



5MS FOR DIE-STRUCK JEWELRY MAKING

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INTRODUCTION

In the fall of 1992, my introduction to die-striking jewelry began in the heart of the jewelry district in New York City. It was my first job in the United States, having recently emigrated from Ecuador. I was hired as a press operator at a company with over fifty years of experience in the industry. This company housed thousands of die-striking tools to produce 14K and 18K gold components.

My primary task was operating the press. Each day, I passed through the toolroom on my way to the pressroom and observed the toolmakers performing specialized tasks. The tasks consisted of hub engraving, making forcers in the Sinkler EDM, and polishing the master dies with diamond paste. I was fascinated by these processes. Though I had been trained in the operation of machine tools back in Ecuador, I was not a toolmaker.

One late afternoon, while performing the trimming operation on a hollow earring, I noticed the part had a large burr. The toolmakers had already left for the day, but I knew how to sharpen the tool. So, I went to the Toolroom and started sharpening the die. While I was dressing the wheel on the surface grinder, the owner approached and asked me something I didn't fully understand. My English was limited at that time, and I worried I would be fired for operating a machine without authorization. The next day, I explained the situation to the manager, and he told me that the owner had asked who had taught me how to dress the wheel (a crucial step in preparing the stone for sharpening the die). Later that day, I was called to the office, where the manager translated for me. I told the owner that I was an industrial mechanic and had experience operating machine tools. After that meeting, I was promoted to Apprentice Toolmaker. The rest, as they say, is history.

Little did I know that my first job would mark the beginning of my career in tooling for the jewelry industry. Over the past three

decades, throughout my career, I've worked hands-on in many areas of toolmaking and fabrication. My involvement in initiatives like Six Sigma, Single-Minute Exchange of Dies (SMED), 5S, and other lean manufacturing projects has not only enhanced my technical expertise but also helped me grow as a leader and problem solver. In this paper, I will present a 5M approach to identifying root causes of common die-striking defects and propose corrective actions to address them effectively.

DIE-STRIKING, STAMPING, COINING, DEEP DRAWING AND MORE

Gold, silver and platinum jewelry components such as rings, bracelets, earrings, charms, coins, lockets, settings, and findings made by die-striking result in high-quality products due to the nature of the die-striking process. In this process, a blank is struck in dies under high pressure. This force not only transfers the die shape but also compresses the metal, resulting in a strong, dense surface that is easy to polish and free from defects like porosity which can sometimes be found in cast parts. Die-striking incorporates other techniques such as blanking, piercing, trimming and bending. While these operations do not further compress the metal, they work with raw materials that already have a compacted grain structure maintaining the overall quality and durability of the final product.

Various types of tooling, such as conforming dies, non-conforming dies, and deep-drawing dies, can effectively produce different designs, whether for small-scale or high-volume production. I will focus more on a medium- to high-volume operation rather than in a small shop or studio operation.¹

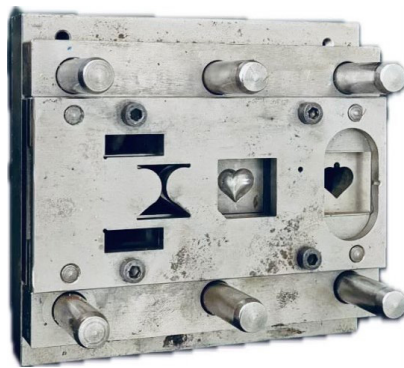


Figure 1: Progressive die (image courtesy of ZC S.R.L.)

QUALITY CONTROL MEASURES

Throughout the die-striking process, operators follow quality control measures to ensure that all parts meet specified tolerances and quality standards. Rigorous inspection is essential to guarantee that die-struck components meet critical quality standards. This ensures optimal performance during the following jewelry making steps and enhances the experience of the end user.

Key quality control measures include:

- Calibration records
- Incoming material inspection records
- First piece inspection data
- In process inspection data
- Final inspection data
- Corrective action records
- Preventive action report
- Deviation request records

CONTINUOUS IMPROVEMENT

Documenting processes is vital for continuous improvement. Without written procedures and reports valuable information is lost, making it difficult to expose problems, defects and inefficiencies. In this paper I will introduce samples of process forms designed to help you get started with data collection. Analyzing data collected from quality inspections can reveal important trends. For example:

- Is this quality issue related to a specific vendor?
- Is this defective part made in a new press?
- Is there an issue with a particular alloy?
- Is this defect part of a particular continuous casting batch?
- Does a new team member need more training?

Identifying the root cause is a learning opportunity and proactive step toward preventing future failures. However, resistance to change is a common challenge. People are often hesitant about a new approach or suggestions, especially when a process has been carried out the same way for years.

In a previous role, I was assigned to a Single-Minute's Exchange of Die (SMED) team. At the time, tool changeover was not measured, and the process to prepare a press for production was inefficient, often taking between one and three hours. Improvement began when we started monitoring changeover times for each machine.

We identified several constraints but focused first on an achievable goal: organizing the changeover carts. These carts were disorganized and cluttered with extra tools. By performing a 5S exercise, we decluttered the carts, reducing their weight by more than half. This seemingly simple change had a dramatic impact, motivating operators to collaborate further. As a result, we reduced changeover times to 15–30 minutes. Although this task was challenging, the results were transformative. Once we achieved this milestone, the team was in a better position to implement additional improvements. When implemented correctly, lean manufacturing and quality management tools can effectively guide problem-solving efforts and the application of corrective actions, driving continuous improvement and operational excellence.

