Machine Vision Based Spur Gear Measurement

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Abstract- *A gear is very important element of any system. For proper functioning of system a gear must be of accurate dimensions. So precision measurement of gear is the crucial step in gear inspection.The present methods of gear inspection are either costly or tedious. The purpose of this paper is to use machine vision technique to develop system that can measure dimensions of a spur gear accurately and rapidly. Such a machine vision system has been developed for spur gear measurement. A CMOS camera has been used to capture images of a spur gear. The program for measurement has been prepared in NI vision builder. The developed system has been calibrated in metric units. Using a sample gear, software results were verified with actual dimensions.*

Keywords- Measurement, machine vision, spur gear, computer vision, automatic inspection.

I. INTRODUCTION

A Gear is one of the most commonly used element in any mechanisms for transmitting power and motion. For most of the modern industrial and transport applications, gears are important and are frequently used as fundamental components[1].Error in manufactuing of gears causes two main problems, increased acoustic noise in operation and increased wear, both of which are sufficiently serious to cause problems [2].To meet required accuracy in gear, precision measurement of gears is of prime importance. Spur gear has major use among all types of gears in. Hence gear measurement process needs to be automated.

The variation of an actual tooth from the design profile,the profile error, can be measured by variioustechniques. The easiest method is to measure the tooth width at a number of pitches by an adapted caliper gauge [3].Another technique is to use gauging with a moving probe, with a displacement transducer attached, which traces the design profile. Many mechanical-probe gear inspection systems are available but these systems are not appropriate for inspection of smaller gears. Some efforts have been made to develop smaller probes capable of measurement of small mechanical elements [4]. The other options are to use a coordinate measurement machine to check the actual profile, or rolling the gear across a stationary probe [5–7]. Optical methods were used for measuring gear-tooth deformation [8], pitch errors and tooth profiles [9]. Younes et al. developed system using laser to measure the thickness, pitch, and tooth flank profile [10,11].The present techniques of gear inspection are either costly or time consuming. Hence many researchers have been working on development of system that solve this issue. Machine vision systems have been widely used in many applications [12–15].

Yih-ChihChiou and Wei-Chen Li developed machine vision system for inspection of polyurethane packing [16]. GaoliangPeng et al. used computer vision technique to inspect and measure O ring [17].Yanli Yang et al. used machine vision system for inspection of conveyor belt [18].HaoShen et al. used vision system for bearing inspection [19].

II. THE DEVELOPED VISION SYSTEM

Fig.1 shows an image of the developed vision system. It consists of two main parts, hardware and An application software. The hardware includes CMOS color camera which is used for image acquisition, white LED lights as an illumination source. The camera is holded in the stand. It is connected with computer via USB interface cable. NI vision builder as an application software has been used to prepare program for gear measurement. It contains many image processing and gauging tools to build required applications.
To perform the measurement, the gear is placed on the platform. The camera captures an image of gear. It is sent to computer and opened in NI vision builder software. The execution of developed program gives measurement results.

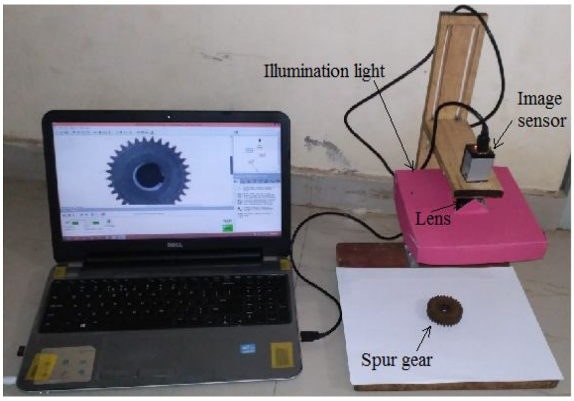


Figure 1. Machine vision system

III. MEASUREMENT METHODOLOGY

First of all based on number of teeth and module, the pitch circle diameter is calculated. To find outer diameter, a point is generated at the top of teeth based on intensity transition using find edge tool as shown in Fig. 2(a). Generally the number of points is equal to the number of teeth. From all these points a circle is formed using circle fit as shown in Fig.2(b). From that center and diameter of outer circle are found out. Similarly to find root circle diameter, points are generated at root using find edge tool as shown in Fig.3(a). Using circle fit, a root circle is generated as shown in Fig.3(b) by which center and diameter are found out. Using all these dimensions addendum and dedendum are calculated. Then a pitch circle is drawn and points are generated in between outside and root circle as shown in Fig.4(a) and 4(b). Using these points teeth thickness on pitch circle and circular pitch are calculated as shown in Fig.5.

