Application of Digital Image Processing Technology in Polyaniline Deposition on the Surface of Carbonyl Iron Powder

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Abstract. With the development of computer, optical instrument and image processing technology, digital image processing technology is used to deposit films on the surface of polyaniline on carbonyl iron powder. In this paper, carbonyl iron powder/polyaniline (CIP/PANI) composites were prepared by in-situ polymerization, using high molecular weight PVP-K90, low molecular weight PVP-K30 and small molecular weight PVP-K30 respectively. Surfactant Tween-20 was used as space stabilizer for dispersion polymerization. The effects of different kinds of space stabilizers and the concentration of PVP-K90 on the in-situ deposition of PANI on the surface of carbonyl iron powder were investigated. The results showed that CIP/PANI core-shell composite with good morphology could be prepared by dispersion polymerization with high molecular weight PVP-K90 as space stabilizer. It is difficult to stabilize polyaniline film with low molecular weight PVP and small surfactant.

1. Introduction

Before entering the digital image processing, we first make a conceptual discussion on the image. The so-called 'image' generally refers to all the actual existence of a message containing a signal, such as people, things, etc. photos. We often say that 'a picture is better than a thousand words', that is, each image contains a lot of information, according to our purpose to take certain measures to deal with it, extracting effective information from the image to solve the problem is the processing technology. Digital image is the image formed by digitally processed pictures with analog signals [1-3]. The reason for digitization is that it is convenient for computer operation and storage. The brightness stored becomes the basic unit of the image, called 'pixel', and the brightness of the pixel is expressed by 'gray value'.

Carbonyl iron powder/polyaniline magnetic composites with core-shell structure have broad application prospects in electromagnetic shielding, microwave absorption, electromagnetic induction and other fields. However, it is difficult to obtain uniform CIP/PANI core shell structure by traditional methods such as emulsion polymerization and solution polymerization. This is due to the larger size of
the iron powder and the failure of the emulsion droplet to completely coat the iron powder [4-5], polyaniline film can be deposited on the surface of iron powder by dispersion polymerization, forming core-shell composite with iron powder as core and polyaniline as shell. Dispersion polymerization is a special type of precipitation polymerization [6-9]. Its main characteristic is that the addition of space stabilizer in the reaction system can prevent the polymerization and sedimentation of the polymerization products and form a stable dispersion [6-9]. At the same time, the results show that the polyaniline film with fairly uniform structure can be formed on the surface of glass, polymer film and carbonyl iron powder by dispersion polymerization [10-20].

Selection of space stabilizers is very important in dispersion polymerization. Several kinds of organic space stabilizers [21-29], including high molecular weight polyvinylpyrrolidone PVP-K90, low molecular weight polyvinylpyrrolidone PVP-K30 and small molecular surfactant Tween-20, were selected in this work. The effects of kinds and dosage of stabilizers on the surface of PANI on carbonyl iron powder were investigated. The influence of in-situ deposition on film formation is briefly discussed.

2. Experimental part

2.1. Development of digital image processing technology

Digital image processing technology is a new technology, but it has shown its unique advantages in all walks of life, causing more and more people's attention.

In 1964, the Jet Propulsion Laboratory of the United States used computers to process a large number of photos of the moon sent back by the spacecraft, and achieved remarkable results by improving the image quality. Then, due to the creation and development of discrete mathematics, digital image processing technology has been rapidly developed, coupled with the popularity of the use of computers and the gradual enhancement of functions, making image processing technology in many industries has become a very common tool.

In recent years, the combination of fuzzy pattern recognition system and artificial neural network recognition system has become a hot topic of digital image processing technology.

Aniline (An, by secondary vacuum distillation), chemical purity, Tianjin Bodi Chemical Co., Ltd; carbonyl iron powder, Beijing University of Science and Technology; ammonium persulfate (APS), analytical purity, Shanghai Epee Chemical Reagent Co., Ltd; polyvinylpyrrolidone (PVP, K90, Mn = 1-1.5 *106), Shanghai Shengpu New Materials Co.Ltd; polyethylene Pyrrolidone (PVP, K30, Mn=0-0.05-7.0 *105), Chemical Reagent Co., Ltd. of China Pharmaceutical Group; Polyoxyethylene (20) Dehydrated Sorbitol Monolate (Twee-20), Chemical Purity, Qingdao Tianliyuan Biotechnology Co., Ltd; Concentrated Hydrochloric Acid (HCl), Chemical Purity, Yantai Sanhe Chemical Reagent Co., Ltd; Anhydrous Ethanol, Absolute Ethanol, Sorbitol Monolate (Twee Analytically pure, Yantai three and Chemical Reagent Co., Ltd.

