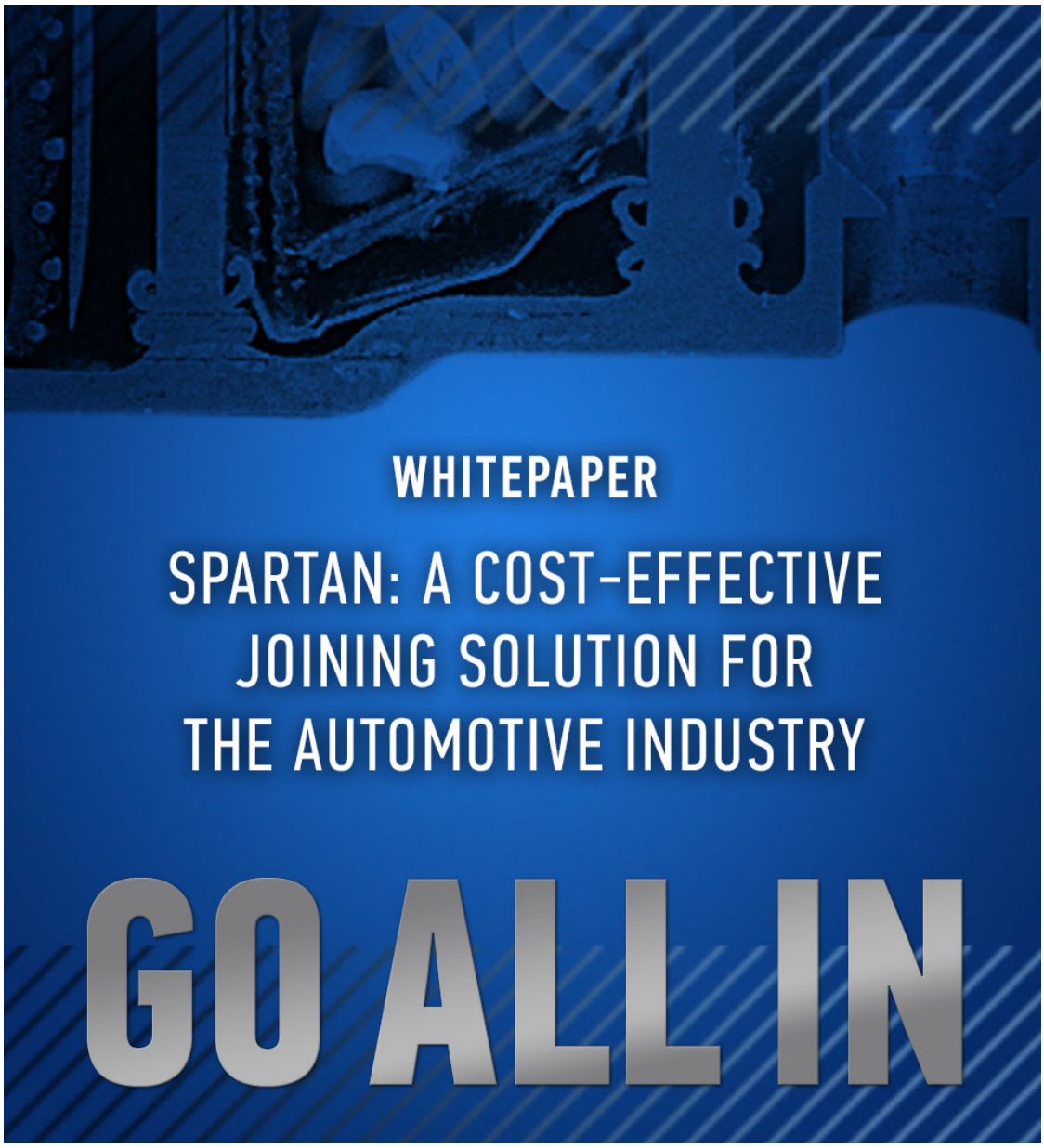

SPARTAN: A COST-EFFECTIVE JOINING SOLUTION FOR THE AUTOMOTIVE INDUSTRY

In the following pages, we will outline the benefits of friction welding, define the different types of friction welding, and describe the friction welding process. We'll also mention current issues faced by the automotive industry. And finally, we'll show how SPARTAN is an effective tool to overcome these challenges and achieve manufacturing goals.

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Overview

INDUSTRY CHALLENGES

After the economic downturn of 2008 and 2009, automotive manufacturers faced growing challenges. Many of which had lasting effects on the entire supply chain. Automotive manufacturers and suppliers needed to reevaluate their operations to remain competitive. They also needed to adopt more efficient and effective practices.

