Understanding Tool Welding: A Guide for Tool Makers

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Note: The intention of this work is to give the tool maker a better understanding of the challenges the tool welder faces by providing an overview of preparation procedures and information. **Please use this information as a helpful guide, not as an ultimate authority**.

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Introduction

The purpose of the paper is to coordinate a better relationship between the tool maker and tool welder by giving the tool maker an understanding of the challenges the tool welder faces in repairing tools. By understanding the tool welder's procedures and terminology, the tool maker will be better informed and make better decisions in regard to tool repair by welding.

Section 1: What is Tool Welding?

Definition

Our definition of "tool welding" is:

"To use a welding machine to weld steel, aluminum, or copper alloys (usually a plastic injection mold, blow mold, or a die) for the purpose of a revision or a repair."

In tool welding, you are repairing an existing tool or making revisions on a new tool. Most often a tool welder is doing more than simply joining metals. They are re-creating a crucial detail that is missing like fixing a damaged shutoff, a broken post, or a rebuilding an area made by a machining mistake. Tool welding takes patience and training to learn, and each professional tool welder has a unique style. Tool welders use certain guidelines in shielding gas pressure, tungsten (TIG/micro-TIG) preparation, and welding speed. Each job is different and requires a different hand movement, position, or machine calibration. The tooling industry often thinks tool welding is "voodoo" or a "black art" of mysterious knowledge. In actuality, the knowledge is acquired through mentoring, experience, and research.

Why is it needed?

Tool welding is needed because it is necessary for the financial well-being of the mold shop and molding company. When a mold needs to be repaired quickly, welding is the most efficient way for this is happen. A variety of welding processes can be used such as TIG, micro-TIG, laser, plasma, and pulse arc. Each process has strengths and weaknesses. In addition, the success and quality of the weld depends on the difficulty of the repair, the quality of the machine, and the skill level of the welder. Simple edge and shut off problems can be repaired efficiently with pulsed arc welders and laser welders by the novice with practice. More challenging repairs such as large buildups, gates, sub-gates, ribs, posts and cracks are often done by professional tool welders. This paper will focus on TIG, micro-TIG, and laser welding.

Importance of Mentorship

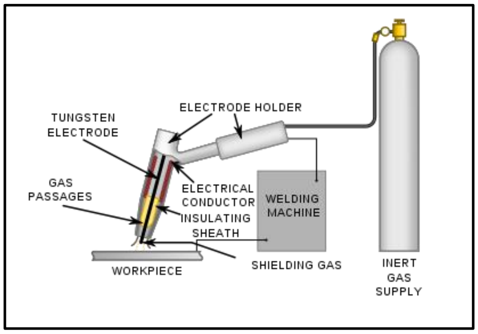
Since the tool welding profession is largely unknown in the general welding industry, little information on tool welding can be found at a library or the internet. The best way to learn the trade is through a mentor who has years of experience in the field. Mentoring is often helpful to the TIG and micro-TIG welding novice, but it can be beneficial to the beginning laser welder as well. Sometimes sound advice and demonstration from an experienced professional can save the novice welder weeks of frustration when learning a particular skill. The author of this publication learned from mentor, and that mentor learned from a previous mentor. Mentoring is much like an apprenticeship. A novice can learn to be a proficient tool welder without a mentor if one has natural skill, a willingness to learn, and patience. But the most of effective way is to combine natural skills and patience under the sound guidance of a mentor. This will lessen some of the pitfalls to welding.

