Technology Introduction

Development of 2D Code Marking Technology with Machining Center

KASUDA Takaaki

1 Introduction

Direct marking of model/lot numbers, serial numbers and other manufacturing information (hereinafter "production information") on products or parts has been carried out since long ago to ensure traceability. This is called direct part making.

Recently, as more and more information needs to be marked in a smaller space, two-dimensional (2D) codes are often used.

It is desirable also for KYB Sagami Plant to implement 2D code marking. However, the need for introducing a new dedicated system for marking made it difficult for the Plant to conduct due to the cost and space limitations. We have since developed a marking technology using an existing machining center (hereinafter "MC") installed on the machining line to achieve 2D code marking at a lower cost with no space limitation. This article will introduce this marking technology.

2 Overview of Developed System

2.1 Overview of direct part marking

Examples of direct part marking are shown in Fig. 1.

Direct part marking may have a variety of purposes including product identification and quality/production management. It has been spread widely, not only in the manufacturing industry but also in many other different fields.

Fig. 1 Direct part marking applied to various fields

2.2 General features of direct part marking

Direct part marking generally uses alphanumeric characters and/or barcodes. Recently the 2D codes typified by the QR code or data matrix have been introduced in many cases.

2D codes have the following merits:

① Much information in small space (highly concentrated information)

② Resistant to soiling/damage and readable by a code reader with few errors

On the machining line in Sagami Plant, machined parts are provided with marking of production information in alphanumeric characters. However, the need for 2D code marking is growing with a higher number of part numbers and a greater variety of production information to be marked.

2.3 General marking techniques and their downside

On the machining line, cast iron parts are machined by the MC. These parts can be marked mainly in two ways. The two techniques have the following features:

(1) Laser marking

A laser marker is used to melt and remove part of the surface of the target piece to make a tiny concave sequentially, thereby expressing alphanumeric characters or 2D code.

This is the most popular marking technique in recent years because it can be used for a wide variety of materials from metal to plastics.

(2) Stamping

Stamping is a kind of plastic working technique that uses a tool called a "punch" to make a punched inscription. A single punched inscription consists of a semisphere concave (hereinafter a "dot"). Arrays of multiple dots can express alphanumeric characters or 2D code.

Next, the estimated cost and space needed to introduce these techniques to the machining line are shown in Table 1.

Money is necessary, but space is more important for the machining line that may often be under great space constraints. The plant has to manage to secure space to install a new marking system.

Table 1 Comparison of major marking techniques

	Laser marking	Stamping
		
Base price	3 million yen	1 million yen
① System price (estimate)	6 million yen	4 million yen
② Additional space	+3.0 m²	+3.0 m²

* System price = Base price + Price for attached facilities + Layout cost

2.4 Development of new marking technology

Then, I got the idea of making similar punched inscriptions by machining with the MC from the dot profile made by stamping. If this idea is realized, marking equivalent to stamping becomes possible with the existing MC, creating breakthrough marking technology with no space constraints.

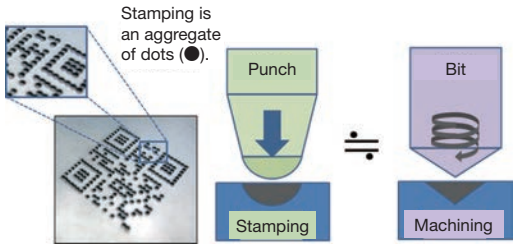

Fig. 2 Outline of new marking technology

3 Purpose

To develop 2D code marking technology with no space constraints for the existing machining line

4 Goals

① Additional space: 0 m²
② Marking time: Equivalent to stamping
③ Cost: Equivalent to stamping

5 Requirements

① The technology shall be able to be retrofitted to the existing MC.
② The technology shall be of general-purpose type for future applicability to various products.

6 Development

6.1 2D code marking element test

6.1.1 Machining test

As an element test, the MC was used to engrave a 2D code imitating stamping.

The test procedure is shown in (1) to (4) as well as in Fig. 3.