QUALITY MANAGEMENT TOOLS

- Pareto chart
- Histogram
- Scatter diagram
- Check sheet
- Flowchart
- Ishikawa diagram
- FMEA
- Statistical process control
- Checklist

ISHIKAWA DIAGRAM

Ishikawa diagram is a quality management tool used for Root Cause Analysis; it shifts the focus from the symptom to look more closely at the cause. It typically moves through a few distinct phases. The Ishikawa diagram is named after its inventor Kaoru Ishikawa. Also called 5M, it is a quality management tool aimed at determining the different causes related to a given problem or effect, its graphical representation looks like a fishbone, hence its other name: Fishbone diagram.²

- Identify the defect
- Analyze how and why the defect is occurring
- Work on ways to correct the defect and to prevent it from occurring in the future

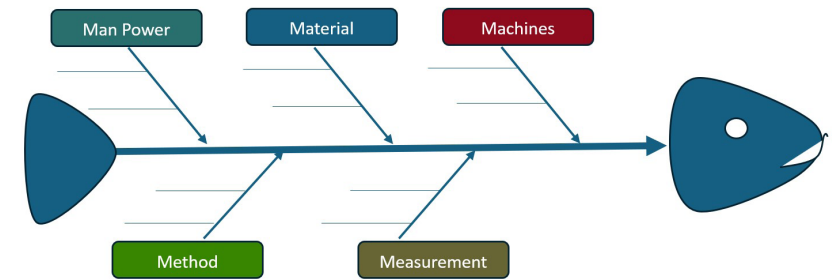


Figure 2: Ishikawa Diagram

DIE-STRIKING DEFECTS

Some defects are straightforward to identify and resolve. For instance, a dirty stamp can result in an illegible impression. In such cases, the operator inspects the part, notices the issue, and pauses production. Defective parts are separated, the dirt or metal particles are removed from the stamp, and production resumes. In other scenarios, resolving a defect may require more effort, such as removing the tool from the press for resharpener. While some defective parts can be repaired, rework is often necessary to conserve material, reduce labor costs, and meet deadlines. However, there are instances where defect conditions are beyond repair, necessitating the scrapping of parts. On rare occasions, a defect in the process can cause extensive damage, affecting multiple tool components and leading to significant operational setbacks.

Table 1: Die-striking defects

Defect	Possible Root Cause
Excessive burr	• Incorrect tool/die setup • Poor quality die design • Dull die section and/or punch • Incorrect die/punch clearance • Misalignment in press • Undersized or worn pilots • Incorrect bolster plate
Incomplete shape	• Incorrect tool/die setup • Poor quality die design • Broken die • Material improperly fed • Broken or bent pilots • Fluctuations in material thickness, width, hardness, flatness, or camber • Incorrect bolster plate
Scratches	• Defective material • Poor quality die design • Feeder/straightener/rollers defective • Stock guides defective or misaligned • Dirty press bed or other equipment
Cracks	• Material temper is hard • Incorrect alloy • Poor quality die design • Contaminated material • Incorrect tool/die setup • Incorrect metal fabrication process • Incorrect die-striking process • Lack of lubrication
Surface imperfections	• Incorrect tool/die setup • Tool surface is worn out • Material is over-annealed • Broken forming die • Scrap or debris in die
Incomplete hallmarking or artwork	• Incorrect tool/die setup • Broken stamp • Dirty stamp • Foreign material embedded in stamp

Undersized component (thickness/weight)	• Incorrect tool/die setup • Material thickness variation below lower limit tolerance • Press parallelism defective • Bolster plate defective • Incorrect die-striking process
Oversized component (thickness/weight)	• Incorrect tool/die setup • Material thickness variation above upper limit tolerance • Press parallelism defective. • Bolster plate defective • Incorrect die-striking process
Missing pierced hole	• Incorrect tool/die setup • Broken punch • Poor quality die design
Foreign material embedded in part	• Defective material • Unclean work area • Damaged feeding rollers
Incorrect shape (bending /dapping operation)	Material temper inconsistent, greater spring back
Blisters	Gases trapped in the metal exposed after annealing or soldering or hard enamel

1. MANPOWER (OR HUMAN POWER)

These roles are usually distinct. However, in smaller operations, roles may be combined, with fewer personnel performing multiple functions. For instance, a toolmaker might handle both design and tool making tasks while a tool setter could also take on operator responsibilities.

1.1 Tool designer

Designing die-striking tools requires many skills and considerations. Tool designers must have a solid understanding of precious metals and tool steel properties, press operation, quick die change tooling, and die maintenance. They work closely with engineering and toolroom personnel to identify potential quality issues early in the tool design process. The complexity of the tool design depends on the production volume. For short runs, simpler tooling designs, such as single-operation tool sets, may suffice. For larger production volumes, more sophisticated, progressive dies are typically designed to meet demand efficiently.