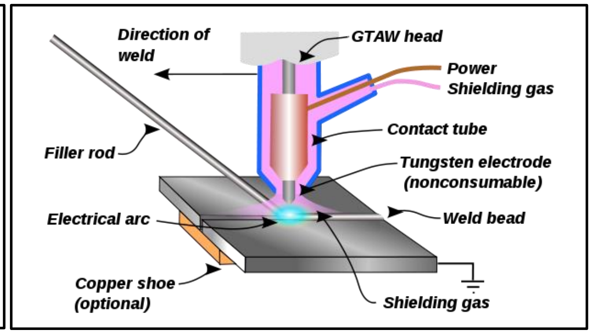
Section 2: Types of Welding for Tools

TIG Welding

Before laser welding and micro-TIG welding, the main way to repair molds was through the process of TIG welding which is still used for buildups and conditions that would be impractical for a laser welder or a micro-TIG machine. Gas tungsten arc welding, also known as GTAW or TIG, is comprised of a torch carrying a tungsten electrode which produces on arc and requires a pedal for controlling amperage or power. Argon or helium is used as a shielding gas to protect the weld puddle from oxygen contamination. Filler rod is added to the weld puddle. Tungsten is used as a non-consumable electrode because of its high melting point of 6,191°F which is above the temperature of the weld arc. The tungsten is sharpened on a grinding wheel to ensure no cracks or striations occur, and it will ignite properly in startup. Having the tungsten ignite properly is paramount. An improperly sharpened or an otherwise contaminated electrode can cause “arc wandering” when starting the welding process which could possibly damage areas of the work piece. The welding process can be activated in two ways. One way is through “lift-start” whereby you gently press the sharp tip of the electrode to the work piece and lift up while pressing on the foot petal to control amperage. From a welder’s perspective, “lift-start” is the safest way to control the initial arc start up because the rate of “arc wandering” is reduced. Nonetheless, the weakness of “lift-start” is that it does slightly contaminate the tungsten tip with repeated use which can create startup problems. In the second method called “hi-frequency start”, the arc is initiated by holding the torch/electrode close to the work piece—but not touching the work piece—and pressing the pedal. In this method the arc will ignite on the piece. More skill is required for “hi-frequency start” and proper tungsten preparation is critical. You will also need a work piece clean of any contamination. “Hi-frequency start” is often used in tight, hard to reach areas where “lift-start” would be impractical. In addition, the stability of “hi-frequency start” can often depend on the quality of the machine and the area you are welding.

TIG Welding Setup





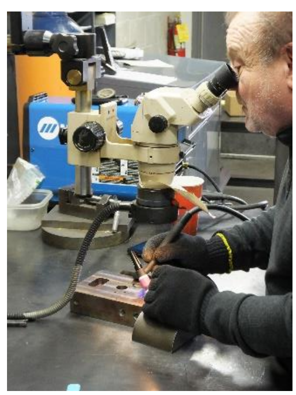
TIG Welding Facts

- Used for large buildups (1/8" and more)
- TIG produces larger welds compared to micro-TIG or laser welding
- Most tool welders learned their profession on a TIG machine

Micro-TIG Welding

The welding process of micro-TIG welding is similar to TIG welding. However, a micro-TIG welder uses lower amperages, smaller electrodes, and smaller filler rods, which is done under a microscope to produce a smaller weld. Using lower amperages reduces heat and distortion. Even with the advent of laser welding, micro-TIG welding is still a necessity because of its effectiveness and speed. To be a micro-TIG welder you should first learn TIG welding. Although using a microscope can be a challenge, the welder can easily transfer their knowledge of TIG welding to micro-TIG.

Micro-TIG Welding Setup



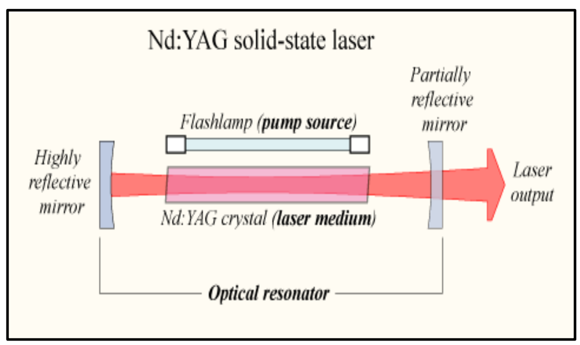
Micro-TIG Welding Facts:

- Lower amperage output than TIG
- Small diameter filler rods (.010” to .030”) are used for smaller buildups
- Access is more limited due to the microscope than TIG, but it is more accessible than laser welding