Digital four-probe conductivity tester, SZT2000-4, Shanghai Hongqiao Detector Material Factory; Scanning Electron Microscope, JSM-6700F, JEOL Japan Electronics Instrument Company; Ultrasonic Cleaner, KQ-50B, Kunshan Ultrasonic Instrument Co., Ltd.

2.2. Preparation of CIP/PANI Composites

A proper amount of carbonyl iron powder was added into a beaker containing an appropriate amount of space stabilizer aqueous solution. The beaker was shaken by ultrasonic wave for 0.5 h and then stirred mechanically in an ice bath for 0.5 H. Then hydrochloric acid and aniline monomer (the mass ratio of aniline to carbonyl iron powder is 1:1) of 0.15 mol. L⁻¹ were added into the mixed solution and Pre-stirred for a period of time. Then a certain concentration of APS aqueous solution (the ratio of APS to An monomer is 1.25:1), ice to ⁰C, its one-time addition to the above mixed solution to initiate the reaction, the initial reaction temperature is controlled at 0 ~ 2. After the reaction started, the reaction temperature was tracked and the experiment was continued after stirring for 2 h. Carbonyl iron powder/polyaniline composite particles were obtained by magnetic separation after the reaction.
The polyaniline particles deposited on the surface were washed off with ethanol and distilled water until the washing solution became colorless. After washing, the samples were taken for electron microscopic characterization. The remaining samples were placed in oven and dried and dried at 35 degrees Celsius for other characterization tests.

3. Application of digital image processing technology
At present, the application of digital image processing technology is more and more extensive, especially in the mechanical manufacturing industry, more and more precision and ultra-precision processing technology is used, and making the application of digital image processing technology in mechanical design, manufacturing, testing and material analysis and other fields are increasingly widespread.

3.1. Application of NC machining for micro parts
At present, the micro-hole processing of spinneret head in China is manually processed on a punch by means of a microscope. This kind of processing method has great labor intensity, serious damage to human eyes, and large errors. It is difficult to guarantee the unity of the same batch of products. With the development of numerical control technology and equipment manufacturing industry, it has become an inevitable trend that numerical control machining replaces manual operation. It is an important link to improve wet spinning process to realize numerical control positioning of spinneret micro-hole.

Then the CCD imaging system is used to collect the images of the micro-holes. The offset between the micro-holes and the visual center is processed by the calculation software to drive the motion control system to re-locate the micro-holes. The whole spinneret hole is processed in turn. At the same time, real-time adjustment and real-time detection greatly reduce the cumulative error of micro-hole positioning, and the detection accuracy reaches sub-micron level. It has a certain significance to solve the problem that the micro-hole machining of spinneret head depends entirely on manual operation and relieves the fatigue state of human eyes. At the same time, this machining system is not only applied to spinneret head, but also can be used in other fields as long as the fixture is designed reasonably.

Fig. 1 Schematic diagram of NC machining of spinneret hole

1. Motor; 2. Optical lens; 3. Punch pin; 4. Spinneret head; 5. Mobile platform; 6. Light source; 7. Fillet head micropore section enlargement; 8. Motor control platform; 9. Motion control card; 10. Image acquisition card; 11. Computer.
3.2. Application of parts failure detection

At present, the rolling element often fails due to the large alternating load in rolling bearings, and the early stage of failure is often manifested in the generation of cracks. Generally, crack detection is carried out by manual method, but the result is inefficient and the misjudgment rate is high because of artificial physiological function or visual fatigue.

In view of the above problems, an intelligent inspection system based on digital image processing technology for bearing rolling surface defect can solve the defect problem of parts in working failure state by taking advantage of its good reproducibility, high processing accuracy, wide application and good flexibility. This testing system mainly uses computer instead of manual visual measurement and the permeability principle of fluorescent magnetic powder, and designs a fluorescent magnetic particle imaging nondestructive testing system [3]. Its working principle is: using CCD to photograph the appearance of rolling element of rolling bearing, get the crack test image, then use image processing software to process and analyze the formation and shape of crack, judge the crack and detect the

Fig. 2 Temperature-time curves of in-situ polymerization with different concentration of PVP-K90.

