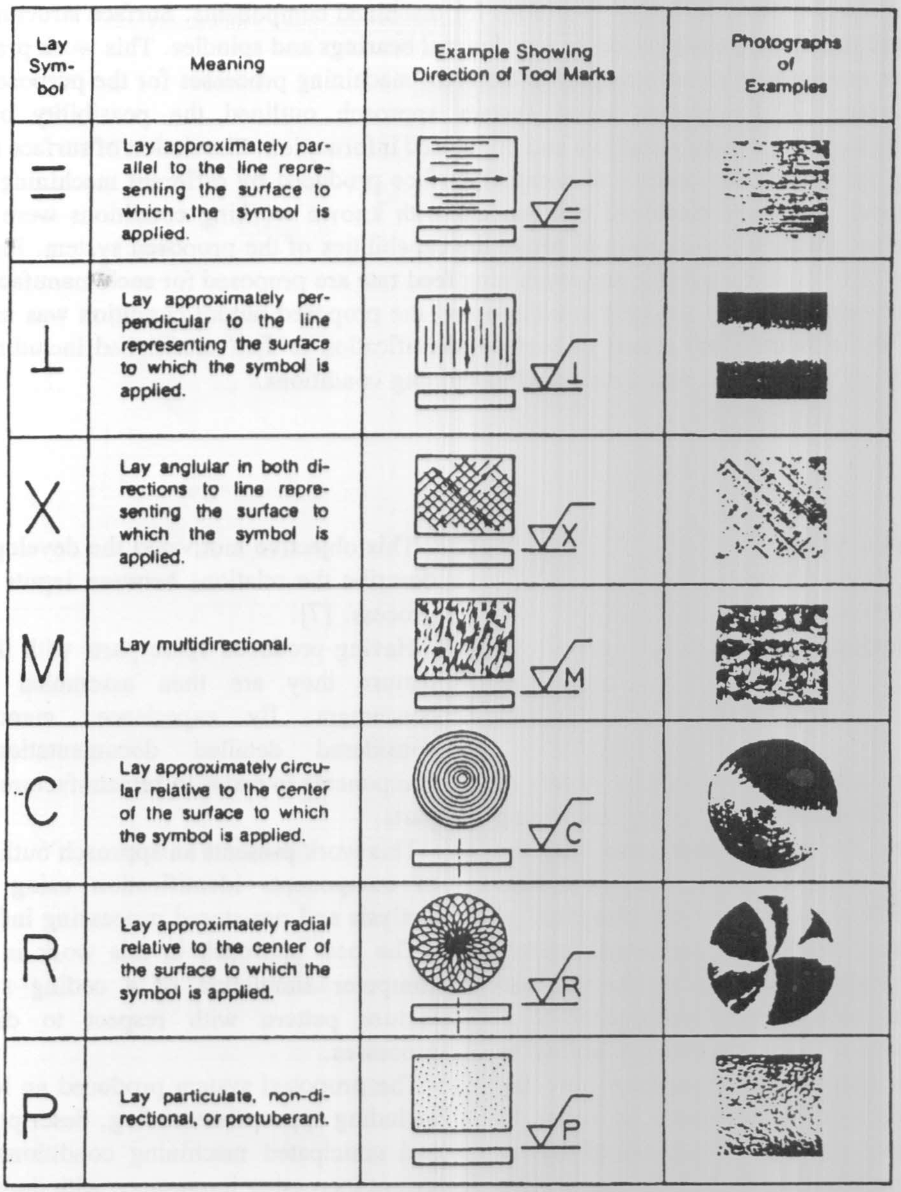


Figure 1. Lay symbols for surface texture designation.

