Design and Analyze of the On-Line Detection System of the Surface Quality of Crystal Oscillator Shell Based on Machine Vision

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Abstract: - The Quality of Crystal Oscillator Shell has important influence to its capability as the benchmark clock unit of circuit. So it is important to detect its quality. Based on the basic principle of machine vision for on-line detecting, machinery structure of the system is designed firstly, then according the requirement of product detecting, the periphery control system is researched, al last, the Detection of the Surface Quality is realized based on the Euler and binary. The experiment indicates this system has the advantages of precision, no contact and stabilization. This system can work with the auto punch and according the surface quality of crystal oscillator shell, the abrasion state of punch mould is estimated indirectly. The product automaton is realized.

Key-Words: - Crystal oscillator shell; On-line detection; Machine vision; Mechanism; Periphery control system.

1 Introduction

Crystal Oscillator has the advantage of high frequency stability, small volume, high precision, and it is widely used as the source of benchmark clock in all kinds of analogical and digital circuits. The quality of crystal oscillator influences the normal work of hardware circuits system directly, and that the punch quality of crystal oscillator shell will influence the quality of crystal oscillator to some extent certainly.

Punch is used to continuously strike out the shape of crystal oscillator, whose work process is totally automatic, including fixing material and punching, it can be continuously work for several hours without any worker. The punch quality of crystal oscillator shell is guaranteed by punch mould mostly, so if the punch mould is mangled and the punch still continuously work, lots of wasters will be produced. Therefore an automatic detecting system, which can be used to detect the quality of crystal oscillator shell, is extremely necessary to a punch product line. The system indirectly judges the mould status mostly through detecting the crystal oscillator shell. It is not necessary to have a high work frequency, but make sure to detect once every several minutes. If some abnormity is detected by the system, it will stop the punch immediately.

In modern manufacturing industry, such as to automobile component production line and medicines reagents production line and so on, similar difficult problems also exist. Lots of traditional detecting technologies do not meet the demand of modern manufacturing industry any more, so it is necessary to research some new product detecting technology. Among all kinds of technologies that have been researched on, machine vision detecting technology has the advantages of high speed, high precision and high automation; moreover it can meet the demand of modern manufacturing industry and also show the vast application prospect in reality. It has become a popular research field [1-4]. Machine vision detecting technology has the following outstanding advantages compared with traditional detecting technology: (1) high

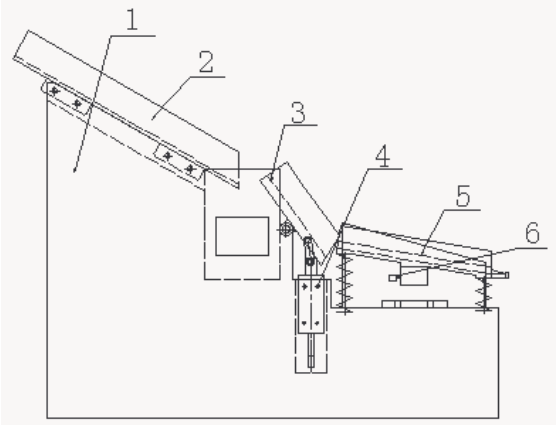
detecting speed; (2) high precision; (3) non-contact; (4) strong ability of anti-interference (5) real time.

Crystal oscillator shell defect on-line detecting system based on machine vision is the detecting system used in crystal oscillator shell production line. Machinery structure of the detecting system is designed firstly, and then according to the requirements of product detecting, the corresponding pneumatic component is chosen, finally the quality detection of the surface of crystal oscillator shell is realized used the Euler number and binary area method.

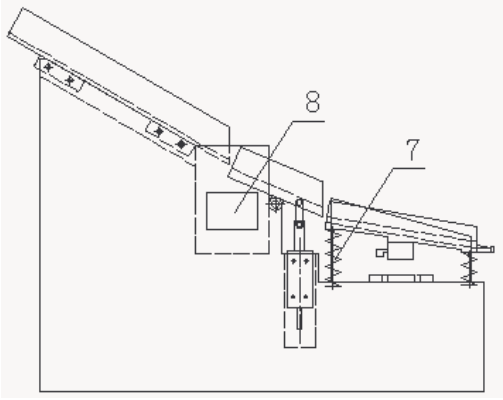
2 Machinery Structure of the Detecting System

Machinery structure is an indispensable part for most machine vision system, and also a basic platform which can be built up for the whole vision system. To this system, the machinery structure appears especially important. The mechanism is designed according to the function which the system needs to realize, including steering, sampling and fixing position machine part mainly, shown in Fig.1.