FUSION VS. FRICTION WELDING

Traditionally, the automotive industry favored fusion processes, such as TIG and MIG welding. But, after careful evaluation, design engineers turned to friction welding. A solid-state joining process, friction welding offers many benefits over traditional methods. Unlike fusion welding, you can join bimetallic metals. This is because materials are plasticized rather than melted. Friction welding also offers reduced cycle times and stronger welds than fusion welding.

MTI'S SPARTAN FRICTION WELDING MACHINE

Cost became another topic of contention after the recession. Design engineers want a quality product. If it were up to them, cars would last forever. But, to remain globally competitive, projects need to stay on-budget. This is where engineering and purchasing might disagree. To offset these concerns, MTI responded with the SPARTAN product line. These basic direct drive friction welders produce quality welds at a practical price.

Understanding Friction Welding

To fully understand SPARTAN's role in the manufacturing process, we must first understand friction welding.
Already a friction welding expert? Skip ahead >

FRICTION WELDING: WHAT IS IT?

Traditionally, welding is known as a fabrication process that joins materials by causing fusion. While many methods of welding involve an energy source such as a gas flame, electric arc, or a laser—friction welding does not. Friction welding is a forging technique. It involves generating heat with relative motion and high force. The result is friction between two materials, generating heat to soften them and join them together.

TYPES OF FRICTION WELDING

Friction welding takes many different forms. MTI offers the three most in-demand — all of which are solid-state processes. This means that materials being joined through friction welding are heated to a temperature that makes them plasticized, not melted. Since materials are not melted in the friction welding process, the result is a part featuring solid, 100% butt joints that are durable for years of use. Distortion is minimal and quality is consistent, even across high volume production runs, thanks to friction welding's ability to accommodate automated processes. The three most popular types of friction welding are:

- Rotary Friction Welding — in which one part is rotated at a high speed and is pressed against another part that is held stationary.
- **Linear Friction Welding** — in which one part moves in a linear motion at high speed and is pressed against another part held stationary.
- **Friction Stir Welding** — uses a spinning tool and axial forge force to create a bond between two pieces, which creates extremely high-quality, high-strength joints with low distortion.

WHY FRICTION WELDING?

As a solid-state joining and welding solution, the friction welding process helps companies make smart business decisions because it offers several advantages, including:

Highly Durable Welds

Bonds are seamless in their solid state, which means they're designed to hold up in tough circumstances where traditional welding may fail. Increased bond strength means longer lasting parts and that affects the ultimate bottom line.

Self-Cleaning Welds

During the friction welding process, the combination of heat and force applied between two parts produces more than just a solid-state weld. One of the most notable results of the process is the formation of flash. As two parts are heated and the material at the weld interface softens, the excess material starts to extrude

away from the weld interface. That extruded material is called flash. Flash formation also provides a unique benefit through self-cleaning at the weld interface. When flash formation takes place, any contaminants – such as coolant or grease – that are present on the weld interface between the two parts will be expelled during the welding process. Essentially creating a self-cleaning weld.

Reduced Weight for Numerous Applications

Friction welding produces lighter finished products, making it a great solution for many tough engineering challenges. That's because it allows for different materials to be joined together – including many combinations that are otherwise considered unweldable.

Consistent Quality

A friction weld – done on a wide variety of part sizes and applications – provides forged quality joining that MTI's customers demand. Since the weld is machine controlled, the process is consistent and repetitive, eliminating human error while producing weld quality that is independent of an operator's skill.

Dissimilar Metals

The truly unique thing about friction welding is the ability to join different metals. Metal combinations not normally considered compatible using conventional welding methods can be joined by friction welding.

Reduced Costs & Material Waste

Since a friction weld is stronger than conventional welds, it requires less raw materials to achieve the same fatigue and torque characteristics of the conventional part. This means a reduction in both raw materials costs and post-welding machining time to remove extra material.

Rotary Friction Welding

Friction welding can be used for a variety of part geometries and applications including automotive air bag components, water pumps, air conditioning compressor pistons, shock absorbers, and axles—just to name a few. For the purposes of this paper, we will focus on rotary friction welding, which also happens to be the most popular type of friction welding.

TYPES OF ROTARY FRICTION WELDING

There are three different types of rotary friction welding: Direct Drive Friction Welding, Inertia Friction Welding, and Hybrid Friction Welding.

Direct Drive Friction Welding

Direct drive friction welding is the oldest form of the rotary friction welding process. Direct drive friction welding can be used to join a variety of part geometries and materials, making a high-quality, solid-state joint. Here is the MTI process for direct drive welding:

1. Like all rotary friction welding, the process is started by rotating one part while the other part stays stationary. The rotating component is accelerated up to the desired weld speed using an electric motor, and this speed is maintained throughout most of the process.

