'93 KACC (1993.10.20~22)

Grinding Robot System for Car Brazing Bead

°Hyo-Sik Kang, Woo-Ho Lee, Jong-Oh Park, Gwang-Se Lee* and Hyoun-Oh Shin*
Robotics & Fluid Power Control Lab., KIST
*Div. of Production Tech. Development, Hyundai Motor Co.

ABSTRACT

In this paper, design of an automatic grinding robot system for car brazing bead is introduced. Car roof and side panels are joined using brazing, and then the brazing bead is processed so that the bead is invisible after painting. Up to now the grinding process is accomplished manually. The difficulties in automation of the grinding process are induced by variation of position and shape of the bead and non-uniformity of the grinding area due to surface deformation. For each car, the grinding area including the brazing bead is sensed and then modeled using a 2-D optical sensor system. Using these model data, the position and the direction of discrete points on the car body surface are obtained to produce grinding path for a 6 degrees of freedom grinding robot. During the process, it is necessary to sense the reaction forces continuously to prepare for the unexpected circumstances. In addition, to meet the line cycle time it is necessary to reduce the required time in sensing, signal processing, modeling, path planning and data transfer by utilizing real-time communication of the information. The key technique in the communication and integration of the complex information is obtaining in-field reliability. This automatic grinding robot system may be regarded as a jump in the intelligent robot processing technique.

1. Introduction

Up to now the finishing process of the car brazing bead is usually conducted in manual operation. But, workers' avoidance due to inferiority in the working environments and routine work, and non-uniformity in quality require accomplishment of the grinding automation. For this purpose it is required to measure the positional errors resulting from the deformation of the car panel during brazing and fixturing jig errors. This paper aims at designing the automatic grinding robot system for finishing the brazing bead with replacement of the manual operation. The grinding area including the brazing bead is modeled through measurement using optical sensor system, thus producing the robot grinding path.

2. System Configuration

The robotic grinding system for brazing weld bead is shown in Fig.1. This system is composed of an ABB IRB2000 robot combined with an S3 controller, an IBM PC having a 486-DX2 CPU, an air powered grinding tool equipped with a flexible abrasive disk, and a KEYENCE laser displacement sensor. The path data in the cartesian coordinates passed from the PC are converted to the joint value in the robot controller. It is implemented using the C programming language and CTS (Communication Tool Software) library for communication interface between an ABB robot controller and the personal computer.

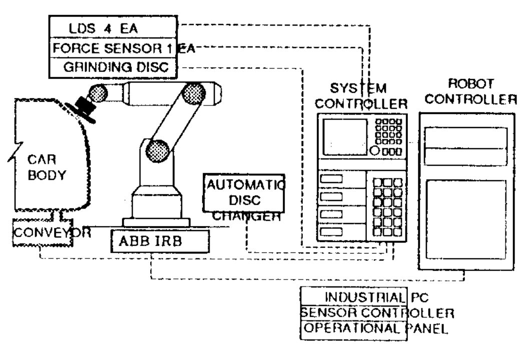

Fig.1 The overall configuration of the robot grinding system.

3. Process Analysis

The flow chart for the execution of the overall grinding process is shown in Fig.2.

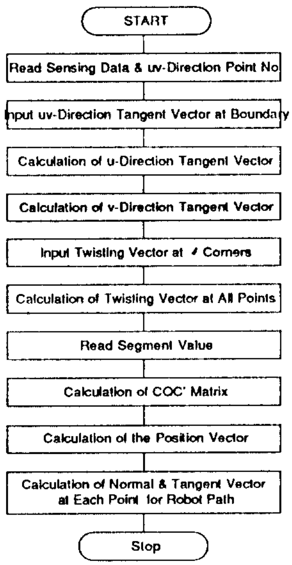

Fig.2 The flow chart for the overall grinding process.

3.1. Measurements

To model the car body surface including the brazing bead, four LDS's (laser displacement sensor) are utilized and the measurement scheme is depicted in Fig.3 and Fig.4.

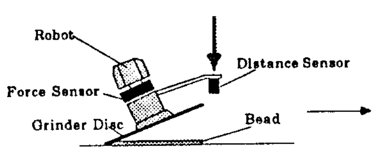

Fig.3 The grinding tool system.

The measurement data are obtained at the discrete points on the car body surface all of which is 1 mm apart from each other. Between the discrete points ten measurements are accomplished by moving the sensors in the step of 0.1 mm, and then the measured data are averaged to avoid erroneous measurement. The timing chart representing the measurement scheme is shown in Fig.5.