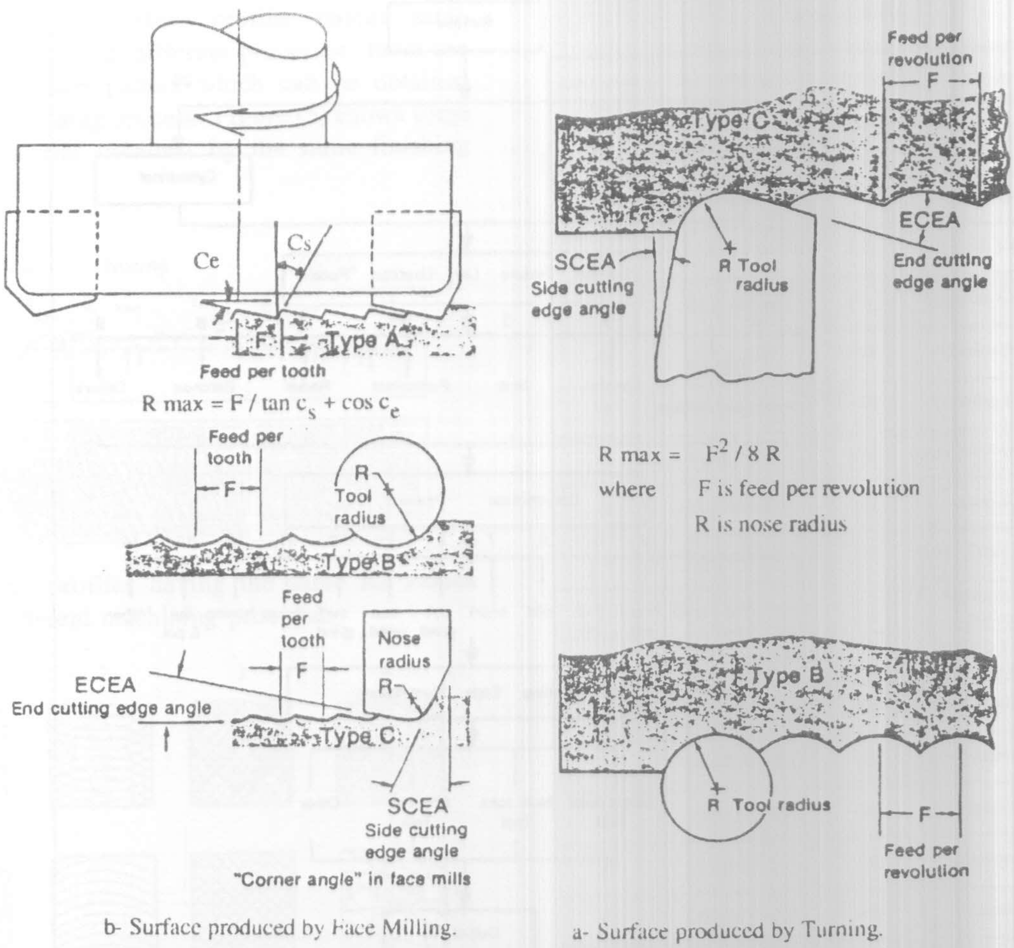


Figure 2. Surfaces produced by Turning & Milling with the types of tools used in the theoretical surface finish calculations [8].

Figure (2) showed two examples of surfaces produced by a defined tool geometry, a) turning & b) face milling in which it is clear that tool geometry and feed rate has a clear effect on surface profile values Rt & Rz.

Figure (3) summarized different surface texture lay direction patterns with the classification of the corresponding deterministic machining processes.

Rupture and flaw marks are considered as surface defects which may include ridges, digs, cracks, ---etc. These defects are dependent on other sources such as vibration, incorrect chucking, ...etc.

SURFACE CODING SYSTEM

Each surface has an assumed directionally across which measurement should take place [1]. Based on surface profile, analysis of recommended machining process may be suggested. For non-isotropic surfaces in which measurements should take place in more than one direction, possibilities for machining process recommendation are more complex.

