Dot-Peen Marking

Process and Guide

Abstract

Industrial marking and part traceability use a variety of marking processes. Dot-Peen is one of the marking methods used. The dot-peen marking process uses a fast actuating stylus “hammer” and CNC 2+ axes controls. The “hammer” impacts the part material indenting a small hole or dimple, while the CNC motorized axes moves the “hammer” to draw the characters of the mark. The Dot-Peen marking process with the CNC motorized axis is over 40 years old and with many different manufacturers of the Dot-Peen marking machines there are also many different systems and configurations to choose from. Several factors to consider include motor type and size, pin type and size, axes design, communication, and software controls. Reliability and cost are weighed based on the application requirements.

Table of Contents

Introduction

Industrial part marking is used in manufacturing production to both identify parts and track parts. Two different groups of identification include temporary and permanent marks. Stickers, ink, and RFID tags are considered temporary part marking techniques. Direct part marking processes are considered permanent because they change the material. Direct part marks are made by the following methods: indention, dot-peen, scribe, electrochemical etching, and laser marking.

The Dot-Peen process provides a permanent mark that indents the surface of the material. This process does more than change the color of the surface like laser and electrochemical etching. The Dot-Peen mark can be quickly varied unlike the indention (steel stamping) marking methods. The CNC axis controls allow for random marks and logos.

The mechanics required for a Dot-Peen marking machine are the pin assembly, and the CNC controlled motorized axes. A minimum of 2 motorized axes are required. There is a wide range of motor and axes available. In addition, the pin actuation can be powered by electricity or compressed air. Additional mechanics include the frame, approaches, rotational axis, and part handling.

The electrical motors, pin valves, and sensors are controlled via a drive board and electrical communications. The controls can be part of the mechanical head or a separate box. Some systems have external software for configuring marking layouts and controlling the marking head.

There are many different manufacturers of Dot-Peen marking machines. Each provide a different value to the customer. Some applications value may be the best price, while others are more focused on uptime and reliability. Lean manufacturing requirements for high volume production require that the part marking be integrated seamlessly into the production automation.

Definition Dot-Peen

The name of the process Dot-Peen is derived from the word “Peen”. The peening process uses a hammer to change the metals shape. It is a cold forming process used to change the shape of rivets (Figure 1- Peen a rivet) and hold material in place, and many other uses.

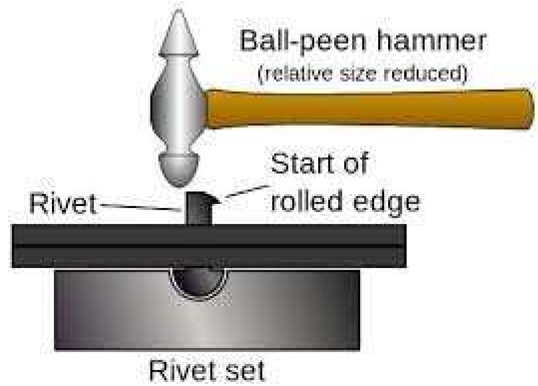


Figure 1- Peen a rivet

The “Dot” is used to describe the mark configuration. At the time of the invention of this marking process, Dot Matrix printers were the normal printing process.

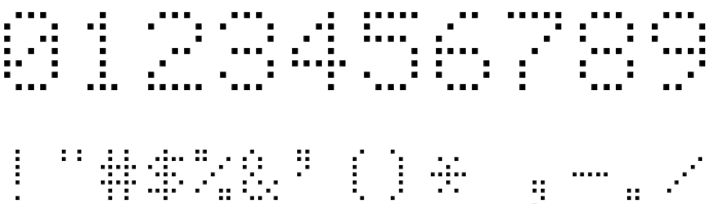


Figure 3 - Characters as printed from a Dot Matrix printer

The characters in this printing process were made up of a series of dots as shown in Figure 3.

Figure 2 shows a close-up of a Dot-Peen mark. The marks are made up of a series of dots. These dots are depressed into the subsurface. The process is the combination of both peening and a series of dots.