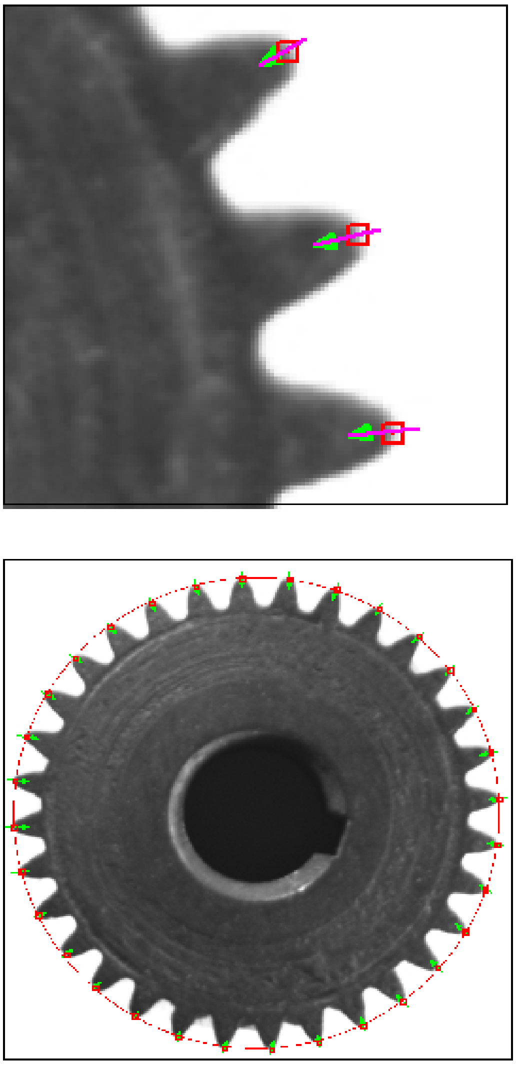


Figure. 2.(a) Points generation for outer circle (b) Outer circle fit

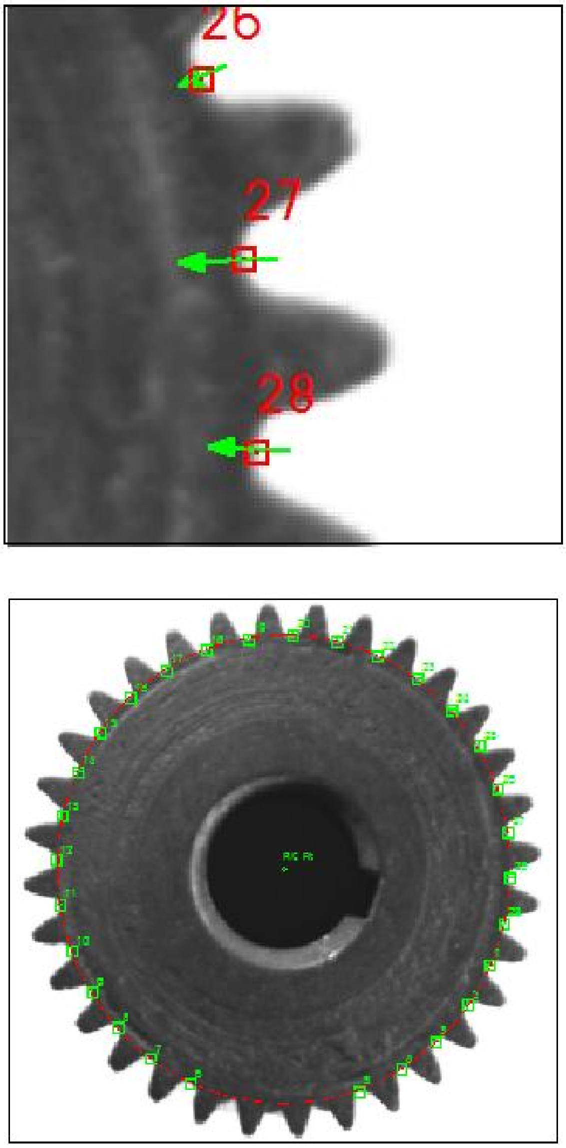
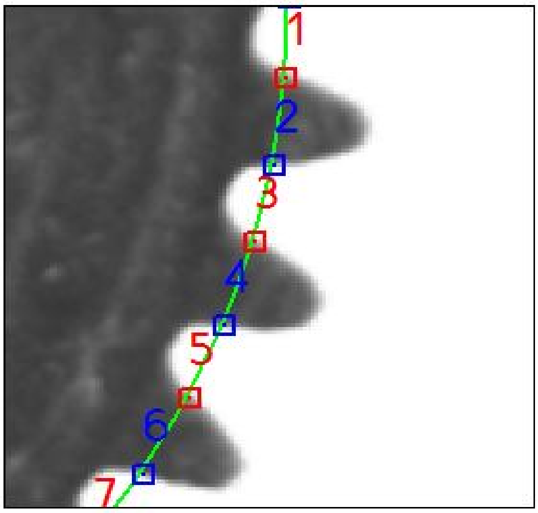