Laser Welding

LASER stands for Light Amplification by Stimulated Emission of Radiation. In terms of welding, the laser is different from TIG/micro-TIG because it uses a pulsed beam of focused light to create a microscopic weld. No pre-heat or post-heat is required for a tool that is to be laser welded. The laser beam is fixed in one position under a microscope. This means the work piece needs to be adjusted to the laser beam by a moveable table or arm that is calibrated to the machine. Proper positioning is critical and this can prove challenging for larger, heavier blocks. Laser welding greatly reduces heat and distortion. However, the process can be slow in some tasks. Laser welding is the easiest welding process for the novice to learn at first since you are no longer concerned with a proper arc initiation. The laser will pulse perfectly every time according to your adjustments. The welder only needs to focus on applying filler rod and work piece position. When going beyond basic repairs the skill level can increase dramatically. Welds smaller than micro-TIG is easily achievable. Sometimes weld porosity (see Section 4) can be a problem in certain processes. Laser welders come all sizes and power outputs to service molds large and small. Below is a photo of a medium sized laser welder with a moveable table and a diagram of the laser beam delivery process.

Laser Welder Setup & Diagram



Laser Welding Facts

● Minimal heat output

● No pre-heat or post-heat required

● Pinpoint weld deposits

● Minimal discoloration

● Weld can be small enough that a quick stoning can return a mold to service

● Small welds on aluminum and copper alloys (the only welding process that can do this efficiently)

● Time consuming for large buildups

● Welding large tools can be time consuming and unwieldy

Questions to Decide on a Welding Process

1) How big is the piece and the area being welded? How critical is the area being welded?

   The more weld added, the longer the process will take. Sometimes laser welding can take exponentially longer than TIG/micro-TIG welding depending on the job. However, laser welding has reduced distortion.

2) Is this a finished piece? Will “sink” (see Section 4) be a problem?

   Laser welding reduces “sink”. TIG/micro-TIG welding increases “sink”.

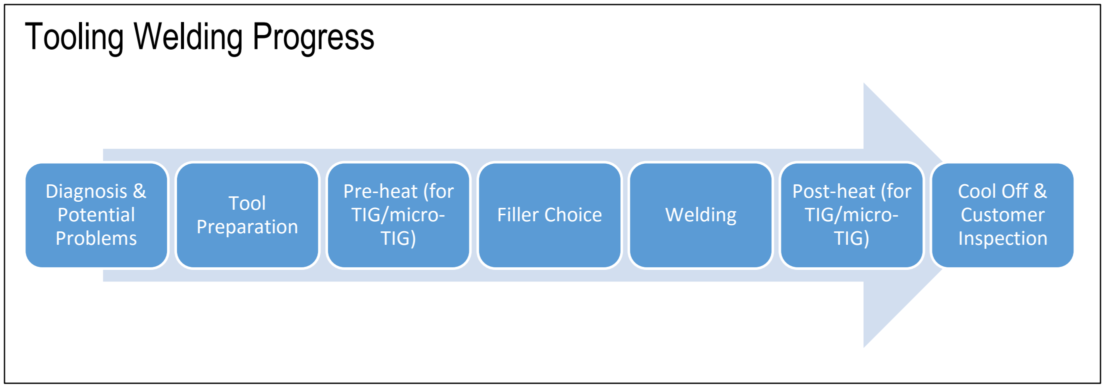
3) Does the tool have to be a certain hardness?

   With TIG/micro-TIG welding you can apply hard filler rod directly to edges and smaller details.

4) Why do does the customer want it welded a certain way?

   The customer may have concerns with a certain process and needs further clarification before making a decision.

Section 3: Tool Welding Procedures



Step 1: Diagnosis & Potential Problems

Informed welders can determine the best repair process and relate their knowledge to the customer. Here is a series of questions welders may use to diagnose the problem and devise a welding solution.

A) What am I welding?

Is it just a shim weld? Is it a molding surface? Am I fixing a crack? Do I have to go over an edge? Do I stay away from the edge?

B) Where am I welding?

Is the damage in the open area? Is it deep in a cavity? Will my access be easy or challenging?

C) What is to be achieved?

Will welding it according the customer instructions fix the problem?

D) What type of steel is it?