In order to identify surfaces with respect to manufacturing process conditions a coding system for such identification was established using the classification shown in Figure (3), in which machined surface are classified into two types; flat surfaces having an input code 10 & cylindrical surface with the code 20, this will lead to the surface texture lay direction patterns with 9 input codes from to 9 as shown in Figure (3). This classification is the key for the construction of the flow chart and the interactive programme. The determination of the machined process and the cutting conditions as output codes are shown in the last third parts of the chart. Leading the interactive action to a final ID-code for the surface.

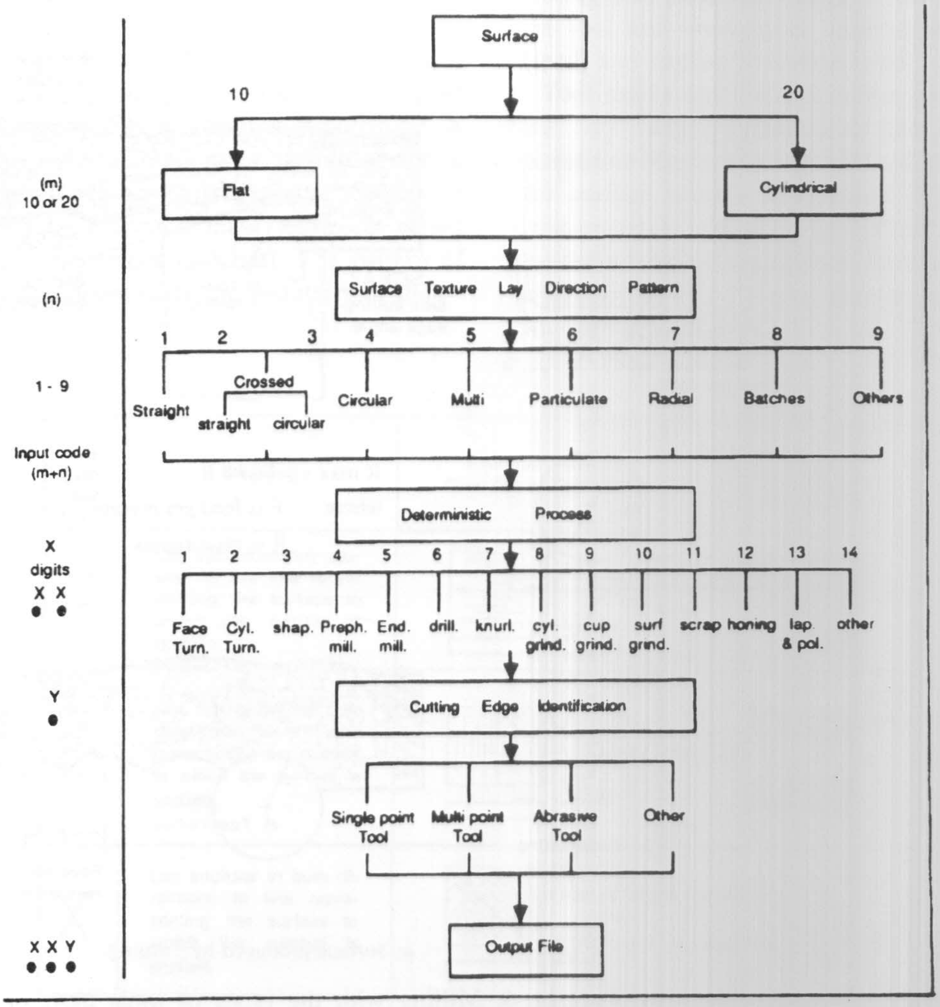


Figure 3. Classification of surface identification and machining process.

According to the classification shown in Figure (3), Table (1) is constructed giving the input and output codes for different cases covering the different possibilities and probabilities in Figure (3) ending with the proposed final code for the surface, ID.

SURFACE ROUGHNESS PARAMETERS AND MACHINING CONDITIONS

As already shown in Figure (2) it is clear that it is possible to calculate the theoretical surface finish parameters from machining process parameters (conditions).