1.2 Toolmaker

The toolmakers are highly skilled craftsmen who typically learn their trade through a combination of academic coursework and on-the-job training. They work closely with the production floor personnel during die trials and troubleshooting. Toolmakers can work independently and make tool designs by themselves. They make prints or sketches and use different types of machine tools, including conventional and CNC milling machines, lathes, wire EDM, ram EDM, surface grinders, to shape tool steel into tools and dies. They are also responsible for heat treating, preventive maintenance (PM), and tool repairs.³

1.3 Tool Setter

The tool setters handle and set up the dies in the press. In addition to adjusting the dies, they install other press equipment. They work closely with the toolmaker when the dies are tested for the first time. Tool setters are familiar with material specifications and provide reports for non-conforming materials. They use calipers, micrometers, and other inspection instruments to verify the parts meet quality requirements. At the end of the run, they're responsible for removing the die and all the press equipment such as slides, separators, conveyors and safety instruments. Tool setting is a precise operation requiring careful attention to detail. Any misstep during setup can lead to tool component damage, sometimes as early as the first stroke of the press.

1.4 Press Operator

Press operators are responsible for running the press efficiently, and ensuring the parts produced meet quality standards. They are trained to use various types of measurement tools such as calipers, micrometers, and go/no-go gauges. Operators play a crucial role in quality control, as they are the first to detect defects. They are also tasked with stopping the press if changes are observed in the parts being produced. Operators provide valuable feedback, and many successful modifications and improvements to the die-striking process have originated from their recommendations and suggestions.

1.5 Quality control inspector

Quality control inspectors are responsible for monitoring the quality of incoming raw materials and die-struck components. They conduct in-line inspections and random audits to ensure quality is maintained throughout the entire process. As will be discussed later, many defects are caused by nonconforming materials, often due to insufficient or lack of material inspections.³

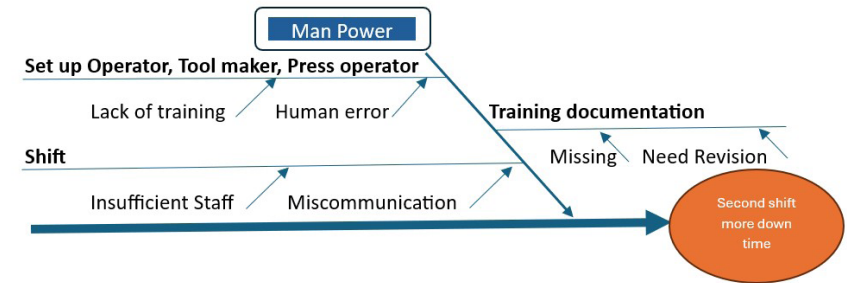


Figure 3: Manpower

Defect: Production records show a constant breakdown in equipment; dies are breaking more often in the second shift.

Corrective Actions:

- Write or revise standardized operating procedures
- Use checklists to minimize room for errors
- Overlap shifts for direct communication and ultimate updates
- Add toolroom support for second shift

2. MATERIALS

The quality of the die-striking process is correlated to the quality of the raw materials. Whether purchasing or making them, the flat stock, rods or tubes need to be carefully inspected prior to the press operation. If the materials are poor quality the die-striking operation will not fix these defects. On the contrary, defective material can be the cause for voids difficult to note at the die-striking level and be exposed at the finishing stages.

Material Specifications:

- Temper/hardness
- Thickness and width
- Flatness
- Straightness
- Camber
- Grain size
- Color
- Age-hardening properties
- Suitable for post-processing operations (ex: hard enamel)

Imagine a situation where a name-tag tool has been serviced by the toolroom; hours have been employed in servicing and resharpening the die. The expected production is 50,000 parts. If a material with unacceptable camber tolerance is not rejected, the tool will be compromised and all the cost involved in the die service could be wasted after just a few strikes due to a misfeed. The image below shows a large amount of scrap because the strip was not straight.



Figure 4: Scrap produced by unacceptable camber (image courtesy of Gold Industrial Machinery Co.)

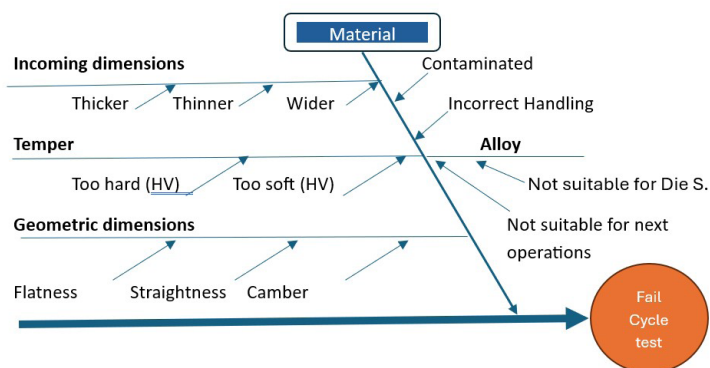


Figure 5: Material

Defect: The component fails to function as intended; the alloy designed for age-hardening in a two-step process was not used.⁴

Corrective Actions:

- Revise Bill of Materials (BOM) requirements
- Write or revise standardized operating procedures for incoming material inspection
- Use checklists to minimize room for errors
- Isolate the nonconformance material and write the report
- Contact the vendor to notify the defect

3. MACHINES

The number of machines and types required for a particular operation depends on several factors, including the desired output, the type of product being die-struck, available floor space, and more. Below, I list the equipment I am familiar with. However, by no means is this a complete list. Over the course of my career, I have seen rapid growth and downsizing. In both cases it is necessary to follow the Original Equipment Manufacturer (OEM) recommendations for minimal distance around the machines. Factory layouts must be carefully planned to minimize motion and ensure safe operations. I recall a case where a defective part was caused by improper factory layout, specifically, the scrap chopper was positioned too close to the die, which interfered with the stamping operation. In another case the straightening device was removed due to “lack of space.”