The function of this vision system is to detect the defects of crystal oscillator shell in the product line real time. Only one production can be detected each time, and it can only detect one sample every certain time, because it takes certain time to realize the action of actuating mechanism. Firstly, a steering slot (shown in Fig.1(a) machine 2) is required from a high speed and mass-produced production line to the system of actuating mechanism, which can realize the transfer of product and be linked up with the following machine. Secondly, the function of sampling, which is realized by outsourcing electromagnet and sampling steering slot (shown in Fig.1(a), machine 3 and 4) is indispensable because there is time interval while detecting products. Finally, it is necessary to collect stable and quiescent images of products to detect the crystal oscillator shell, besides it is a repeatable process and state, that is to say the images collected from every sample must be in the same state, and this function can be completed by vibration steering slot and eccentricity electric motor, as showed in Fig.1(a), machine 5 and 6. Part 1 in Fig.1(a) is an assemble platform that cooperates all these parts.



a. No-sampling state



b. Sampling state

1. Machinery assembles platform 2. Steering slot
3. Electromagnet 4. Sampling steering slot
5. Vibration steering slot 6. Eccentricity electric motor
7. Spring 8. Flume

Fig1. System of steering, sampling and fixing position machine

The function of this equipment is realized by the following steps: part products that come from the production line are carried downward along the steering machine. If the equipment is not in sampling state (as showed in Fig.1(a)), which means when electromagnet electrifies and sampling steering slot moves up, crystal oscillator shell will come out from machine 8 shown in Fig.1(b). Here flume is designed, which is convenient for the products to drop automatically, and a recycling device can be put here to reclaim those products that have not been detected.; if the equipment is in sampling state (as shown in Fig.1(b)), which means when electromagnet electrifies and sampling steering slot falls back, crystal oscillator shell will drop to the vibration steering slot through sampling steering slot. Vibration steering slot is driven to vibrate with certain frequency by the vibratory source of eccentricity electric motor, in

the process of continuous vibration, crystal oscillator shell gradually moves to the back of vibration steering slot--level allocation slot, and the state of crystal oscillator shell on the level allocation slot could only be underside up or top up, these two kinds of states are just the target states of the following works.

3 Analysis and Design of Peripheral Electromechanical Control System

3.1 Function analyze

Peripheral electromechanical control system should mainly meet the following demands:

(1) Precision and high speed: the control system should be able to respond to the input of the production line in time and pass it to the camera in order to take images, at the same time it also should be able to respond to the output of the superordination machine in time and control the manipulator to act.

(2) Stable and reliable: the actual work environment of the vision system is production workshop or other lieu which has lots of disturb, so the vision system is demanded to be extremely safe and reliable in resisting the electromagnetism disturbance and screen.

(3) Good universality and convenient interface: the control system is demanded to adapt to all kinds of controlled members, because process control, motion control and logic control are very complex, and also have lots of interfaces in this vision system.

(4) Good expansibility: in the actual work of this vision system, it should be able to expand various function modules on the basis of not replacing the control system when the work environment or lieu varies.

3.2 Structure and composing of peripheral electromechanical control system

According to the anterior functional analyze, the structure of control system is designed, shown in Fig.2.

Analysis of each unit shown in Fig.2:

(1) Pneumatic implementation component: it responds to the controller's signal, translates the command which the controller sends out into executive action, and helps to complete the image collection work.

(2) All kinds of Electromagnetic valves.

(3) Travel switch: it restricts the time and location that the cylinder runs, and carries the location signal to the controller through sensor, because if the cylinder piston's location is not restricted, it will not only increase the working hour, but also produce oscillation.

(4) Controller: it controls each component to work systematically. It receives the detecting result from mainframe continuously, also controls the executive result and sends executive component's location and state to the mainframe.

(5) Auxiliary device: it includes muffler, oil and fog separator, piezometer, change connection and so on. Those also ensure to placidly control and protect pneumatic implementation component from eyewinker's pollution, which will result in jam and noise.

(6) Gas source: it is used to produce the power.

(7) Alarm device: it is used to show the detecting results.

(8) Industry control computer: it is the platform of the whole control system.