Is it for a plastic injection mold? Is it a die cast? Does it require a special rod? Is it aluminum? Is it copper based?

E) What can go wrong?

How can I hurt this piece? How can I mess it up? Is there a risk in unintentionally damaging other areas? Is there a coating on it? Is there a plating on it?

These are some questions a welder may ask. If there are risks and considerations, the welder wants the tool maker to know before welding. Mistakes can happen when there is a lack of communication between the tool maker and welder.

An agreement regarding the risk and outcome should be made by both parties before starting a job. Some repairs have such a difficult access that absolute clarity is needed because the area in question may be too small to add more weld later. The customer needs to know and understand the possible outcome if the process fails. Consistently asking questions can seem redundant, but it makes sense there is good communication between both parties.

Step 1 Continued: Potential Problems

- Chrome plating:

  Flash chrome, in general, does not inhibit the welding process enough to cause a major problem. However, heavy chrome plating will crack and lift from the heat distributed from welding. In heavy chrome applications the chrome should be stripped away before welding.

- Nickel Plating:

  In general, light nickel plating can be welded. When welding heavy nickel plating, the nickel will melt away from the heat distributed of the torch (TIG/micro-TIG) causing a sunken area around the border of the welded area. This effect results in an unacceptable finished surface. Heavy nickel plating should by stripped before welding.

- Titanium Nitride:

  This treatment can be welded. However, it can require stoning around the edge of the weld to remove minor pitting caused by the transferred heat of the welding torch (TIG/micro-TIG).

- General Nitride:

  Nitride can be welded, but the welding process for laser and TIG/micro-TIG will leave porosity (see Section 4) in the weld area. The piece may have to be re-welded to fix the porosity.

- Carburizing:

  This treatment cannot be welded. All carburized tools must be surface ground before welding.

- Plastic:

  Remove all plastic from cracks, corners, and sub-gates. If the plastic cannot be removed from a crack, then the crack should be ground down deep enough to allow several layers of weld to be deposited.

● EDM Finish:

An electric discharged machining (EDM) finish can have a hard re-cast layer that acts as a barrier to the weld puddle. As a result for TIG/micro-TIG, the amperage must be increased substantially to break through this hardened surface layer. This results in a difficult to control weld puddle which can cause damage to the surrounding detail. With laser welding, you have to increase the beam power much higher than normal to break through this re-cast layer. Because of these issues, the re-cast EDM finish can cause major difficulties, especially when welding in confined intricate areas. Grinding down the EDM re-cast layer will result in better welds.

Step 2: Preparing the Tool for Welding

Listed below are basic procedures for preparing a tool for welding.

1) Remove all oil and grease (including EDM oil).

2) Grind away rusting and pitting.

3) Brush the area with a stainless steel brush.

Step 3: Pre-heating (TIG/Micro-TIG)

Pre-heating is one of the most important procedures prior to TIG/micro-TIG welding. The reasons are highlighted below.

● It is a general assumption that tool steels should be pre-heated before welding to minimize cracking. While this is accurate, a more defined reason for pre-heating is to prevent the martensitic transformation (hardening) around the weld area. This hardened area around the weld can result in future problems when the tool is in service.

● Tool steels should be pre-heated, although some steel manufactures suggests that certain steels of a size, type, and repair situation can be welded without pre-heating. Follow your steel manufacturer guidelines. Tool steels are quite resilient and can usually hold up to the stresses of welding. However, this does not apply to die steels. <u>Welding die steels is always a risky endeavor and cracks can form even if every heating guideline and preparation is met.</u>

● Pre-heating slows down weld contraction during the welding process, which allows for “peening” and minimizes “sink” (see Section 4) in the weld zone.

● Pre-heating should be at a temperature range from 100°F to 700°F depending on the steel type.

● Mold and die steel have different pre-heat guidelines that should be reference by your steel manufacturer.

● With the exception to 420ss, properly heated steel will change color. (see Step 5: Post-heating & Color Change for more information).