3.1 Presses

Presses are classified by one or more of the following characteristics: source of power, method of actuation of slides, number of slides, frame type, and bed type.

Manual: These presses are powered by hand or foot. The most common type in this category is the bench-type arbor press.

Mechanical: These presses use a motor to transfer energy from the flywheel to the main shaft, converting rotational motion into linear force. Special high-speed presses can perform over 400 strokes per minute.

Hydraulic: These presses use oil pressure in a cylinder with a closed end, reacting against a piston to move the slide.³



Figure 6: Hydraulic Press (image courtesy of Gold Industrial Machinery Co.)

Pneumatic: A pneumatic press utilizes a pneumatic system to apply force, where compressed air powers the press. This drives a piston or a series of pistons that apply force to the workpiece.

Servo electric: These presses use a servo motor for precise control of press movement. They are more energy-efficient than traditional hydraulic presses.

Press Frames

Gap frame: The housing of the gap-frame press is cut back below the gibs to form the shape of a letter “C.” This design allows for feeding wide stock from the side or large sheets from the front. Some models have an open back that allows feeding the stock front to back.

Straight side: A type of mechanical press characterized by a rigid, straight-sided frame with vertical columns on all sides. This design provides maximum stability and precision.

Press Specifications

Press tonnage can range from 5 tons to several hundred tons. It is recommended to operate the press at no more than 75% of its maximum capacity. When purchasing new presses, factors such as table dimensions, stroke, speed, daylight opening, and overall dimensions should be considered.

Bolster Plates

One often overlooked component of the press is the bolster plate. These plates are centrally located on the top of the bed by dowels. Threaded holes or T-slots are machined from front to back to receive T- or regular bolts. For some dies, specific bolster plates are built. Continuous pressing without proper support under the die shoe can cause it to bend. Additionally, using an incorrect bolster plate with a narrow dimension can result in scrap being trapped in the tool, potentially causing damage to the die.



Figure 7: Open bolster plate (image courtesy of Gold Industrial Machinery Co.)

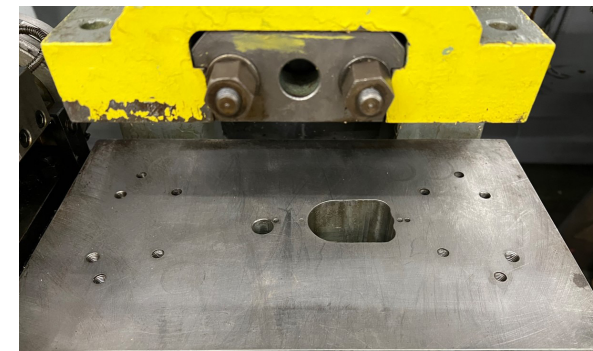


Figure 8: Solid bolster plate (image courtesy of Gold Industrial Machinery Co.)

3.2 Tools and Dies

Die-striking tools and dies are used to cut or form metals into a desired design or profile. Some dies are simple, such as a round blank with dowels and a shank, while others consist of multiple components, including die sections, punches, punch holders,

stripper plates, springs, and backup plates.³ The forming and cutting sections are typically made from hardened tool steel, while other parts are made from softer steel. Forming dies with shapes or artwork, as well as hallmarking dies, feature a negative impression of the design. These tools are usually mounted in die sets that fit in the press or are custom-made for quick die changes.

Single Operation Dies

This type of die performs a single operation on a part with every stroke of the press. It may pierce a hole, blank a disc, form a design, or perform a combination of these operations.³ A single-operation die may not produce a complete part. It may require a series of single operation dies to complete it. Single operation dies may be used for low-quantity production or if the part is too large.



Figure 9: Set of single operation dies (image courtesy of ZC S.R.L.)

Examples of single operation dies are:

- Blanking die: This die is used to cut specific shapes, producing blanks for other die-striking operations.
- Coining die: This is a special tool that transfers designs with detail, resulting in an unmatched surface finish.



Figure 10: Coining die 1 (image courtesy of Gold Industrial Machinery Co.)



Figure 11: Coining die 2 (image courtesy of Gold Industrial Machinery Co.)

Progressive Dies

A progressive die is a complex tool made up of a series of stations arranged in sequence. Each station performs a specific operation on the metal strip as it moves through the die. This type of tool may include pilots to precisely register the strip at each location. A feeding device is required to advance the metal automatically at precise intervals or progression. For short runs, a hand feed operation is practical, however safety devices are required to prevent accidents.

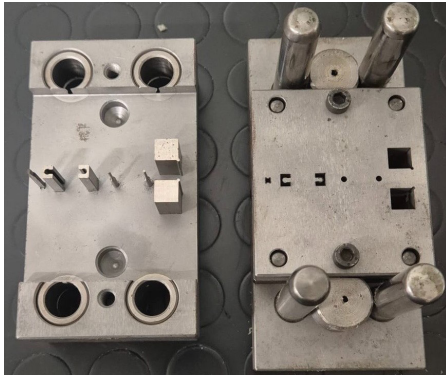


Figure 12: Progressive die (image courtesy of ZC S.R.L.)

Both single operation and progressive dies, when utilized within their designed parameters and maintained regularly— including resharpener, lubrication, cleaning, and inspection of die components— can ensure optimal die performance and prevent premature wear. Additionally, applying the recommended force and avoiding overloading the die will help maintain consistent quality and reliable operation throughout the expected tool life.