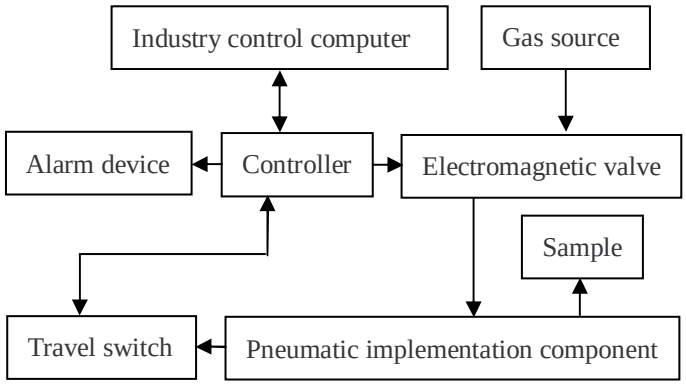


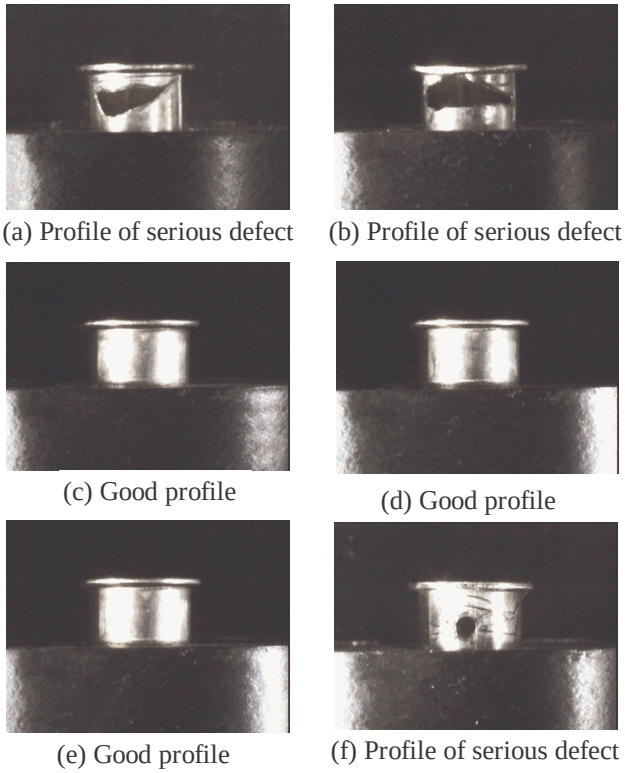
Fig.2 Structure of control system

4 Identification Algorithm of the Surface Quality of Crystal Oscillator Shell

4.1 Acquire and preprocessing the image

The vision detecting system of laboratory environment is open type, so imaging is easily affected by the light of outside environment. However the system finally used in industry spot is totally enclosed, and the influence of environment's light is much less, moreover all the surfaces of background that appear in CCD's ken are covered with the weak reflectance substance (such as oil paint) in order to pretreat and post treat the image conveniently. The surface quality of crystal oscillator shell includes the quality of top side, underside and profile; here the profile is taken as an example. Fig.3 is the images of defective and normal profile source that is obtained in simulate industry scene environment. Fig.4 is the flowchart of processing image.

Fig5 is the image obtained by morphologic operation which closes first and opens after. Characters are abstracted on the basis of that.