By considering the total geometry, the peak to valley height (R max) can be obtained by the following equation [8].

$$R\ max = F^2\ 8\ R$$

where F is feed per revolution

R us nose radius

Similar relationship can be developed for other processes such as the surface produced by face milling (case b in Figure (2)):-

$$R\ max = F\ /\ \tan c_s + \cos c_e$$

In reality surface roughness parameters are not sufficient to give a complete description of physical characteristics for some surfaces.

Several surface can be of quite different appearances but having the same surface roughness parameters. Figure (4) shows an example for three surface profiles having the same Rz parameters and are machined by different machining processes, it is clear that to distinguish between the three surface in the roughness parameters alone are not sufficient and a need for a vision scanning is a must. Similar to surface profiles having same roughness parameters with different processes, there are different surface vision patters which can be obtained using the same machining process. Figure (5) shows some surface texture visions obtained by the same finishing process.

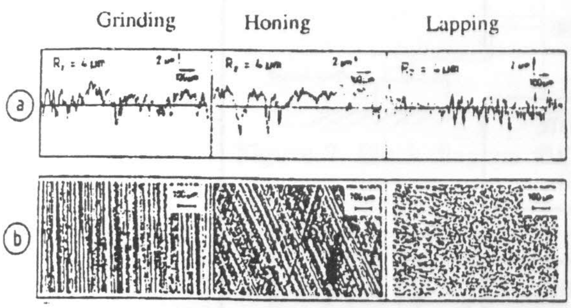


Figure 4. Surface profiles having the same Rz values obtained from different machining processes.

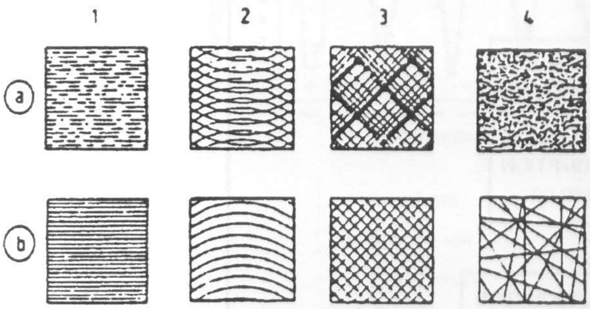


Figure 5. Surface texture according to DIN 4761 for 1) surface grinding 2) side grinding 3) Honing 4) Lapping.

It is clear that the vision patterns for surface in surfaces in case (a) differs from the patterns in case (b). From the above conflict it is clear that surface vision patterns are not sufficient complete identification of surfaces.

The use of a scanning unit with a complete integrated measuring system will give the possibility to introduce a complete identification o surfaces specially with those having undefined geometry.

PILOT TESTS FOR THE ID. SYSTEM

A knowledge system & identification programme is developed and written in BASIC language. Figure (6) summarize the main steps followed by allowing an interactive dialog between the operator & the software to input some data or suggestions & finally reaching the step in which a final report is obtained including the codes for identifications.

Table 1. Coding system for surface geometry evaluation.

Input code (m+n)	lay "pattern" Description	Output code X Y ●● ●	Process Description	Surface Code
11	Flat & Straight	031 042	shaping & single Milliny	11031 11042
12	Flat & Straight crossed	031	shaping & single (twice)	12031
13	Flat & Straight crossed	052	End mill & Multi	13052
14	Flat & Circular	011	Face turn & single	14011
15	Flat & Multi	103	Flat surface Gr./Abr.	15103
16	Flat & particulate	133	Polishing & Abr.	16133
17	Flat & Radial	093	cup Grinding & Abr.	17093
18	Flat & Batches	111	Scrapping & single	18111
19	Flat & Others	144	Others	19144
21	Cylind & Straight	021 062	Cylinder. turn drilling	21021 21062
22	Cylind & Straight crossed	072 123	knurling & Multi. Honing	22072 22123
23	Cylind & circular crossed	000	not applicable	23000
24	Cylind & Circular	000	not applicable	24000
25	Cylind & Multi.	083	Cyl. grind & Abr.	25083
26	Cylind & Part.	133	polish/lapping	26133
27	Cylind & Radial	000	not applicable	27000
28	Cylind & batches	000	not appliicable	28000
29	Cylind & others	144	Others	29144
30	Conical	----	----	----

Figure (7) shows the block diagram of the identification measuring system build around the portable stylus type surface roughness measuring device "Surtronic 2".