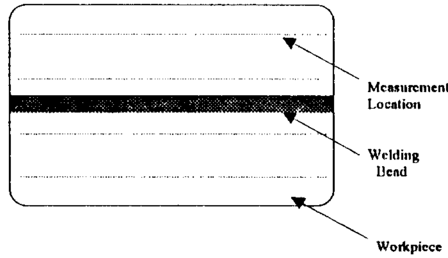

Fig.4 The grinding surface and the measurement locations.

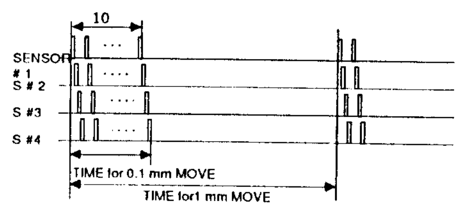

Fig.5 The timing chart representing measurement scheme.

The measured data are filtered using 3σ method and Moving Averaging method.

3.2. Surface Modeling

To model the free surface of the car body, Ferguson surface modeling technique is utilized. The flow chart for this method is shown in Fig.6.

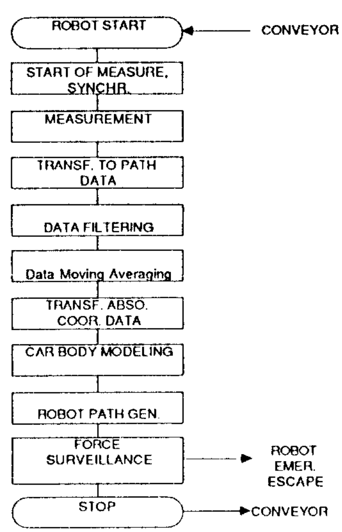

Fig.6 The flow chart for Ferguson surface modeling.

Surface modeller in the figure produces position and tangential and normal direction vector at a point on the free surface utilizing the measured data passed from the Laser Displacement Sensor.

3.3. Robot Path Generation

By using the user-defined grinding angle and depth along with the above obtained position and direction vectors, robot grinding path is generated. Fig.7 shows the flow chart.

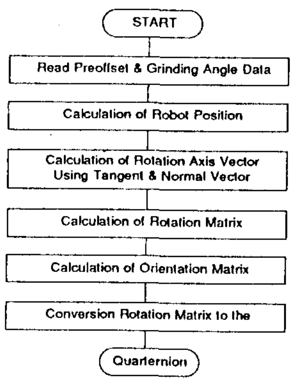

Fig.7 The flow chart for grinding robot path generation.

3.4. Time Analysis

To implement the grinding system in the field, it is important to analyze the line cycle time. For this purpose the cycle time for each procedure is estimated from a series of experiments and the feasibility of the field setup is investigated based upon the time analysis.

For the time analysis, the following detailed procedures are considered.

a. Measurement	: 1.938 sec
b. Filtering	: 0.211 sec
c. Surface Modeling	: 1.640 sec
d. Robot Path Generation	: 0.280 sec
Total Time	: 4.070 sec

4. Experiments and Discussions

To determine the parameters of the grinding process, a series of experiments was performed by implementing the practical robot grinding system. The process parameters affecting the product quality are robot feed rate, air pressure for the air powered grinder, grinding angle between the grinding disc and the workpiece, grinding depth, and the roughness of the abrasive disc. The grinding depth is the distance by the amount of which the grinding disc is fed to the normal direction of the workpiece.

The workpieces used for the experiments are similar in the shape to the practical brazing bead of the car body. The geometrical dimensions of the brazing bead are 8-9 mm in width and 0.7-0.8 mm in height.

In these experiments, the setup parameters are the air pressure of 6 bar and the grinding disc made of A36 papers. Then, the influence of the other parameter values on the grinding process is investigated.

- Robot Feed Rate

The processing speed is most affected by the robot feed rate. At a low speed under 20 mm/sec, the surface of the workpiece is heat-affected showing the surface color of black. As the robot feed rate increases, the grinding speed is gradually increased. At a high speed over 100 mm/sec, the surface of the workpiece is scratched.

- Grinding Depth

This parameter mostly affects the metal removal rate. With the increase of the grinding depth, the metal removal rate is increase. But, in a large depth the rotation of the grinding disc ceases.

- Grinding Angle

This process parameter is the angle between the grinding disc and the workpiece surface, and thus affects the processed area. At an angle between 10 and 15 degrees the grinded surface has good roughness.

5. Summary and Further Works

The experiments in this paper shows the technical feasibility for the intelligent finishing automation using industrial robots.

On the base of such experiments the reliable grinding robot with self-adaptability to uncertain finishing atmosphere will be installed in production line.

This system may be counted as a good example of intelligent finishing robot in Korea.

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