(1) Decide the character string to be marked (32 alphanumeric characters for testing purposes).
(2) Convert the character string into a 2D code using a personal computer (hereinafter "PC").
(3) Plot the 2D code on an X-Y coordinate and manually write a program for machining the black dots.
(4) Use the program to carry out machining with the MC.

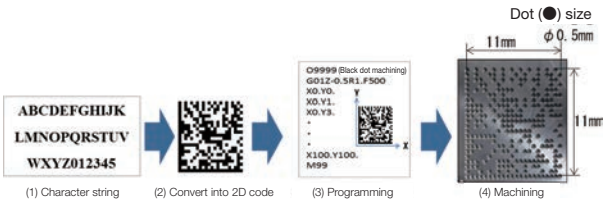

Fig. 3 Element test procedure using MC

6.1.2 Reading test

In the reading test, the engraved 2D code was read by a code reader, which verified the readability.

6.2 Development of mass production system

In actual mass production, production information consists of variable character strings for model, part, lot and serial numbers. Naturally there is an infinite number of combinations of character strings to be converted into 2D codes and accordingly there would be an infinite number of machining programs (Fig. 4).

Therefore, the technology cannot be applied to a mass production line unless steps (1), (2) and (3) in 6.1.1 are automated.

Fig. 4 2D code for mass production

6.2.1 Developing a system to automatically create machining programs

To make it possible to apply the technology to a mass production line, discussions were made on automation of steps (1), (2) and (3):

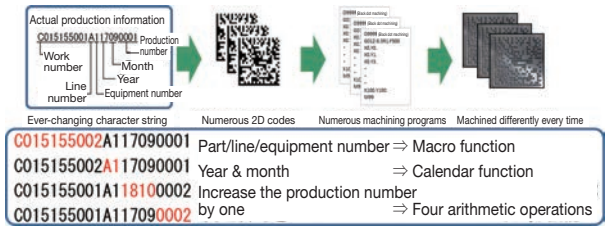

Fig. 5 Automatic generation of character strings

(1) Automatic generation of character strings
Automatic generation of an ever-changing character string can be realized using macro, calendar and four arithmetic operation functions of the MC controller.
(2) Conversion of the character string into 2D code
Similarly, only the MC controller functions were used to try to convert the character string into a 2D code. This trial revealed that conversion is impossible because of the advanced mathematics required for conversion.

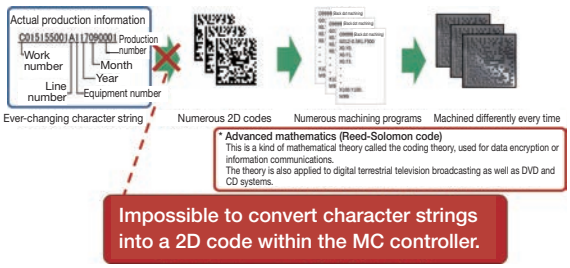

Fig. 6 Conversion of character strings into 2D codes

(3) Generation of machining programs from 2D codes
It is also impossible to automatically generate a machining program from a 2D code, which is a graphical pattern, by using the functions of the MC controller only.

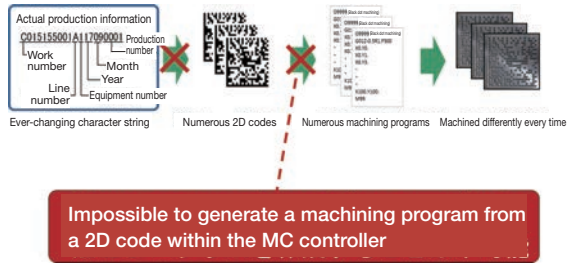

Fig. 7 Conversion of 2D codes into machining programs

Then, we developed a system to enable steps (2) and (3), which cannot be implemented within the MC controller alone, using a PC that is connected to the MC via LAN cable.

This system has the following merits.

Since the MC⇔PC connection is established via Ethernet, the PC can be placed anywhere. In extreme cases, the PC could be installed in a space that cannot be used for any other purpose in an office or on the line.