Automation

For high-output dies, installing automation technologies is advisable. However, retrofitting older machinery to integrate with new dies and automation capabilities can be challenging and may require careful consideration and adaptation.



Figure 13: Automated coin operation (image courtesy of Gold Industrial Machinery Co.)

3.3 Other Supporting Equipment

Furnaces

They are primarily used for annealing stampings and can be static or continuous. In the belt furnace type, they have atmosphere-controlled chambers to protect the metals from oxidation. The cooling rate is important— some alloys require a rapid water quench. Another application for furnaces is the age-hardening process.

Feeders

For single-operation dies, the feeding of the blank can be by hand (dual-hand buttons are required) or with semi-automated equipment to load and unload the part from the die. For progressive die operations there are different methods to feed the material: hand feeding, air feeder, or built-in mechanical roller feeder or a detachable type. One of the advantages of a detachable is that if the press is running a single operation die, the feeder can be used in another press. The disadvantage is that the changeover time needs to be added to the setup time. To reduce this time, it is recommended to standardize the height for the tools and dies.

Air feeders are used extensively, these devices utilize a mechanical slide that clamps the material and moves forward the present distance before retrieving back. The advantages of the air feeds are cost and versatility. They can be mounted to the press or tool itself and are easy to adjust.

Die cart

A die cart is a tool used to lift and move heavy dies between the storage and the pressroom or toolroom. Die carts can either be manual or powered.

Lubricant applicators

For some die-striking operations, lubrication is required. The lubricant protects the tools by providing a film that prevents surface abrasions, assisting in material flow. There are different methods for applying lubricants. The most popular are dripping, spraying, and with rollers. For thick materials it is necessary to lubricate both sides of the strip.

Scrap chopper

Scrap choppers are utilized to cut scrap into smaller pieces. This is an efficient tool to handle for recycling of the metal.

Levelers and straighteners

Flat-stock levelers and straighteners are machines equipped with a

series of rolls that progressively correct defects in metal coils and plates. They are designed to remove coil set, crossbows, waves, and buckles.

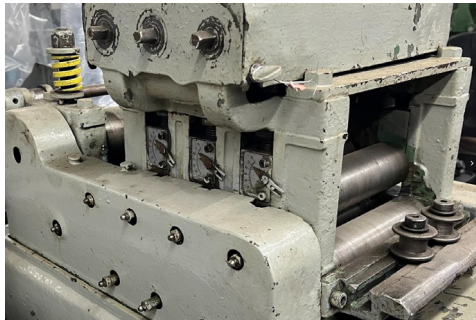


Figure 14: Flat-stock straightener (image courtesy of Gold Industrial Machinery Co.)

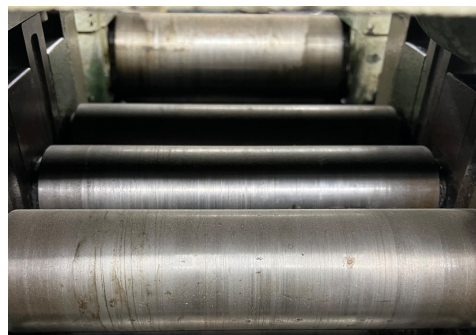


Figure 15: Straightener rollers (image courtesy of Gold Industrial Machinery Co.)

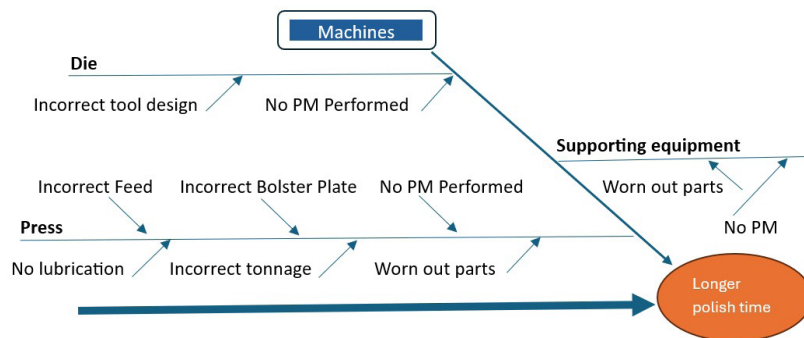


Figure 16: Machines

Defect: Quality records show an increase in polish time in a flat-shaped component. The incoming material is acceptable. A bearing in the straightener was damaged, creating a friction mark in the strip. In addition, the rollers are not polished, resulting in a sheet with roller marks.

Corrective Actions:

- Write or revise standardized operating procedures
- Use checklists to minimize room for errors
- Revise Preventive (PM) for machines
- Polish rollers and replace bearing
- If needed, replace equipment with more efficient models

4. METHODS

4.1 Tool Design

Once the design team creates a CAD model or 2D sketch for a part, the engineering team reviews it to determine whether the component, as designed or with minor modifications such as adding a small radius to sharp corners, should be die-struck or produced through an alternative manufacturing process. The time required to develop die-striking tooling can range from a few days for a single-operation tool to several weeks for more complex progressive dies. Once the tooling is built, making changes becomes costly and sometimes impossible. To mitigate this, it is recommended to assure the design has been approved and further changes won't be needed.

There are situations involving parts with complex designs where it's advisable to build a prototype tool to verify that the die design can achieve the desired outcome before proceeding with more costly developments. Initial blanks can be cut using a laser cutting machine instead of constructing a full blanking tool.