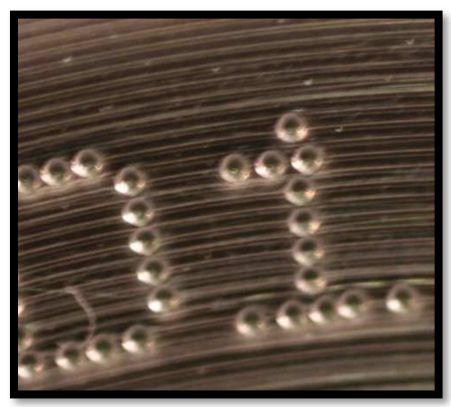


Figure 2 - Close-up of Dot-Peen mark

Peen Definition

peen verb

\ ˈpēn \

peened; peening; peens

Definition of peen (Entry 1 of 2)

transitive verb: to draw, bend, or flatten by or as if by hammering with a peen

peen noun

Definition of peen (Entry 2 of 2)

: a usually hemispherical or wedge-shaped end of the head of a hammer that is opposite the face and is used especially for bending, shaping, or cutting the material struck

Process

The Dot-Peen direct part marking process uses a fast-moving marking pin to peen (or stamp) a series of very small, closely spaced dots to form characters, designs, or machine-readable codes. The dots may be discrete or may blend into each other to form a more continuous line (Figure 4).

Figure 4 Comparison of discrete dots and blended dots

The small moving pin offers many advantages over indention (steel stamp) marking. The pin is small and exerts a limited force on the part substrate to indent just the dimple in the process to create the mark. The pin throw is the amount of movement of the pin during the marking process. The pin throw is important to consider because the part must be placed within the pin throw to assure that the mark will be clear. The pin stroke is usually less than 12mm. The pin will indent the subsurface at any distance within the optimal pin throw, and therefore the Dot-Peen marking process can mark on slightly curved surfaces.

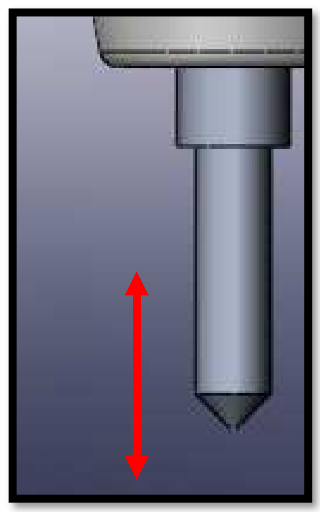


Figure 5 - Pin throw

The pin assembly is mounted to at least 2 motorized axes. The stepper or servo motors move the marking pin assembly to form the characters and designs. Depending on the style and manufacturer of the marking machine the motors may move continuously or stop for discrete peens in the mark.

Mechanics

The mechanics required for Dot-Peen marking machines are the pin assembly, and the CNC controlled motorized axes. A minimum of 2 motorized axes are required. There is a wide range of motors and axes available. In addition, the pin actuation can be controlled via electrical or air power. Additional mechanics include the mounting of the head, safety guarding, approaches, rotational axis, and part handling.

The pin assembly houses the pin and the actuation mechanism. The pin is the "hammer" of the peening process. The tip of the pin may be made from either carbide or diamond. The important point is to have a material that is harder than the substrate being peened, but not so fragile as to crack or be compromised by the impact force of the peening process. The diamond tip is most often used for aerospace 2D machine readable code marking.

Figure 6 - Plastic pin housing

The pin assembly comes in a variety of sizes and constructs. The smaller and shorter the housing, the faster the actuation. The larger and longer the housing, the stronger and deeper the mark. To ensure speed, the pin housing is made of light material. The pin housing is sometimes made from plastic as shown in Figure 6. Plastic housings are used to provide speed with a smaller motor and will also reduce cost. Plastic is not a good material to use in a high production environment reliably. The choice of using marking systems with plastic material in a high wear component results in high repair rates and down time. Metal pin housings (Figure 7) are an element of a more industrial design for Dot-Peen marking machines. The metal housing will also weigh more and require larger motors to match the speed of the plastic housing, and this in turn increases the price of the marking machine. However, lower maintenance costs and more uptime are the result of this investment.