(a) Profile of serious defect (b) Profile of serious defect

(c) Good profile (d) Good profile

(e) Good profile (f) Profile of serious defect

Fig.3 Images of several profile in different defects

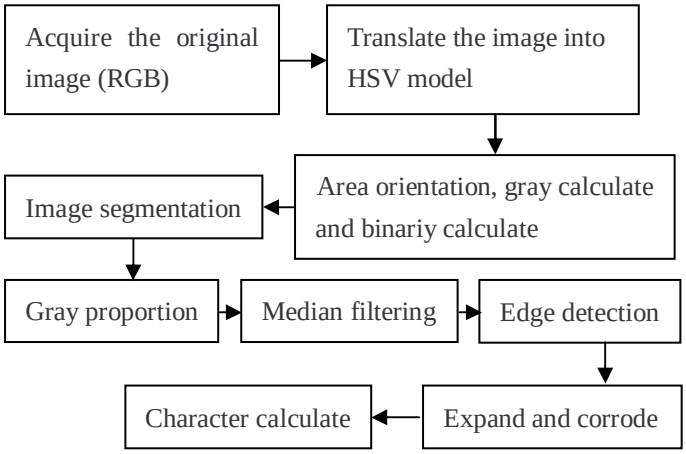
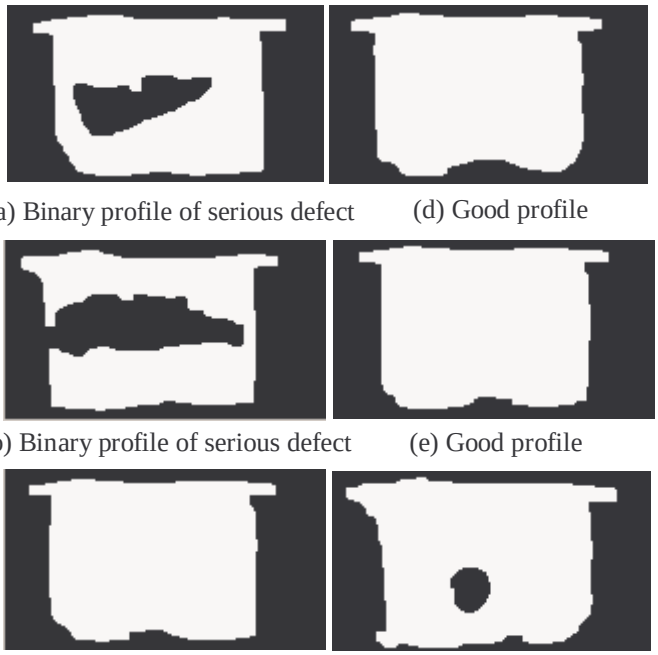


Fig.4 The flowchart of the image processing

4.2 Identification algorithm of profile surface quality on the basis of Euler number and binary area method

4.2.1 Euler number method

There are abutting pels (m，n-1)、(m，n+1)、(m-1，n)、(m+1，n) existing around the pels (m，n) in the binary image. These 4 pels is called 4 near neighbors of the pels (m，n), if superadding 4 pels of diagonal orientation, which are pels (m-1，n-1)、(m-1，n+1)、(m+1，n-1)、(m+1，n+1), these 8 pels is called 8 near neighbors of the pels (m，n). If adjacent pels is defined as 4 near neighbors, and there is a gateway existing between 2 points which have the identical value, it is called 4 connections. If adjacent pels is defined as 8 near neighbors, and there is a gateway existing between 2 points which have the identical value, it is called 8 connections.



(a) Binary profile of serious defect (d) Good profile

(b) Binary profile of serious defect (e) Good profile

(c) Good binary profile (f) Binary profile of little defect

Fig.5 Binary images after morphologic operation

Image recognition is to process, dispose and abstract character of the acquired image so that the image can be estimated or classified. Here topology characteristic is used, and it mainly includes the following 4 parts:

(1) Connecting component: the area that is connected by the pels which has the same gray value is called connecting component, denoted by the letter C.

(2) Hole: if there is an area which pixels value is 0 exists in the connecting component of pixels which value is 0, at the same time, its outside is also surrounded by the area of pixels which value is 0, and this area is called the hole of image, denoted by the letter H.

(3) Connecting number: in binary image, the connecting number of black pixel is defined as the number of black pixels which is passed when it moves along the boundary track composed by the neighbor of black pixel. 8 connections is defined as follows:

$$N(8)=\sum_{k\in C}(\overline{f}(x_k)-\overline{f}(x_k)\overline{f}(x_{k+1})\overline{f}(x_{k+2})) \quad (1)$$

There into

$$C=\{1,3,5,7\}; \quad (2)$$

$$\overline{f} = 1 - f; \quad x_0 = x_9 \tag{3}$$

The position of x_k is shown as Fig.6.

(4) Euler number: the difference between the number of connecting component which the pels value is 1 and the number of hole is defined as Euler number, denoted by the letter E, namely:

$$E = C - H \tag{4}$$

The calculation of 8 connections' Euler number is shown as follows:

$$E(8) = V - E - D + T - F \tag{5}$$

In Equ.5, V is the total number of black pixel; E is the summation of two types structure element as shown in Fig.7 (a); D is the summation of two types structure element as shown in Fig.7 (b); T is the summation of four types structure element as shown in Fig.7 (c), and F is the summation of the structure element as shown in Fig.7 (d).

