CHAPTER 8

CONCLUSION

8.1 INTRODUCTION

This chapter presents the summary of the research work. The salient features of the work done are summarised in the first section and the major conclusions drawn from the results of the experimental studies are given in the following section. The scope for future work is stated in the final section.

8.2 SUMMARY OF THE PRESENT RESEARCH WORK

Surface roughness evaluation using machine vision is one of the current fields of research. There are many issues related to surface roughness studies. Some of them have been taken up in this work. In this work three different materials namely, brass, aluminium and mild steel are machined for different cutting conditions. The surfaces of the material are captured using a machine vision system. Few of the commonly used statistical parameters and Fourier parameters are estimated from the image. A comparative study of these parameters is made and their applications have been discussed. For estimating the optical parameters from the image, a software written in Visual Basic and a program written in Matlab are used.

The effect of the lighting variables on the image based roughness parameter – the arithmetic average of the grey level – is studied using a
fabricated experimental setup. A systematic study of the effect of lighting variables is studied using the Design of Experiments (DoE) procedure.

The three main factors, the grazing angle, inclination of the striations and the illumination distance, are varied in the experimental trials for different specimens. Analysis of variance (ANOVA) on the optical parameters and the influence of the lighting conditions on different surface roughness and different materials are discussed. The Taguchi’s Signal-to-Noise ratio analysis is used to find the level, which gives better result. To check for the validity of the experiments and the analysis of variance, multiple variable regression models have been developed. Adequacy of the model is checked using normal probability plot and residual plot.

To improve the information content of the image, edge-enhancing method used in image processing technique is adopted. Different edge enhancing operations are applied on the surface images and their effect on surface roughness estimation is studied.

8.3 MAJOR CONCLUSIONS

- In the study, it is found that the parameter arithmetic average of the grey level finds good correlation with roughness. This parameter is found good in discriminating roughness of different surfaces of isotropic nature as well as surfaces with predominant lay pattern.

- When the roughness is of lower range, and when there is close control of machining conditions, mean or R1 can be used for distinguishing surfaces of any material.
• When the tool marks are visible and the lay pattern is predominant, the parameter $S_{MOD}$ can be used effectively.

• The Fourier descriptors - the average energy and the central power spectrum percentage show linear relationship with roughness. These parameters can be used individually for effective discrimination of surfaces.

• The influence of lighting conditions namely, the grazing angle, inclination of the striations and the illumination distance on the image parameter is not the same for different materials and also it varies with roughness.

• For reflective machined surface like brass and mild steel, the influence of illumination distance is less and for surfaces like aluminium, which have a dull-machined surface, the illumination distance affects the optical parameter more.

• The effect of striations on optical parameter is almost the same for all the material. Keeping the striations in a direction perpendicular to the light source gives the best result for most of the specimen.

• For smooth surfaces, the influence of the grazing angle is high and for rough surfaces the effect of grazing angle is less in the case of reflective surface. The trend varies with the reflective properties of the surface and for materials like aluminium, which are less reflective the effect is almost insignificant.

• Edge enhancing operators generally improve the information content of the image and thereby, on the optical roughness parameter.
The combination of edge operations - Sobel and Laplacian give a better estimation of the surface roughness on milled and ground surfaces.

The models that are developed for the lighting conditions illustrate that the factors affecting the lighting conditions are reasonably considered in the study.

The coefficient of determination and the plots of normal probability and residuals confirm that experimental errors are not abnormal.

8.4 SCOPE FOR FUTURE WORK

Quantification of surface finish is being accorded more priority in the inspection plan of a manufacturing process and means are tried to automate the inspection task. Surface estimation by machine vision is tried as a method for quicker evaluation. In the machine vision system, many methods of analysis are done to find the best technique, which gives high evaluation accuracy. An acceptable and practical procedure for evaluating roughness is yet to be explored.

In this work, few of the image parameters based on the statistical distribution of the grey intensities and Fourier descriptors are compared. The study can be extended to parameters based on the co-occurrence matrix.

The study on the roughness parameters is made on machined surfaces of the same material. The applicability of the machine vision technique for differentiating surfaces of different materials can be analysed.
• The influence of the lighting conditions on surfaces in dry conditions is studied in this work. This work can be extended to find the influence of lighting conditions on surfaces immersed in oil medium.

• For enhancing the images, some of the first order and second order edge enhancing operators are applied in the image processing. The usefulness of the wavelet operators can be analysed in surface evaluation.