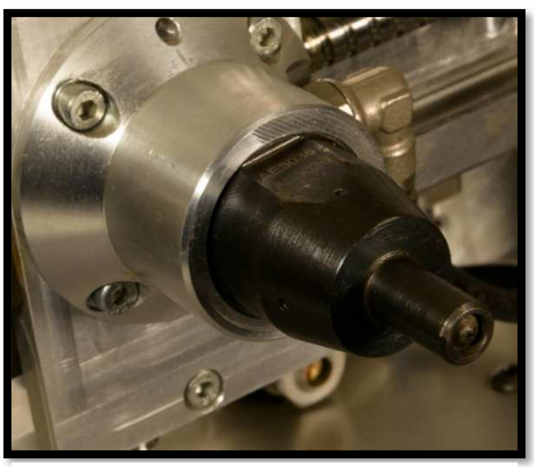


Figure 7 - Metal pin housing

Variations: Air VS Electric powered pin

Most Dot-Peen marking machines have a pneumatic powered pin. The pin is held within a small cylinder and a valve quickly pushes a pulse of air behind the plunger. The pin is quickly returned via a spring ready for the next pulse from the fast acting air valve. The spring and the pin are both considered wearable parts and spares should be kept on hand for replacement when needed. Some systems use a double acting cylinder for more control of the pin. This will reduce the speed of the pin actuation but will offer more discrete control of dot placement.

Figure 8 - Close-up of carbide pin

The electric solenoid will pulse the pin in a similar method. However, the electric system will not provide the same amount of force as the pneumatically driven Dot-Peen pins. The reduced force is a great benefit to marking fragile parts or extremely precise parts such as aerospace. However, the reduced force results in a mark that is not as deep as the pneumatically driven pin.

Figure 9 - Pin, Spring and Housing

Mechanics (Continued)

The pin assembly is moved via at least two CNC controlled motorized axes to form the marks. The working length of the axis vary from 1” (25mm) to over 30” (762mm). Either stepper or servo motors are used to move the housing along the axis. The marking axes themselves can be made from single or double linear rails, lead screws, or ball screws. The linear rails are used in combination with either plastic, rubber or Kevlar belts to move the housing.

The plastic belts with the single linear rail offer the most cost effective solution for the price concious customer. However, Dot-Peen machines made using this combination are not suggested for production marking due to the lack of reliability and imprecision of the resulting marks. Kevlar belts offered by some manufacturers provide superior uptime and reduced repair costs. The price between these two types of stepper driven linear rail systems is very similar, but the kevlar belt will provide a better ROI.

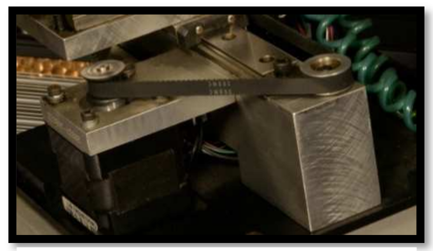


Figure 10 – Inexpensive plastic belt drive

Figure 12 - Lead screw examples

The lead screw and ball screw axis are a more industrial and precise solution for Dot-Peen marking. A lead screw (Figure 12) turns rotary motion into linear motion combining a screw and a nut where the screw thread is in direct contact with the nut thread. In comparison, a ball screw (Figure 11) axis incorporates ball bearings into the screw mechanism. Recirculating balls within circuits, meaning that the screw shaft which passes through the ball nut rotates smoothly using ball point contact – which offers very low friction and close contact between ball and screw.

The ballscrew mechanism provides the best and most precise control over linear motion, with high efficiency and positional accuracy. Low friction means that you need less rotary input power to create the linear motion – allowing for a smaller powered motor; this also allows for a smaller footprint.

Figure 11 - Close-up of ball screw axis

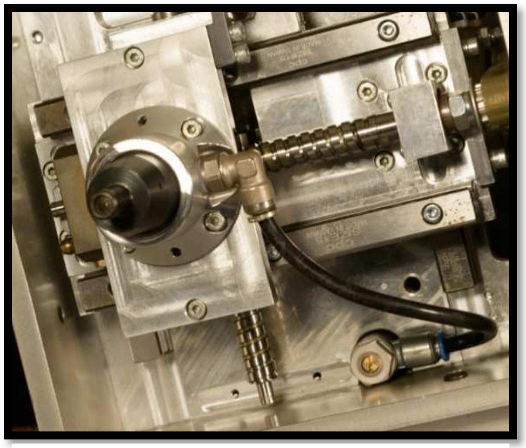


Figure 13 - Dual rail and ball screw drive

The most industrial machines use the ball screw drive in combination with multiple linear rails. Figure 13 shows an example of a dual linear rail axis with the oversized ball screw drive. This marking machine is designed for heavy production and extended life.