Step 4: Filler Material

- Suppliers do not offer filler rods that are an exact match for every steel on the market.
- When welding on a new “soft tool” every effort should be made to match the composition of the base material.
- A softer rod can be used to allow for faster machining. This decision should be made by the customer.
- On larger repair areas a base layer of softer rod can be used to reduce the possibly of future stress cracks in the welded area. The base layer can be topped with a harder rod.
- If the mold runs an abrasive material, the top layer hardness should match the hardness of the base material.
- Die repair welding should always be topped off with a hard layer. Given the properties of the steel, a hard layer must be applied in order for the tool to work properly in service. Otherwise, the welded area will be too soft.
- Often when confronted with an unknown steel, type 420ss can be used as a filler material. The reason 420ss is frequently used is because it shares the same wear resistance and hardness of most tools.

Step 5: Welding

Each welding process requires a certain technique, positioning, and machine calibration. With laser welding, the position of a microscope/laser beam to a correct distance and angle is critical. Also, tools that will be micro-TIG welded have to be positioned under the microscope. For tools not welded under a microscope, such as regular TIG, the welder works under a helmet that has an auto-darkening feature for eye and face protection. Eye protection for laser and micro-TIG machines is handled through the microscope in an auto-darkening feature. Experience in each process allows the welder to accurately calibrate TIG/micro-TIG amperage, laser beam power and displacement, and gas displacement. Tools that have been pre-heated need to maintain the pre-heat temperature range through the welding process.

Step 6: Post-heating (TIG/Micro-TIG) & Color Change

- Follow the guidelines of your steel manufacturer regarding proper post-heating procedures. Post-heating should take place immediately after welding. After post-heating, the steel should be left to cool slowly. Don’t attempt the rush the cooling process.
- It is essential that tools with a textured surface be post-heated and stress relieved when welded on a TIG machine. Laser welding textured surfaces does not require post-heating.
- Pre-heat and post-heat procedures will cause the steel to change color with an exception made to 420ss. There is often a misguided perception that a color change means the steel has been over heated.

● Post-heating does not mean stress relieving, which is done by a heat treatment professional. Technically, all steel manipulated by EDM, grinding, or welding should be stress relieved. See the chart below for basic guidelines. Exact color changes at exact temperatures is dependent on the steel type.

2000°F	Bright yellow	1093°C
1900°F	Dark yellow	1038°C
1800°F	Orange yellow	982°C
1700°F	Orange	927°C
1600°F	Orange red	871°C
1500°F	Bright red	816°C
1400°F	Red	760°C
1300°F	Medium red	704°C
1200°F	Dull red	649°C
1100°F	Slight red	593°C
1000°F	Very slight red, mostly grey	538°C
0800°F	Dark grey	427°C
0575°F	Blue	302°C
0540°F	Dark Purple	282°C
0520°F	Purple	271°C
0500°F	Brown/Purple	260°C
0480°F	Brown	249°C
0465°F	Dark Straw	241°C
0445°F	Light Straw	229°C
0390°F	Faint Straw	199°C

Step 7: Cool Off & Customer Inspection

As stated before, no attempt should be made artificially cool off a tool. Forced rapid cooling is not recommended. Once the piece is cooled off enough to be hand held, it is carefully cleaned and returned to the customer. The customer then inspects the piece and asks any questions.

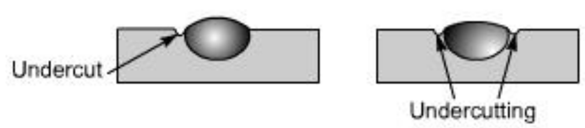
Section 4: Welding Problems

Since tool welders work under defined specifications, problems can arise that can disrupt work flow. The problems can be numerous. Here are some examples.

Undercuts: A Tool Welder's Definition

An "undercut" occurs when weld on an edge does not align to the existing material after machining. This notch in the steel can be felt by running your fingernail across the weld area. Undercuts are the most frustrating situations any welder can face, especially a novice. Some steels have more undercutting problems than others. Many welders have their tricks and know what works best. For TIG/micro-TIG welding, the strategy is to lower amperage to control the heat of the weld puddle and carefully dip the filler rod so you lump the weld over the edge just enough not to create an undercut. For laser welding, you gently push filler halfway into the pulsed weld area and let it lump over the edge. If done properly, you can snap off the un-welded filler rod. You can also create a “clean” laser edge by holding a piece of filler rod slightly below the edge by placing the pulsed bead halfway between the edge and filler rod, melting both down. You finish the area by welding in the gap with filler rod.