Table 2: Tool Design Checklist

DESCRIPTION	YES	NO	N/A
Tool design meets safety standards			
Fasteners are located for easy tool maintenance			
The tool fits the press type the tool will be operated by			
Quick die change			
Material utilization is maximized			
Additional polishing off sets added to part			
Strip growth calculated			
Calculated spring back factor added			
Calculated material thickness/straightness variation allowed			
Material temper and grain size required			
Misfeed detection sensors (if press is equipped)			

4.2 Tool and Die Making

Once the tool design is finalized, technical drawings are produced, and toolroom personnel fabricate the individual components. The process of tool making for dies has evolved over time. Initially, it was a manual process, which was very time-consuming. With advances in Computer-Aided Design (CAD), Computer-Aided Manufacturing (CAM) software, and Computer Numerical Control (CNC) machinery, the tool fabrication process has become more efficient. For commercially available parts such as die sets, dowel pins, screws, and springs, these are sourced from suppliers.

4.3 Tool Steel

For die-striking tools, the most used steels are air-hardening types. Blanking and trimming tools are made of A2 and D2 tool steel with a Rockwell hardness of 60 on the Rockwell C scale. Piercing tools, punches, and die buttons are usually commercially available in M2 or M4 tool steel. For high-volume production, different types of coatings and carbide components are cost-effective, as tool life is extended at least five times more than regular tool steel. Stamps and artwork tools are typically made of D2 tool steel. For coining dies, S7 is a common shock-resistant tool steel with a Rockwell hardness of 56-58 C scale. Once all the parts are fabricated, the tool is assembled.

Table 3: Tool and Die Making Checklist

DESCRIPTION	YES	NO	N/A
Die number			
Manufacturing date			
Progression			
Material Thickness			
All guards present			
No sharp edges			
Quick die change provisions			
Correct shut height per press requirements			
Tool steel type stamped in die components			
Tool steel correct hardness			
Parts are tempered after WIRE and sinker EDM			
Acceptable die shoe thickness			
Die finish polished where applicable			
Coating or surface treatments			
Easy maintenance die sections			
Die protection			
All fasteners are tightened			

4.4 Tool Qualification

This is a critical step in the tool development process. Even with a well-designed tool, the tool trial can expose quality issues that were not accounted for during the design stage. While testing the tool, it is important to document the press parameters as well as the routing steps. This will be effective for transitioning to full-scale production. In Table 4 is a die card example for a progressive die operation.

Table 4: Die Card Front

Die No.:	
Press No.:	Feeder No.:
Bolster Plate No.:	Feeder Pitch:
Tonnage Range:	Feeder Acceleration:
Speed:	

Table 5: Die Card Back

Date	Qty	Notes

Recommend service of die after _____ parts

4.5 Manufacturing Process

Orders are received, and the new tool is retrieved from storage and safely transported to the press. For heavy dies, a die cart is used. The material which has been inspected and approved is located by the press area.

Tool Setting

Tool setting can be a simple task for a single operation die, but for a progressive die, it can be a more complex operation. Proper training in the correct use of the press and press equipment is crucial for an efficient and safe changeover. Tool heights must be standardized to minimize adjustments to the press equipment. One of the most common die repairs is caused by incorrect alignment of the strip between the feeding unit and the die. The timing of the feed equipment should be adjusted to permit the release of the stock at a position where the pilots have entered the stock. The feeder should be installed square and parallel to the press bed and centered to the die. Cleanliness in the operation is a key factor. Imagine a situation where the bolster plate was not cleaned properly, and a small piece of metal is left behind. When the new die is placed over this piece of metal, the parallelism of the tool is compromised, possibly causing damage to both the tool and the press. In addition, a bolster plate provides support for coining operations, and its opening allows parts to be ejected from the die. An issue can arise when the bolster plate opening is extremely wide and does not provide adequate support to the die.

Quick Die Change

The decision to implement a quick die change may vary from pressroom to pressroom. It can involve basic, simple task elimination, or it can be an elaborate, large-scale process requiring standardization of die heights and purchasing or making die clamping methods. Quick die change reduces downtime, increases tool setting accuracy, and contributes to safety in the pressroom.

First Piece Making

Press tonnage or press ram height is adjusted so that parts are made to meet the part specifications. A defined quantity of sample parts is produced, and these parts are measured by the tool setter or toolmaker to ensure they meet the specifications on the part print (instructions may be provided either on paper or electronically). Once the samples are made, they are sent for inspection. The quality inspector checks the parts using the print and other supporting documents. If approved, the operator receives the order to continue with production. If the samples are rejected, the tool setter needs to make the required adjustments, or the tool is sent to the toolroom for repair.