The motors are key to the Dot-Peen marking process. Both stepper and servo motors are used in Dot-Peen machines. Stepper motors are used in over 95% of the Dot-Peen marking machines. The use of a stepper driven ball screw axis has been proven in high production marking for both uptime and precision marking. Servo motors with ball screw axes do offer the top of the line solution for uptime, reliability, speed, and precision. This combination is reserved for marking applications requiring the perfect mark everytime. Examples include Aerospace and VIN (Vehical Identification Number) applications.

Figure 14 - Sheet metal frame benchtop machine

In this competitive market, many systems are designed with the minimum size of motor, and for use only with the pin pointing down. If the head is positioned in any other orientation the motors will be undersized to accomodate the weight of the pin assembly during the marking process. Also, the longer the belt driven axis the larger the motor required.

The motorized axis and pin assembly are usually, but not always, mounted in a frame. The the frame is to protect the internal working components from debris and external objects. Many frames are designed to be mounted on a single column bench top stand. Sometimes these same frames are sold for integration for automation. The benchtop frames (Figure 14) do not have the same build as those solely design for automation. Figure 15 is an example of a solid build for automation. Mutliple sides for mounting, and the solid frame to withstand external damage, and vibrations.

Figure 15 - Solid frame for use in automation

The Dot-Peen process uses 2+ CNC controlled motorized axie. Two is the minimum required. A third axis is needed when marking around the OD of a round part (Figure 17). Another important use of the 3rd axis is an approach. As mentioned earlier, the placement of the part needs to be within the pin throw which is usually under 12mm. Part loading and unloading may inadvertantly cause damage to the pin due to this close proximity. Many manufacturers recommend a slide or approach be installed to assure proper clearance during the part movement. Figure 16 shows a popular option, a simple 1" integrated apporach. Dot-Peen marking machines can be designed and manufactured with up to 6 axis. An effective cost saving option is a dual headed marking machine. Average savings are about 25% over the cost of two independent marking heads. In addition, the dual headed system will meet the cycle time of laser systems but with a reduced cost.

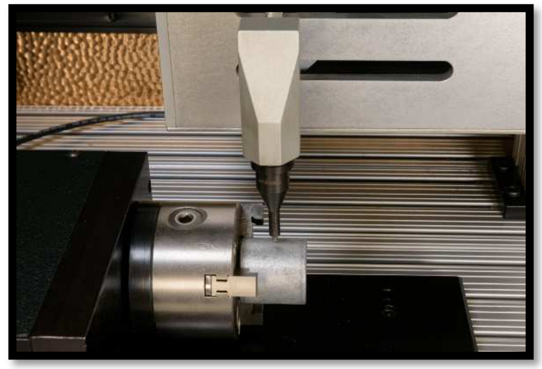


Figure 17 - 3rd axis to mark around part

Figure 16 - 3rd axis used as approach

The complete marking station or installation will require any number of additional mechanical components. The marking station may require a floor base or pedestal mount for automation. Depending on the safety requirements guarding may be required. Most often guarding is required if more than 8mm or ¼" of pin throw or motion may cause a pinch point. A push button cycle start or camera could also be incorporated as part of the marking process. While each of these items is application dependent, part holding or fixturing is the one last mechanical component required of all Dot-Peen marking applications.

The Dot-Peen mark is as much depedent on the quality of the marking machine as in the proper fixture or part handling. The fast moving marking pin will cause sideload on the part. If the part is not securely clamped in the place then the part will move during the marking process. Any motion of the part will reduce the mark clarity. The fixture must also place the marking surfce perpendicular to the pin (Figure 18).