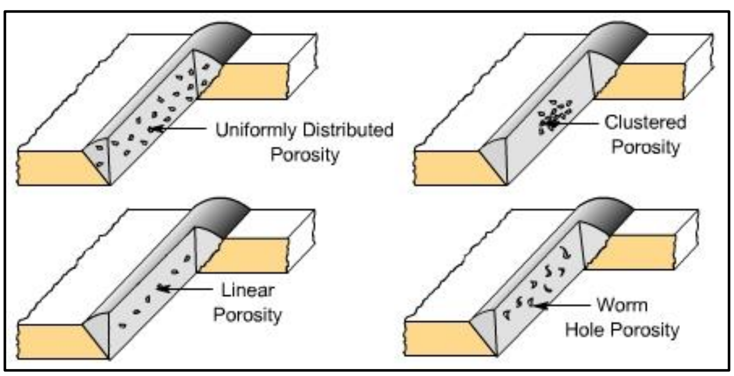
Undercut Diagram



Porosity

Porosity occurs when filler material and base material do not mix properly which can happen for a variety of reasons: contamination by dirt and grinding, coatings, plating, rough EDM, air pockets, or welding too fast. Porosity occurs in all welding processes to various degrees. Ineffectual use of shielding gas is the most common culprit to porosity. Laser welding can have porosity at times since there can be trapped air in between individual weld passes. Some laser welding jobs require multiple weld passes for a buildup and this is where you have to pulse, without filler, to clear out pockets of air after every weld pass. With TIG/micro-TIG welding, you can use your torch to skim over the entire area and re-melt to push out the pockets of contamination. Smoothing over the welded area can be difficult if the weld is in a tight corner or a hard to reach area.

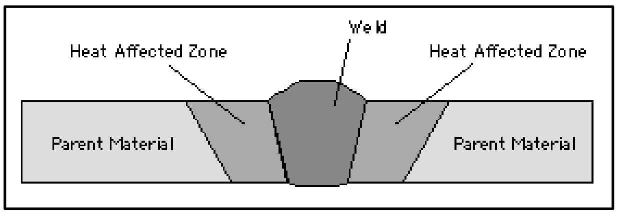
Porosity Examples



Sink

"Sink" is the result of steel contracting after cooling from welding and shrinking below the original level of the existing steel. It is occurs in the heat affected zone (HAZ) of the weld and is often displayed in a ring like shape. The condition is more of a problem with TIG/micro-TIG welding. Welding deep areas will produce the most amount of sink because there is a greater contraction of the weld upon cooling.

Demonstration of a HAZ (Heat Affected Zone)



Procedures to Reduce Sink (TIG/Micro-TIG)

● Use proper pre-heat and post-heat. When the tool is properly pre-heated, the welder can use lower amperages since they no longer have to compensate for the lower temperature of the piece.

● Use only enough amperage to achieve a proper melt.

● "Peening" the welding, using a punch and hammer during the welding process, will push down the welded area and push up the steel in the HAZ and reduce sink. The process can be performed when feasible.

● Laser welding the HAZ after TIG/micro-TIG welding will help reduce sink.

With the advent of the laser welding, sink can eliminated or reduced to a near immeasurable level depending on the steel type and what is being welded which makes this process excellent for textured surfaces.

Cracks During or After Welding (TIG/Micro-TIG)

Cracks in or near the weld area of a pre-heated tool is not a common occurrence when doing small buildups and shutoff edges. Dies are the exception. Good mold steel rarely cracks in basic repair situations, and bad steel can crack despite all precautions taken. The best defense against cracking is proper pre-heating and post-heating (to the steel manufacturer guidelines) and "peening" when feasible.