The system consists of the main following units:

a- Surface roughness measuring unit in which surtronic (Taylor & Hobson) was used using standard pickup (Type 112/110) attached to an analogue meter unit displaying the surface roughness parameter (Ra).

b- Signal analysis unit in which it consists of an analogue to digital converter board and a microcomputer (P.C.)

c- Scanning unit which consists of scanner head and controller (This unit is recommended for work)

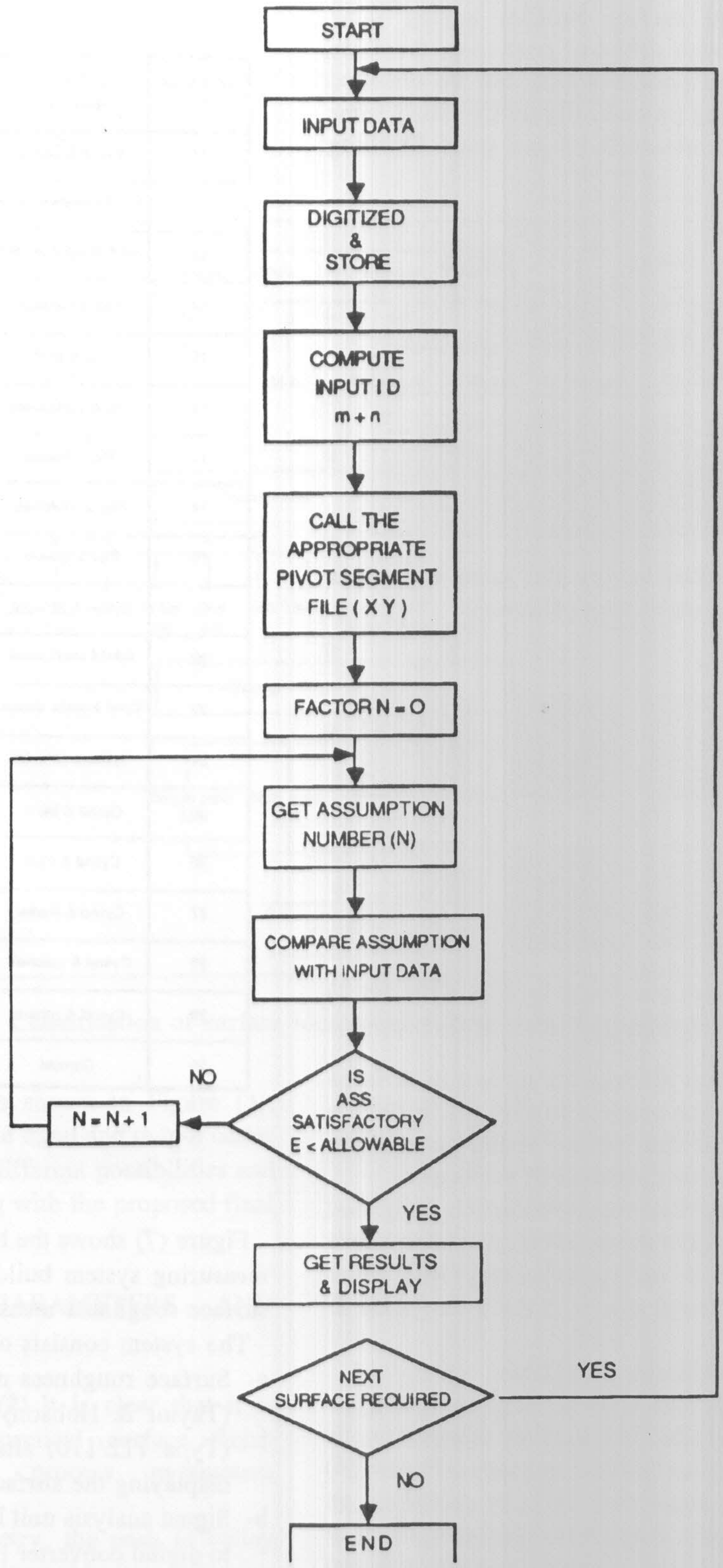


Figure 6. Flow chart of surface ID interactive programme.