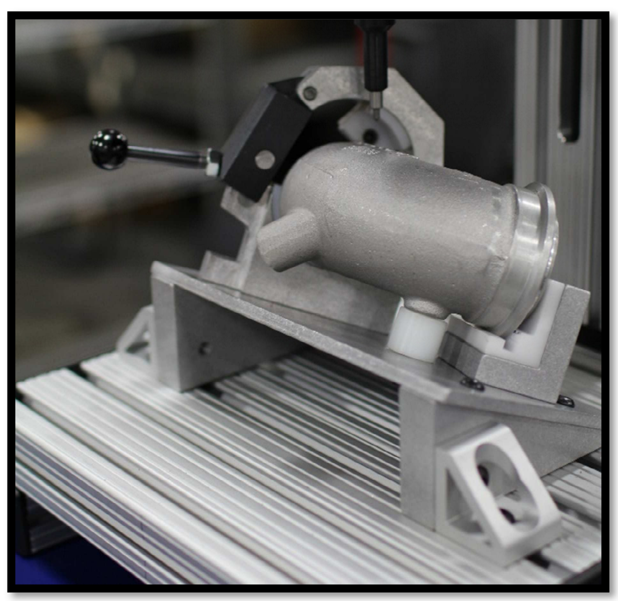


Figure 18 - Fixture to place marking surface perpendicular to pin

Electrical controls

Figure 19 - Motor controls in marking head

The marking axis motors are controlled with either a single drive board especially designed for the dual axis system or individual drive controls for each axis. The drive card may be installed in the marking head itself (**Error! Reference source not found.**). This reduces the cost of the marking system, but the drive controls may be adversely impacted by the vibrations of the marking process. The drive board in the marking head is best suited for low volume marking applications.

Dot-Peen marking systems designed for high volume production usually have an external control box (Figure 20). This will separate the electrical controls from the vibrations of the marking head. The controls may also be placed in a more controlled environment. Reducing debris from destroying the board and maintaining an even temperature.

Figure 20 - Example of a 2-axis external control for Dot-Peen marking machine

Some Dot-Peen manufacturers have flexible marking controls. Programmable controllers allow for the use a single machine control for different marking heads. The ability to have a single backup for multiple head styles will save cost on spare parts.

Communications and Commands

The HMI controls of the Dot-Peen marking machines offer a wide range of functions and controls. The most basic are provided in a simple LED screen integrated into the system itself. This method is usually the most limited in function and capabilities. The marking layout is not seen as it will be marked. The commands are limited to simple DOS type menu system. The LED HMI controls are provided on the most economical systems.

Figure 21 - LED screen HMI

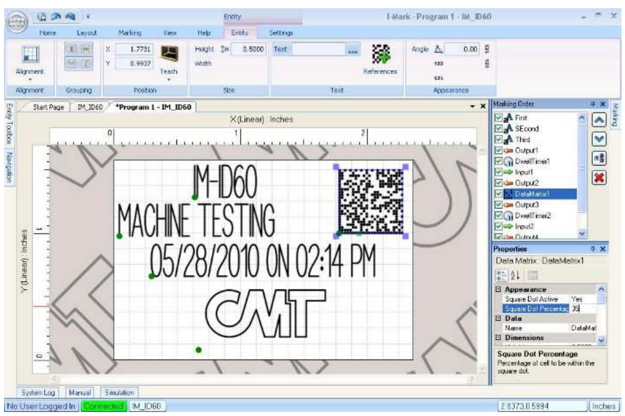


Figure 22 - Windows software for Dot-Peen marking

A significant number of Dot-Peen marking machines work with a Windows based software package. Some of these packages are included free of charge and may also include updates free of charge. The benefit of the Windows software is the WYSIWYG format is the ease in which a marking layout can be designed. Additional benefits of the Windows software include easy uploading of custom logos and using non-marking entities into the commands. The non-marking entities could include “waypoints” in the tool path to assure that the pin does not contact part obstructions. Other non-marking commands include waiting for outside communications, or axis controls or motions.

Outside communications are most often used in fully automated production. The station or system PLC can provide a wide range of commands to the Dot-Peen marking machine. These commands can be as simple as an ASCII string to be marked. In this case the Dot-Peen marking machine provides the functionality of a “printer”. The information is sent in an ASCII string to a RS232 port with the information to a “placeholder” in the marking machine. The placeholder is in a designated position in the marking layout, it also has font, font size, and perhaps power and speed associated with it.