Common Reasons for Cracking after Welding:

● The tool has microscopic crack prior to welding. Heat generated from welding opened the crack to a noticeable appearance.

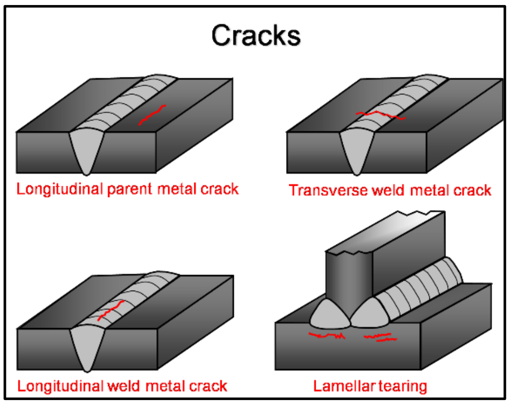
● Something went wrong in heat treating causing a hard and brittle surface area.

● Not properly pre-heating and post-heating die steel.

● Having a large buildup (often .060” or higher) causing stress from various weld passes.

● Welding a hard, brittle EDM re-cast layer (especially in corners). Sometimes EDM re-cast layers can have the same hardness as carbide and welding on this surface will result in a surface crack.

Crack Examples



Fixing a Crack

One of the most common tasks for a welder is to repair an existing crack on a tool or die. The question to be asked is why did the tool crack in the first place? In addition, will welding the crack as specified fix the original problem?

Below are procedures for fixing a crack:

● Clean out all debris from the crack. Contamination will keep the welder from seeing the weld detail causing the weld to be unacceptable.

● Cracks should be ground out into a “U” shape. Grinding a “U” shape allows the welder to use a lower amperage combined with multiple welding passes.

● If a crack is welded without providing a weld channel, machining after welding will remove most of the weld leaving a thin weld layer which will re-crack quickly.

● Cracks should not be ground deeper or wider than the thickness of the thinnest wall running alongside the crack.

Section 5: Tool Welding Trade Knowledge

Everything given the reader up to this point is the way the welder is "supposed" do it, or the "right-way", or "by the book". However, time is often enemy of the tool welder and tool maker. Proper techniques and procedures are often compromised to rush out jobs for the purpose of keeping a production line running or a tool build on schedule. In this section, "real world" procedures and information will be covered.

Pre-heating & Post-heating (TIG/Micro-TIG)

Everything—depending on the certain specifications of the steel or the repair you are working on—should be pre-heated and post-heated and even stress relieved by a professional heat treatment company. This is the standard line. However, in "real world" predicaments, it's impossible to pre-heat, weld, and post-heat a large block and have it back to the customer the same day. The welder must compromise by adjusting procedures to complete the task so the job can be turned around as quickly as possible. The procedures a tool welder uses to "push" a job does not replace proper pre-heating and post-heating. Welders are essentially taking a risk—a risk based on experience and knowledge—to meet customer demands.

Filler Rod

As discussed previously, there may not be an exact rod match for your piece of steel. A welder carrying filler rod for all of the tool steels in existence in various sizes would result in a large overhead of unused rod. Welders carry filler rods based on the needs of their customers.

Sample Rod List:

420ss	TIG/micro-TIG, Laser
H13	TIG/micro-TIG, Laser
H13 MOD	TIG, micro-TIG Laser
Buildup	TIG
Ampco 940	TIG, Laser
Alum. Bronze	TIG, Laser
Alum. 4043	TIG, Laser
Alum. 5356	TIG, Laser
17-4-PH	TIG, Laser
308ss	TIG/micro-TIG, Laser
316ss	Laser
410ss	Laser
P20	TIG/micro-TIG, Laser

P20-MOD	TIG/micro-TIG, Laser
M2	TIG, Laser
Magic Rod	Hail Mary

Filler rod choices are dependent of the advice of the welder and customer preference. Some customers want a softer filler rod for ease of machining and this is where the welder will use a "modified" rod that is softer. Other customers request only hard filler rods. Usually slighter softer rods are used on repairs and harder rods are used for new molds being revised. In laser welding, sometimes using a filler of the same hardness as the base material can lead to problems with penetration and microscopic cracking in the weld. Therefore, softer stainless rods like 410ss are often used as a repair on harder steels such as S7 and H13.