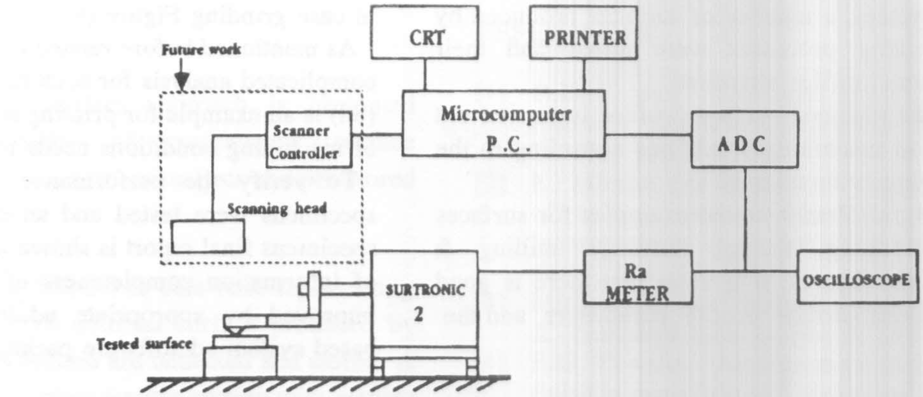
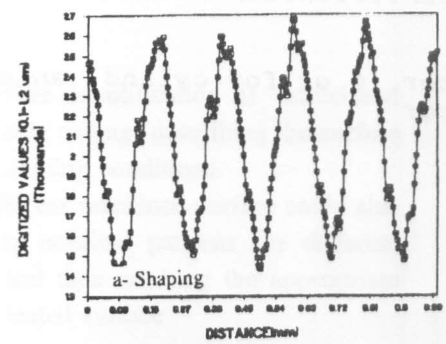


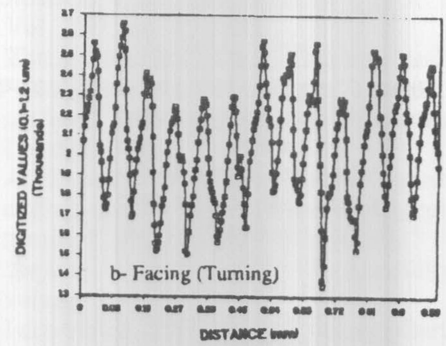
Figure 7. Block diagram for surface ID measuring system.



Ra = 5 um

a) Rt = 16 um

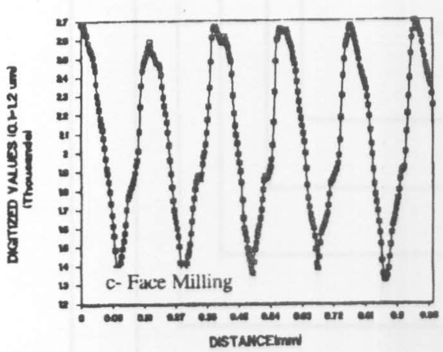
f = 0.2 mm/st.



Ra = 5 um

b) Rt = 15.6 um

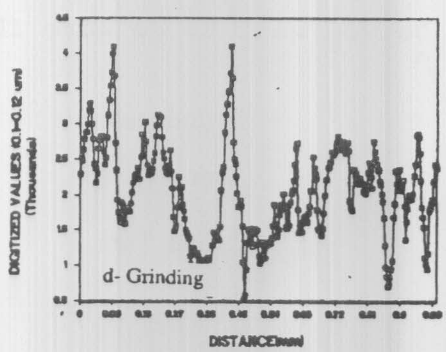
f = 0.09 mm/rev.