In this paper, 8 neighborhoods Euler number is used. The rule is as follows: when the calculating value of Euler number is 1, the profile is good; otherwise, it's a defective profile. The advantage of this method is simple and direct, but it is possible to have an erroneous judgent, when the binary image of profile is as shown as Fig.5 (b). The Euler number is 1, and it's a bad profile.

m-1,n-1 x_4	m,n-1 x_3	m+1,n-1
m-1, n x_5	m, n x_0	m+1,n x_1
m-1,n+1	m, n+1 x_7	m+1,n+1

Fig.6 8 near neighbor pixel

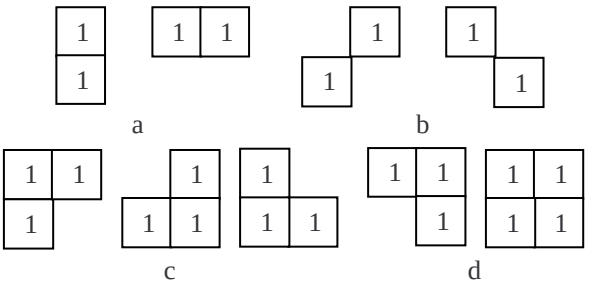


Fig.7 Structure element of calculating E, D, T and E

4.2.2 Identification algorithm synthesized Euler number and binary image area method

In the actual application, the image is processed by Euler number and binary image area method. The principle of the binary image area method is to count the number of the white pixel. Calculating each area of 6 binary images shown in Fig.5, and the result is shown in Table 1.

From Table 1, we can see that when the binary area method is used separately, the binary images area of the defective samples in Fig.5 (f) is similar to Fig.5 (c), Fig.5 (d) and Fig.5 (e), therefore the surface defect detection can not be fulfilled by binary area method only. However, synthesized with Euler number method, we can acquire the result of table 2.

From Table 2, we can see that the profile detect of crystal oscillator can be effectively identified if we synthesize the Euler number method with binary area method. We may set the area threshold value as 7500, the sample is good when the Euler number is equal to 1 and the binary area is larger than 7500.

100 samples are used to experiment by this method, and the recognition rate reaches to 85%.

Table 1 Area of binary image in Fig.5

Number	Area of binary image
Fig.5(a)	6838
Fig.5(b)	5349
Fig.5(c)	7988
Fig.5(d)	7868
Fig.5(e)	8059
Fig.5(f)	7930

Table 2 Calculating results of Euler number and binary area method

Number of binary image	Area value of binary image	Euler number
Fig.5(a)	6838	0
Fig.5(b)	5349	1
Fig.5(c)	7988	1
Fig.5(d)	7868	1
Fig.5(e)	8059	1
Fig.5(f)	7930	0

5 Result and Discussion

Automatization vision detecting has already been becoming the extremely important component in

modern CIMS. Vision detecting is usually an indispensable tache when it comes down to the application of various detections, production surveillance and accessory identification in production and manufacture.

CCD or CMOS camera is commonly used by vision detecting system to acquire the detecting image and translate it into the digital signals, then advanced hardware and software technology of computer is used to processing the image digital signals to gain all kinds of target image eigenvalues, thereout various functions are realized, such as accessory identification or defect detecting and so on. Based on the results, it will display the image and export the data, and the actuating mechanism steered by the feedback information will complete the Automatization flow, such as position adjusting, quality filtering, surveillance alerting and so on.

The vision detecting system of punch quality of crystal oscillator shell designed and analyzed based on the fundamental principle of machine vision:

(1) The complete set of detecting mechanism of crystal oscillator shell is designed and realized, including the entire design of steering slot, sampling steering slot and vibration orientation slot. It can meet the demand of vision sampling.

(2) Peripheral electromechanical system is designed according with mechanism. The peripheral electromechanical system composed of industry control computer, control card, pneumatic executive component can assist image collecting cell module effectively, and it takes charges of locating the crystal oscillator shell component to the eyeshot of CCD.

(3) The original image collected by the system is an RGB image. The preprocessing of image includes the gray calculating, picking-up the efficient image information, image smoothness, binary calculating and morphologic operation. With regard to the result of preprocessing, profile defect detecting algorithm is developed based on the Euler number and binary area method. The precision is improved by controlling two thresholds. The validity of this method is proved by the result of the experiment.

(4) The vision detecting system developed by this paper can matched with automatization production line of crystal oscillator shell.The precision of detecting is improved and the payout of corporation labour force capital is saved, moreover it makes the manufacture high automatization.

But because of the small volume of crystal oscillator shell, difficult orientation and many other influencing factors, the image collecting and the detecting algorithm should keep on being improved and complemented in order to increase the detecting efficiency . Besides, with the development of high speed network and database technology, in the future, the vision sample detecting system of crystal oscillator shell should have the function of long-distance control, data share and so on. Different kinds of detecting system could be connected together through LAN. This can share the resource, cooperate with each other, work together and increase the efficiency and precision of detecting.

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