Figure. 3. (a) Points generation for outer circle (b) Outer circle fit



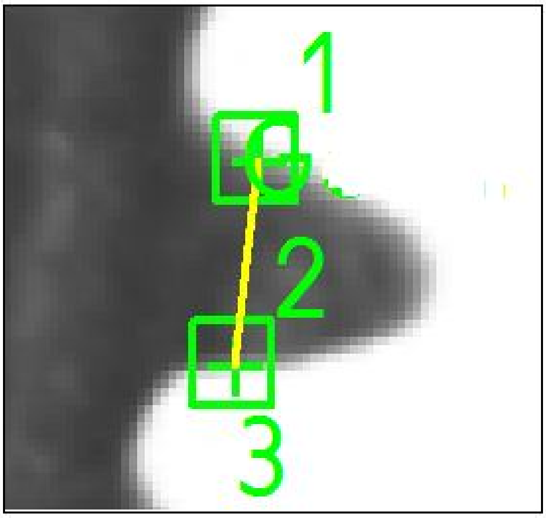


Figure. 4(a). Points generation on pitch circle (b) Tooth thickness measurement

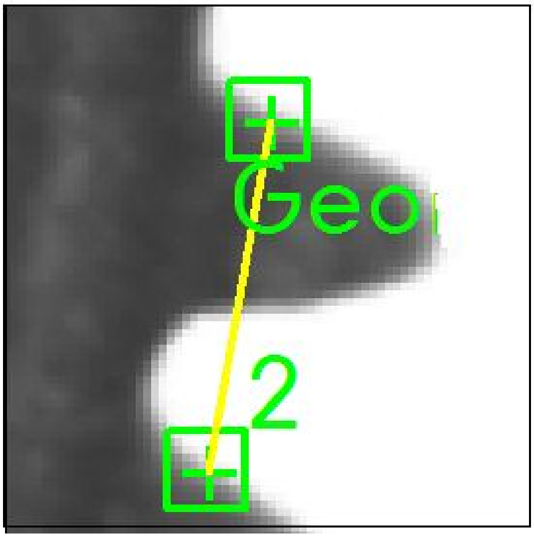


Figure. 5. Pitch measurement

IV. RESULTS

The proposed system was calibrated using vernier caliper of 0.02 mm leasat count.The measurement results obtained from software is shown in Table 1. Here pitch circle radius is 24mm. From software results, addendum circle radius =26.23 mm and dedendum circle radius = 23.03 mm. Hence addendum = 26.23 -24 = 2.23 mm and dedendum = 24-23.03 = 0.97 mm.

Table 1 Comparision of results

Parameter	Software result	Actual value	Deviation
Module	1.5	1.5	0
No. of teeth	32	32	0
Pitch circle diameter	48	48	0
Addendum circle radius	26.23	26.38	-0.15
Dedendum circle radius	23.03	23.1	-0.07
Addendum	0.97	0.92	-0.05
Dedendum	2.23	2.20	-0.03
Tooth thickness	2.51	2.56	-0.05
Diametral pitch	0.667	0.667	0
Circular pitch	4.56	4.56	0

V. VERIFICATION AND DISCUSSION

To verify the proposed system, dimensions were measured manually using vernier caliper and gear tooth caliper of 0.02 mm least count. A comparison between the actual and the calculated values of gear parameters as well as the difference between the two values are listed in Table 1. Positive differences mean that the calculated values are greater than the design values and vice versa.It can be seen that the software results are consistent with actual value.

VI. CONCLUSION

The vision system has been proposed as a new non-contact measurement system for inspection of spur gear. A program has been developed to analyze the captured images and perform the measurement using developed image processing and analysis algorithms.The proposed vision system has been calibrated and verified by measuring sample gear and comparing the calculated parameters with the actual values of spur gear parameters. The accuracy of the system depends on the size of the gear to be measured. For smaller gear, the accuracy is higher and vice versa.

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