Aluminum & Copper Alloys

Aluminum and copper alloys come in various grades and types. Both can be laser welded and TIG welded, but they cannot be micro-TIG welded effectively. Most often a micro-TIG welding machine does not have enough power to efficiently melt the base material enough to add filler rod. Laser welding is an effective option since it requires no pre-heat, but the buildup will be small and therefore timely if you have to do a substantial repair. Power loss due to beam reflection (where the laser beam bounces) can be a problem in laser welding when welding on angles. TIG welding at the correct amperage works well, but the weld will also be larger due to the nature of the materials. Aluminum and copper alloys are often TIG welded on AC (alternating current) which gives the machine a very noisy but effective cleaning action to break through oxidation. However, in order for AC to work well on larger molds, aluminum and copper alloys have to be pre-heated to at least 300°F and it is difficult to heat a large aluminum/copper alloy block to that temperature. Also, both materials can change physically if they get too hot. On aluminum, the cleaning action of AC can possibly etch into the surface on the sides of the weld. For this reason, welders use DC (direct current) which does not have a cleaning action, but you can weld at a lower power and cooler temperatures. This technique requires knowledge and experience. The difficulty of welding copper alloys can change with the amount of copper in the material. The more copper based the material is the more difficult it is to weld.

Understanding Customer Needs

It takes time for tool welder to learn the customer and this is why welders ask a lot of questions. For example, when a customer says they want a .040" buildup the welder might give them at least .060" to cover themselves. This is why a welder often asks: "what are you finishing at?"

In addition, the procedures discussed in this paper have to be taken on a case by case basis. Sometimes areas are too small to properly grind out. Often times, tools are not prepared properly. Customers often request little pre-heat and post-heating. Sometimes the customer will the request laser welding or TIG/micro-TIG in areas where it is not practical. The welder provides a delicate balance in appeasing the wishes of the customer and making sure the tool is prepared and welded in the most effective process.

Special Note on Laser Welding

Since pre-heating and post-heating is a necessary part to a successful TIG/micro-TIG welding job, a common thought is to eliminate the time by having tools laser welded. As discussed before, laser welding has strengths and weaknesses. In certain jobs, laser welding is more effective than TIG/micro-TIG welding. The laser beam can pinpointed exactly where you want. The weld deposits are small which is critical when dealing with small details. However, sometimes laser welding can exponentially longer in time than micro-TIG on projects leading to more expense. The quality of penetration in laser welding is dependent on the power source and the position of the focal point. Sometimes it does not penetrate as well as TIG/micro-TIG welding which can be a problem for shutoff edges. Laser welding can have problems with rough surfaces and contamination. It is not recommended for certain steels like powered metals. Porosity and beam reflection can also be a problem depending upon certain conditions. Yet, the benefits can greatly outweigh its weakness. As stated before, certain projects should only be laser welded. A laser welder can access certain areas that a TIG/micro-TIG machine cannot. In addition, a laser welding can put weld deposits in sizes that a TIG/micro-TIG machine cannot match. Often minor porosity can be easily repaired in a second touchup weld. Most importantly, laser welding can be combined with TIG/micro-TIG because you can laser weld the HAZ to eliminate sink.

Section 6: Tips for a Successful Repair

Both tool welders and tool makers can learn from each other and below are two critical tips for helping facilitate a successful repair.

Communicate Effectively

Communication is essential. The welder needs to know clearly what you need to do and asks questions to gain specific answers. With poor communication the welder is left unsure of what you really need. Don’t assume the welder knows what you want. Remember every job to a welder is different regardless whether a similar task was done in the past.

Listen to Your Welder

Take the welder’s advice into consideration and ask questions before making your final decision. With a welder’s advice the customer can often find easier and better ways to repair tools. Use their experience and ask questions.

Section 7: Conclusion

In conclusion, the goal of this paper is to show the tool maker the various welding processes and procedures so they can make better informed decisions. For more information or questions, please visit our website or email.

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