(a)                                                                                                   (b)
(c)                                                                                            (d)
specific information of the crack according to the definition characteristics of the system to crack, and check the system block diagram as shown in Figure 2. Digital image processing technology will be one of the effective means to realize the defect detection of the working surface of parts, with reliable and efficient characteristics.

4. Application of micro size tool measurement
Digital image processing technology as a means of measurement has made great progress, especially in the micro-size tool measurement [4]. In the traditional drill-point parameter measurement methods, such as gauge method and image method, need to be repeated measurement, measurement data by manual recording, has great subjectivity, easy to bring subjective error [5]. The image processing measurement method has non-contact measurement and overcomes human error. A multi-edge drill-point parameter measurement system using CCD as image sensor makes the measurement of micro-size parameters come true.

The multi-edge drill point parameter measurement system is mainly composed of CCD camera, image acquisition card, worktable, lighting system, and computer and corresponding software. The CCD camera lens can be rotated horizontally and vertically downward, and the drill point can be photographed horizontally and vertically. The positioning is placed in a horizontal position and parallel to the center of the CCD lens. The measuring device is shown in Figure 3. The working process of the system is: adjusting the drill point and workbench, using positioning blocks to position the drill point edge in a straight line perpendicular to the light center of the CCD camera; adjusting the position and brightness of the light source so that the light source evenly illuminates the drill point; this is conducive to extracting the effective contour of the drill point and improving the measurement accuracy. Using CCD camera and image acquisition card, the drill point color picture is collected in the computer. Then, the drill point images collected are processed by software, and the parameters of drill points are calculated.

![Fig. 3 Multi edge drill point parameter measuring device.](image)

The scanning electron microscopy of Benz-E series tungsten wire gun with a resolution of 4nm@30kv can be divided into Cube (small pudding) desktop scanning electron microscopy, Genesis (origin) small vertical scanning electron microscopy and Veritas (truth) to the size of the sample bin or the ability to expand the analysis of accessories.

Aluminum sample holder, carbon double-sided conductive tape glued to a layer of powder, put 7 samples at one time. Using the condition 20kV, fast high SNR observation mode. 1024X768 pixel photography time 10s.
5. Application of structural analysis of spare parts

The structural analysis of materials is the key basis for studying the mechanical properties of parts. Using digital image processing technology to process and analyze the microstructure image of materials can effectively assist researchers to carry out more in-depth structural analysis and internal organization research.

When high molecular weight PVP-K90 is used as space stabilizer, the polyaniline film coated on the surface of carbonyl iron powder is of excellent quality (Fig. 4 (c), (d), (e)). However, when low molecular weight PVP and small molecular surfactant are used, the polyaniline film formation cannot be well stabilized (Fig. 4 (a) and (b)). It is suggested that the good stabilization of high molecular weight PVP-K90 is not only related to the decrease of hydrophilic/hydrophobic interaction and surface energy, but also to the long chain molecular structure and special hydrophilic group distribution of
high molecular weight PVP-K90. The specific stability mechanism needs further research. Conductivity of CIP/PANI composites prepared with different mass ratio of PVP-K90, as is shown in Table 1.

**Tab. 1** Conductivity of CIP/PANI composites prepared with different mass ratio of PVP-K90

| \(w(\text{PVP-K90})/\%\) | Average conductivity \((\text{S} \cdot \text{cm}^{-1})\) |
|--------------------------|-----------------------------|
| 0                        | \(5.00 \times 10^{-2}\)     |
| 0.25                     | \(5.60 \times 10^{-2}\)     |
| 0.50                     | \(3.03 \times 10^{-2}\)     |
| 1.00                     | \(9.52 \times 10^{-2}\)     |

PVP-K90 is a kind of high molecular weight emulsifier. If PVP-K90 can stabilize PANI to form a good film on the surface of iron powder only because of amphiphilic interaction and surface energy tending to reduce the double effect, then the small molecular surfactant and low molecular weight PVP which have the same effect in theory should also have the above stable action. Use to make PANI good film forming. Therefore, low molecular weight PVP-K30 and nonionic surfactant polyoxyethylene (20) desorbed sorbitol monolaurate (Tween-20) were selected as space stabilizers to investigate their stability.