Ra = 5 um

c) Rt = 16.8 um

f = 0.2 mm/rev.



Ra = 0.8 um

d) Rt = 4.2 um

Figure 8. Typical O/P measured surface profiles for different machining processes.
a- Shaping b- Facing (Turning) c- Face Milling d- Grinding.

In order to verify the suitability of the proposed identification system, a number of surfaces produced by different machining processes were tested and their surface roughness profiles measured.

Analysis of the obtained surface profiles is carried out with reference to machining conditions according to the procedure previously mentioned.

Figure 8 (a,b,c,d) demonstrated examples for surfaces produced by shaping, facing, (turning), milling & priding. From the figures, it is clear that there is good correlation between surface profile parameters and the machining condition (feed rate & tool geometry), exc in case grinding Figure (8-d).

As mentioned before related to Figure (5) it needs m complicated analysis for such finishing processes. Fig (8d) is an example for printing surface in which detect of machining conditions needs more study.

To verify the performance of ID system, seve specimens were tested and an example of one of th specimens final report is shown in Figure (9). The deg of information completeness of components ID can improved by appropriate additions to the knowle based system ad software package.

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        WELCOME TO  SURFACE IDENTIFICATION PROGRAMME

For flat workpiece please enter 10 or for cylind. enter  20? 20
Direction of layes        Number
     linear                  1
   linear crossed            2
  circular crossed           3
     circular                4
      multi                  5
    particulat               6
      radial                 7
       batch                 8
       other                 9
For direction of layes input 1-9? 1

Workpiece input code is    21

 WELL YOUR EXPECTED FINAL CODE IS   2 1 02 1 12 125

Do you want to do more ID?? n
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- 2 → Cylindrical
- 1 → Linear
- 02 → Cylind. Turn.
- 1 → Single point tool
- 12 → Rt (um)
- 125 → feed rate (um/rev.)

Figure 9. Final output code for surface ID system.

CONCLUSIONS

A knowledge based system approach is presented outlining the possibility of components surface identification using surface texture analysis and pre-stored information.

Simulation of surface batches in data base representing the texture lay pattern of nominal surface produced by different machining processes are collected and stored. A coding system for the surface texture pattern with respect to different machining process has been established for the purposes of classifying different manufactured surfaces.

Final report of surface identification is established including such appropriate coding, describing the surface and the anticipated machining conditions.

Pattern vision for different machined surface could also be obtained by storing nominal patterns for different machining conditions and then catching the appropriate one for the concerned tested surface.

REFERENCES

[1] R.E. Reason, "The trend of surface measurement", *National physical symposium laboratory*, U.K., October 1953.

[2] K. Mintsui and H. Sata, "Frequency characteristics of cutting process identified by an in-process measurements of surface roughness", *Annuals of the CIRP*, Vol. 27, 1987.

[3] Michael Brock, "Surface roughness analysis", *B & K. Technical Review*, No. 3, 1983.

[4] E.G. Thwaite, "Measurement and control of surface finish in manufacture", *Precision Eng.*, vol 6, no. 4, 1984.

[5] D.J. Mahvanez and D.P.E. Newzeland, "Identification of surface roughness", *Proc. I. Mech Eng.*, Vol. 199, no. 4, 1985.

[6] Zhang Honghol, Chen Zhixiang and Chen Rlyao, "Recognition and intelligent control of machined surface", *6th International Conference on CAPE*, London 1990.

[7] A. Shawky, "A comprehensive dynamic model for cutting forces and surface topography in oblique turning", *PEDAC 92*, Alex. 1992.

[8] *Surface Integrity*, MDC Machinability data centre, volume 2, 1980.

[9] Jahrsberich, IWF-Braunshwning, Germany, 1990.