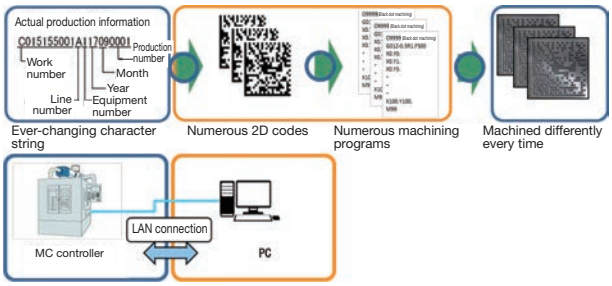

Fig. 8 Outline of 2D code marking technology

- This PC is lightly loaded since it is only used for conversion. Therefore, a general-purpose PC can be used to establish the system, which is very inexpensive.
- Like regular networks, a single PC can be connected with multiple MCs, which makes it reasonable to establish the system.

6.2.2 Establishing mass production system with an eye toward horizontal expansion

The basic system concept was completed. Next was to build a mass production system so that the technology can be actually applied to mass production lines.

To the end, a dedicated software program [Note 1)] (hereinafter the "software") was developed.

The software must have four functions: (A) to upload character strings from the MC controller to the PC, (B) to convert the character strings into a 2D code, (C) to convert the 2D code into a machining program, and (D) to download the machining program from the PC to the MC controller. The functions (A) to (D) must take place fully automatically.

It was confirmed that it actually took less than 1 second for the software to convert the 2D code into a machining program, proving that the technology can be applied to mass production lines.

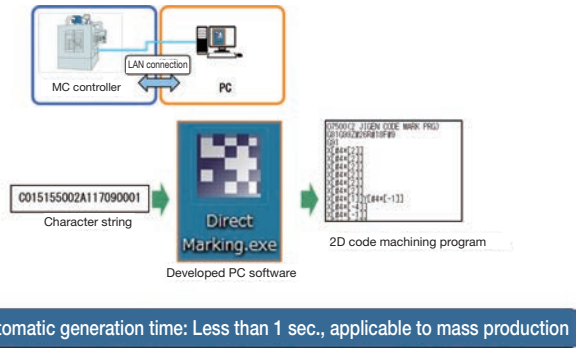

Fig. 9 Overview of mass production system

Furthermore, the software is designed to have the following features with an eye toward mass production and horizontal expansion:

① Automated system

In general, an automated mechanism is shut down when failure occurs. This system is designed to have a system flow that, if 2D code marking fails due to, for example, a broken LAN cable or PC failure, the MC used for marking is shut down.

The system also visualizes where the failure exists, if it occurs, by activating an alarm on both the PC and MC.

② Commissioning and recovery

The software is designed to allow easy expansion to other lines and recovery after failure.

③ Versatility

This software has already been subjected to tests of connection to MCs of several other manufacturers, proving its ability to be retrofitted to existing MCs.

Note 1) This software has been developed jointly with a software manufacturer. Patent is pending.

6.3 Evaluation after mass production

The mass production system was established as stated above and then applied to the machining line. Photo 1 shows a sample 2D code marked with this system.

It has also been verified that the 2D code marking time is almost equivalent to that of stamping.

Costs incurred for establishing the developed software was about one tenth of that for stamping equipment.

Photo 1 Marking provided by this system

7 Results

All goals were achieved.

① Additional space: 0 m^2
② Marking time: Equivalent to stamping
③ Cost: One tenth of that for stamping

8 Summary and Future Tasks

The establishment of this system has made it possible to carry out 2D code marking even on existing machining lines without substantial capital spending.

From now on, I would like to apply the system to applicable machining lines and collect production information and quality data of the machining equipment, contributing to further quality and productivity improvements.

9 In Closing

On this occasion, I would like to thank the software manufacturer and related departments that extended cooperation in establishing the system, as well as all those who gave us guidance and support.

Author

KASUDA Takaaki

Joined the company in 2006.
Production Engineering Sect.,
Production Engineering Dept.,
Sagami Plant, Hydraulic Components Operations.
Mainly engaged in process engineering of control valves.