6. Effect of conductivity on the conductivity of CIP/PANI composite particles
The conductivity of the composites prepared with high molecular weight PVP-K90, low molecular weight PVP-K30 and Tween-20 as space stabilizers are shown in Table 2. As can be seen from Table 2, the conductivity of CIP / PANI composites prepared with different space stabilizers varies little, and all of them are in the order of \(10^{-2}\) \(\text{S cm}^{-1}\).

**Tab. 2** Conductivity of CIP/PANI composites prepared with different stabilizers

| steric stabilizer | Average conductivity \((\text{S} \cdot \text{cm}^{-1})\) |
|-------------------|-----------------------------|
| PVP-K90           | \(9.52 \times 10^{-2}\)     |
| PVP-K30           | \(6.41 \times 10^{-2}\)     |
| TU-20             | \(4.10 \times 10^{-2}\)     |

Note: the mass fraction of space stabilizer is 1%.

It is difficult to give a very precise and clear image in ceramic micro-image shooting technology. The noise in the image has a great influence on the results of quantitative analysis of ceramic microstructure. Therefore, it is necessary to remove the noise pollution in the image before applying the image, so as to ensure the accurate measurement results of ceramic components. Figure 4 shows.

In addition, digital image processing technology has a wide range of applications in other mechanical engineering fields, such as automatic assembly line detection devices and classification equipment, printed circuit board defect inspection, engineering mechanics image stress analysis, postal mail package automatic sorting, mechanical manufacturing production spray paint, welding and assembly. In addition, in some special environments to identify the shape and arrangement of parts and objects, advanced design and manufacturing technology used in industrial visual perception and so on. Among them, the use of digital image processing technology to develop intelligent robots with visual, auditory and tactile functions will bring new opportunities for manufacturing production in China. Therefore, how to use image processing technology in micro-nano manufacturing technology research, will be our research direction [6].

Image is the main source of information acquisition and exchange. Therefore, the application of image processing technology must involve all aspects of human life and work. With the development of precision instruments, optoelectronic technology, computer technology and information technology, the development direction of digital image processing technology in different fields is also slightly different, but can be roughly summed up in two major aspects:
In a word, the research of digital image processing technology in our country started late and is still in the research stage. Therefore, it is the responsibility of every scientific researcher to make great efforts to catch up with and surpass the world advanced level, to improve the application level of digital image processing technology in our country and to enlarge its application scope.

However, the graft stabilization mechanism was challenged in the previous experiments in our laboratory [8-9]. Infrared and ultraviolet absorption spectroscopy analysis showed that the presence of stabilizer PVP was not detected either in the spherical PANI particles obtained by dispersion polymerization or in the PANI films prepared by in-situ deposition polymerization on different substrate surfaces, indicating that the PVP molecules did not exist. Grafting with PANI molecules. The results also show that the stabilization effect of PVP is related to the molecular weight of PVP, which indicates that the stabilization effect of PVP may be more due to its unique amphiphilic molecular structure, hydrophilic-hydrophobic interaction, surface energy driving force and larger steric hindrance effect as macromolecular surfactant.

7. Comparison of stabilizing effects of several space stabilizers
The conductivity of the composites prepared with high molecular weight PVP-K90, low molecular weight PVP-K30 and Tween-20 as space stabilizers are shown in Table 2. As can be seen from Table 2, the conductivity of CIP / PANI composites prepared with different space stabilizers varies little, and all of them are in the order of $10^{-2}$ S cm$^{-1}$.

8. Summary
Tin ball scanning electron microscopy (SEM) is used to detect key items, using E-T secondary electron detector, with high bandwidth, fast search speed, and can obtain large depth-of-field image; and the composition distribution of binary alloys is clearly characterized; the morphological characteristics of micro-submicron scale damage defects are clearly characterized; defects produced by environmental tests, such as Nano white dots can be observed only with two electrons, but backscattered electron detectors are powerless. Cube (small pudding) desktop scanning electron microscope can meet the needs of rapid detection.

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