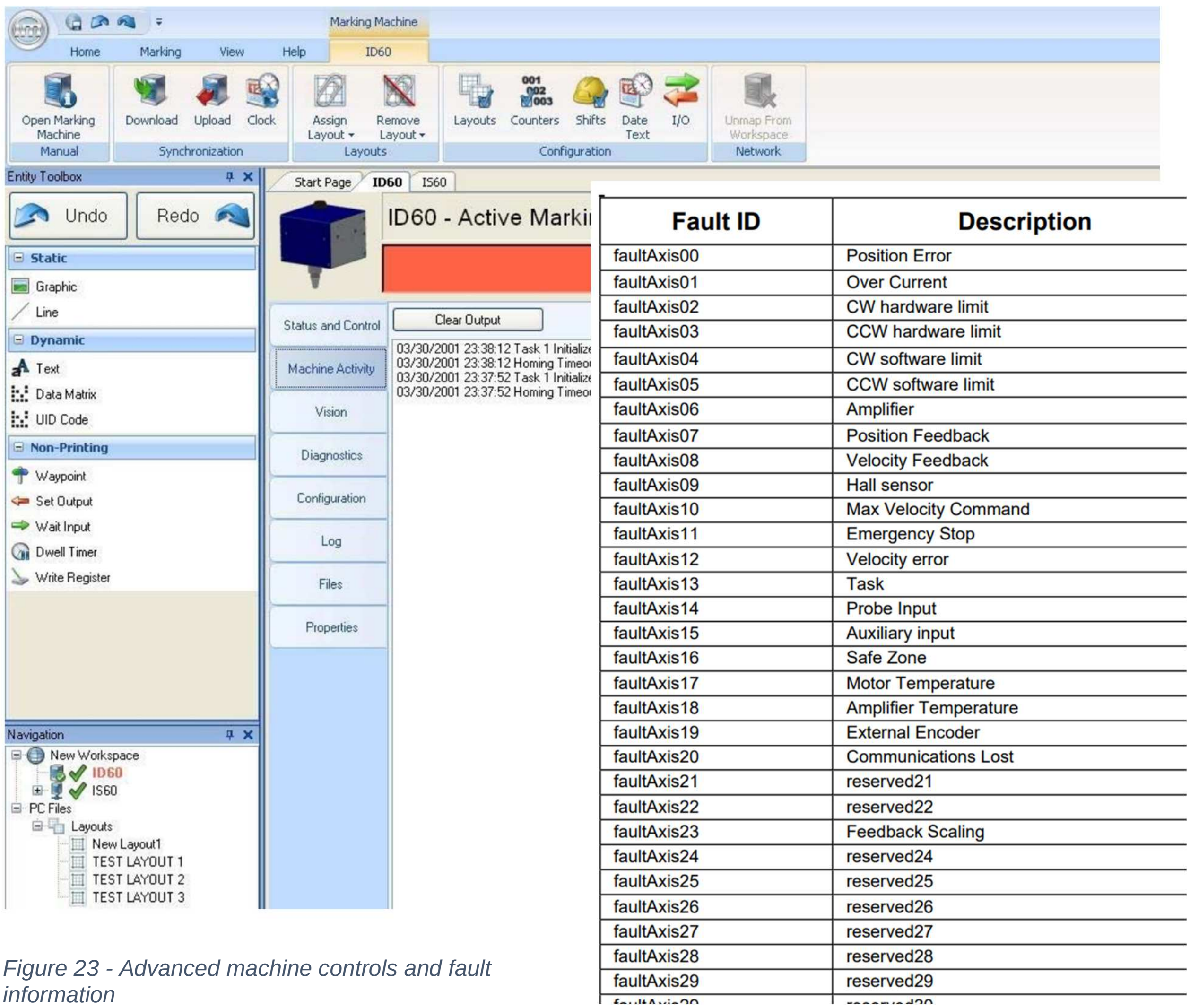
Standard machine controls are also available in many Dot-Peen machines. The machine controls are communicated through Ethernet IP, Profibus, or Modbus. The machine controls include

- Start
- Complete

- Ready
- Fault
- Reset

These standard machine controls will provide the required commands to properly integrate a dot-peen marking system into automation.

Some systems provide real time advanced machine monitoring and fault information. With detailed information it is easy to finetune the marking cycle time.