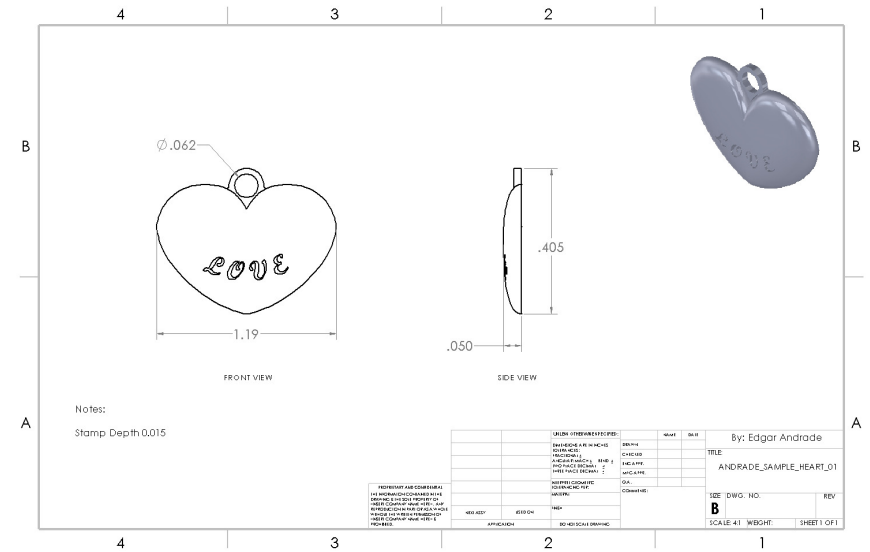


Figure 17: Drawing for die-struck component

Press Operation

Standard Operating Procedures (SOP) are essential for running an efficient die-striking operation. Visual training materials including videos are practical tools that allow operators to perform their task consistently. A proper tooling qualification provides parameters for the production process without having to repeat die trials.

Safety and Die Protection

Presses must have safety features including guards, dual-hand palm switches, light curtains, and other safety requirements. It is forbidden to bypass safety devices such as interlocking guards. When the die or the press requires maintenance, Lockout/Tagout (LOTO) procedures must be in place to prevent accidents. Die protection consists of one or multiple sensors or devices that stop the press in case a part is not ejected from the die or if the feed is short. To have this die protection working, the press needs to be able to connect to these sensors. Presses can also be equipped with tonnage monitoring, which can stop the press in case of an overload.

Table 6: Work in Process Quality Inspection

WORK IN PROCESS QUALITY INSPECTION								
Date	Part No.	Die No.	Press No.		Name	Shift		
Material Description		Material Specification		Acceptable	Rejected	Comments		
	1	2	3	4	5	6	7	8
Thickness								
Length								
Width								
GO/NO-GO Gage1								
GO/NO-GO Gage2								
Stamp Depth								
Burr >.004"								

Press inspections are carried out in different intervals: daily, weekly and yearly. Below is an example of a daily inspection checklist for a press. The operating manual contains this and other important information for the correct machine operation.

Table 7: Press daily inspection

DESCRIPTION	YES	NO	NA
Emergency Stop button is functional			
Safety guards are secured properly			
Fluid and lubrication levels are acceptable, no leaks			
Check for loose bolts or nuts			
Press and die are clean, no tools are left near the die area			
Operating controls are in good working condition			
Check air components for leaks			
Note unusual conditions			

4.6 Die Maintenance

The tool- and die-making process does not stop when the tool is in production. On the contrary, active monitoring of the tool with a proper preventive maintenance program will provide a reliable and predictable die output.

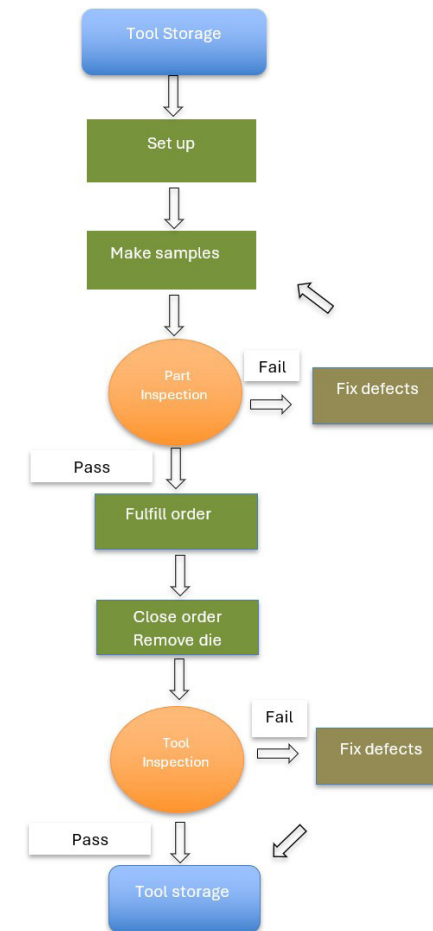


Figure 18: Tool maintenance flow chart

For some tools, die maintenance consist of lubricating the tool only. This is the case for stamping hollow components in small to medium quantities (hundreds of parts a month). For higher quantities, like in the case of findings production (thousands of parts a month), a more extensive die maintenance is required.

Tool resharpener is considered a regular activity, and it is expected for the toolroom to troubleshoot tool failures right away to meet customer demand. However, continuous interruptions are a signal that something more than the die needs to be fixed. An unexpected die repair not only places a stress on the toolroom but also on the pressroom operation. With the die being down, a decision needs to be made whether the press will be set up for other components or if the press will be idle until the die is fixed. A full die service includes a complete sharpening of the die sections and punches. If equipped, all the springs and other die components are verified, and if necessary, they are replaced. On the die card, the frequency for the die maintenance is noted.

After the tool is repaired a tag is placed on the tool. See an example below.

Table 8: Tool repair tag

TOOL REPAIR TAG	
DATE	
TOOL NUMBER	
TOOLMAKER NAME	
FULL DIE SERVICE	
OTHER	
REMARKS	

- Green tag: tool service is completed, and the tool is ready for the next run
- Red tag: this tag is attached to the die when service is required
- Yellow tag: tools can be run with extra monitoring, for a short run

Ideally in the die storage, all the dies should have a green tag.