Fault ID	Description
faultAxis00	Position Error
faultAxis01	Over Current
faultAxis02	CW hardware limit
faultAxis03	CCW hardware limit
faultAxis04	CW software limit
faultAxis05	CCW software limit
faultAxis06	Amplifier
faultAxis07	Position Feedback
faultAxis08	Velocity Feedback
faultAxis09	Hall sensor
faultAxis10	Max Velocity Command
faultAxis11	Emergency Stop
faultAxis12	Velocity error
faultAxis13	Task
faultAxis14	Probe Input
faultAxis15	Auxiliary input
faultAxis16	Safe Zone
faultAxis17	Motor Temperature
faultAxis18	Amplifier Temperature
faultAxis19	External Encoder
faultAxis20	Communications Lost
faultAxis21	reserved21
faultAxis22	reserved22
faultAxis23	Feedback Scaling
faultAxis24	reserved24
faultAxis25	reserved25
faultAxis26	reserved26
faultAxis27	reserved27
faultAxis28	reserved28
faultAxis29	reserved29

Figure 23 - Advanced machine controls and fault information

Case Study 1 – Low volume

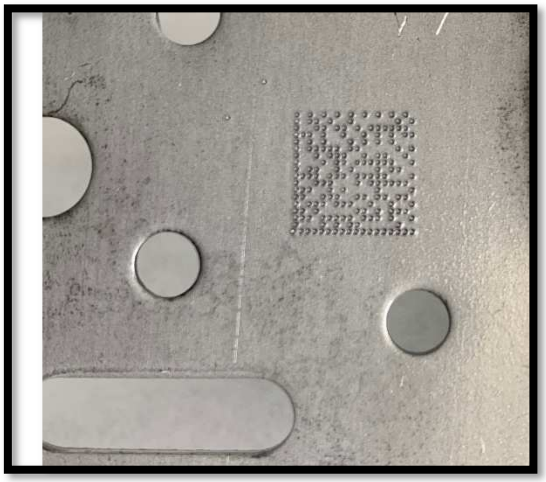
Application: Low volume marking for oil industry steel bands. This light duty stainless steel banding are used in applications ranging from strapping to bundling. Steel strapping or bands are used in the process of binding a metal strap to a box, structure, or other item to ensure that the object does not move.

Marking Details: During the installation process in the oil field the bands need to be marked. The information marked include the date code, field data, or job information. The marks need to be permanent and not wear off in the field. They must not be a topical mark that would wear off like a laser mark or rub off like a paint mark.

Solution: Dot-peen marking process meets the mark criteria for a permanent mark. The application requires both a low volume marking system and one that will make a deep enough mark to be seen after years in the field. The CMT Handy Andy offers an economical low volume benchtop solution and can provide a deep enough mark to be seen through years of wear in the field.

Case Study 2 – Integration system

Application: Marking automotive sheet metal parts with part information. Fully automated car production is the standard today. Part marking solutions have had to advance to meet the new challenges. Direct part marking in high volume automotive production requires extremely fast marking time, limited maintenance and tooling changeover, and maximum marking flexibility.



Marking Details: Advanced part tracking/marking requirements include 2D codes and integration with company MESC systems. Data needs to be sent from network servers marked quickly with the marking system and read with cameras during the production process.

Solution: While laser systems can meet the cycle-time required in the high volume production, costs may exceed the economic reality of the application. The Dot-Peen process can provide all the requirements for high volume direct mark marking of automotive sheet metal part. The industrial high torque stepper motor systems with the ball screw drive assure the precision placement of the dote for the 2D code while providing a more economical solution than laser marking. Pedestal mounted systems with part touch off are ready to install in robot cells for easy integration into automotive production.

Conclusion

Dot-Peen marking process was invented over 40 years ago. Dot-Peen marking machines are used exclusively for industrial part marking. From serial numbering to date codes, dot-peen marks help with part identification and tracking. Dot-peen marks are permanent material changes and are retained after the manufacturing process has completed.

There are many different manufacturers of dot-peen marking machines. Some systems are designed for low volume applications, some for aerospace, and some for high production manufacturing. Selection of the dot-peen machines required for individual applications are based on the production and economic requirements. Consideration for the choice of the machine needs to be based on a balance of upfront costs and long-term maintenance and uptime. Additionally, options now available in dot-peen marking machines can expand the role of the dot-peen marking in the overall automation process.

Authors

Dorthea Peene

Marc Steele