Table 9: Tool repair checklist

DESCRIPTION	YES	NO	N/A
Punches and die plates are resharpener			
Pilot holes are clear			
Artwork or hallmarking stamps are acceptable			
Worn pilots replaced			
Coining stations polished			
Stock lifters are operational			
Bolts are tightened			
Springs are checked			



Figure 19: Piercing tool

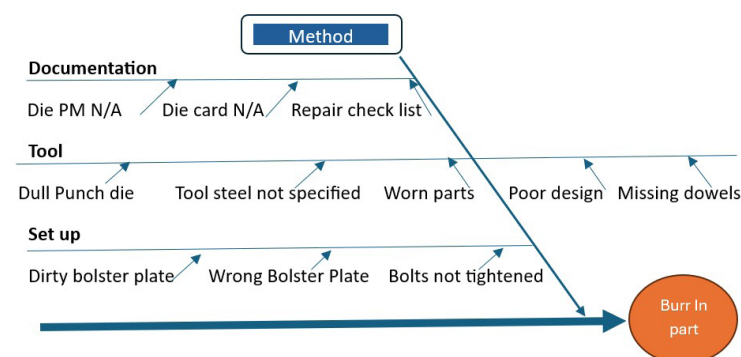


Figure 20: Method

Defect: Pierced hole presents a heavy burr.

At first glance this seems to be a simple task. The toolmaker sharpens the tool, and we are back in business. Well in this case, the tool was reground correctly, but the repair did not last long. Gradually the edge showed premature wear. There was no data available to know when the tool was sharpened and if it lasted for the expected numbers of parts. Asking the production personnel, they “always” have issues with this die but found ways to make it work. The solution was sanding the burr before leaving the department. This was not addressing the root cause, which was that the die was creating non-conformant parts that required rework.

Corrective Actions:

- Write or revise standardized operating procedures for tool repair
- Use checklists to minimize room for errors
- Replace stripper plate as a temporally solution
- Redesign the piercing tool with spare parts for easy service and add a spring-loaded stripper plate

5. MEASUREMENTS

Inspection

This is the process of checking the conformance of a final component to its specifications. In most cases 100% inspection of a process is too expensive. Therefore, there are established methods of sampling a component or process. Inspection must be a continuous activity because, as we have seen, raw materials, machines, and operators are all subject to variability.³

Inspection equipment

Measuring a material before the die-striking operation is as critical as measuring during the operation. It is not enough to rely in the documentation of the incoming material or previous operations; having the correct equipment to measure at the right location will provide the operator the tool to perform a quality job. The equipment needs to be calibrated according to the specified instructions.

Manual tools

Inspection instruments are calipers, gage pins, customized gages, and micrometers with different types of points.

Coordinate measuring machine

High tolerances measuring machines known as coordinate measuring machines (CMM) save time by measuring a part's geometry and physical dimensions automatically. Traditionally measurements were taken using hand tools or optical comparators, but these methods had limitations and potential for errors.

Hardness tester

Hardness testers are devices that measure the hardness of a material by applying a standardized force with an indenter to the material surface, then measuring the indentation to determine the material resistance to deformation. There are different systems: Vickers, Brinell and Rockwell Soft Scale B.

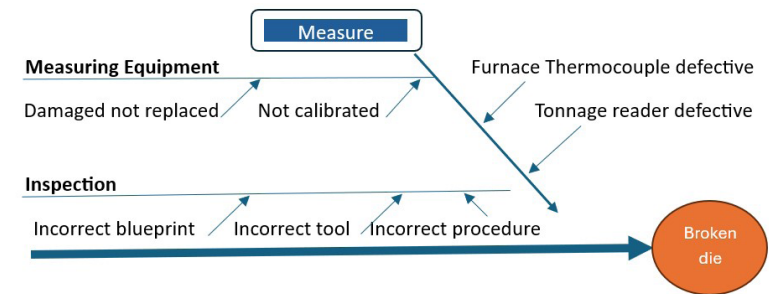


Figure 21: Measure

Defect: Quality Control production reports thinner parts, and after further investigation the cause of the inadequate measurements was bypassing quality control's first part inspection.

For this time, we have a well-documented die-striking process. The raw material, 14K gold with nickel, was inspected according to the specifications. The tool was well inspected for hardening and double tempering. The tool setter had made the press adjustments to reach the thickness based off the part blueprint. The mistake was the part not being sent for inspection afterwards. The instrument used for measurement, the caliper, was not calibrated before measuring, which led to an error in dimension.

Corrective Actions:

- Write or revise standardized operating procedures for inspection equipment calibration
- Write or revise standardized operating procedures for caliper measurement
- Provide adequate storage for calipers

- Use checklists to minimize room for errors
- Replace/repair damaged caliper jaws tips

CONCLUSION

We began by listing the most common defects in die-striking jewelry, utilizing the 5M approach to provide an overview of the process in an industrial setting. Proper process documentation and continuous monitoring for the quality control data are crucial to keep the process under control and to take corrective actions including preventive measures. Looking further into and analyzing the root cause allows addressing the problem's underlying causes rather than merely the symptoms. I hope this paper and the included materials are beneficial for the younger generation interested in this time-tested yet very effective jewelry manufacturing process.

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