2. A low-friction force is added to generate a little heat at the weld interface. This decreases the coefficient of friction and ensures that the motor does not stall due to excessive torque.
3. After a certain amount of time, a second friction forge force that is a little bit greater is brought on. This is just enough to generate heat at the weld interface to soften the material and start creating upset. Upsetting happens when the excess materials are extruded out at the weld interface between the two parts.
4. Once we have achieved a desired amount of upset from the part, the energy input is decreased by braking the machine spindle down to zero weld speed, and the full forge load needed to make the weld is brought on. At this point, all the soft material at the weld line extrudes out as upset.
5. The forge force is maintained for a certain amount of time to allow the part to cool.
6. At this point the weld is complete.

Direct Drive Welding Uses

Direct drive is typically used in the automotive industry because it's:

- Available from many friction welding suppliers
- Allows for reduced changeover time
- Offers lower cost tooling and machine designs since welds typically create less torque

INERTIA FRICTION WELDING

Inertia friction welding uses kinetic energy with applied force to join parts together. The kinetic energy is achieved using flywheels—a set of heavy rotating wheels that are used to store rotational energy. Varying amounts of kinetic energy are needed depending on two factors: the type of materials being joined together and the geometry of the weld. Once the material and geometry are known, it is then possible to pre-calculate the amount of kinetic energy that will be required for the weld. The act of inertia friction welding follows a carefully designed process:

1. Like all rotary friction welding, the process is started by rotating one part while the other stays stationary. With inertia friction welding, the flywheels are accelerated up to a desired speed that will provide the kinetic energy.
2. Once the flywheels are up to speed, the motor is shut off and the flywheels coast, storing all the kinetic energy.
3. At this point the stationary part is forced into the rotating part. This is the forge force which controls the power input of the weld and is maintained throughout the entire process. This creates friction between the parts and results in heat at the weld line.
4. When enough heat is created, the materials will begin to soften and will then begin to extrude and shorten. Upsetting happens when the parts start to bond and the softened materials are pushed out at the weld interface between the two surfaces. Again, the extruded material, which is referred to as flash, self-cleanses any surface contaminants. The softened materials will continue to push out at the weld interface until all the kinetic energy is used up, the rotation of the part stops, and the upsetting ends.

5. When the rotation stops, the weld is complete. The forge force is still maintained a little longer to allow the part to cool.
6. Once this process is completed, the two original parts are now 100% bonded together creating a fully joined, solid-state part. The time it takes to complete a weld from start to finish will vary depending on the power input placed upon the two parts.

Power Input

The power input is controlled by the forge force. To increase the power input, simply increase the forge force. This will increase the torque at the weld interface which will convert the kinetic energy into heat more quickly. The heat will have less time to dissipate so the weld upset will increase.

HYBRID FRICTION WELDING

The hybrid friction welding cycle is a type of rotary friction welding, and is a combination of the direct drive process and the inertia process. The direct drive process has a constant energy input using an electric motor. The inertia friction welding cycle, on the other hand, has rotating flywheels that store the energy needed for the weld, which makes it a fixed-energy cycle.

The Hybrid Welding Process

Hybrid friction welding is a combination of both the direct drive and inertia friction welding processes.

1. Accelerate the flywheels up to a constant speed and hold that velocity for part of the cycle — this is constant energy input.
2. Allow the motor to coast, enabling the energy to be converted from the flywheels, just like the inertia cycle.
3. Apply the forge force by pushing the pieces together to convert this rotating energy into heat through friction.
4. The heat softens the part, which begins to extrude material out from the parent materials, and we get welding upset, like in direct drive and inertia cycles. Welding upset occurs when the two materials begin to forge together, and as they are pushed into one another, both sides experience material softening. Both materials combine to complete the solid-state forging, while excess material from both parts is pushed outward into what is called upset.

You can find more information about the direct drive, inertia, and hybrid welding processes by watching our Whiteboard Wednesday video series:

- Whiteboard Wednesday: Direct Drive Process
- Whiteboard Wednesday: Inertia Process
- Whiteboard Wednesday: Hybrid Process

Automotive Industry – The Current Situation

MULTIPLE CHALLENGES AND THREATS

Threats of tariffs, decreasing customer demand, and stagnating sales are just a few of the issues currently faced by the automotive industry today.

To remain globally competitive, customers in the automotive industry demanded a machine that could keep product costs low, meet rigorous standards, and keep up with changing trends. Tier 1 and Tier 2 automotive suppliers were looking for a solution that could stand up to harsh environments but also help them achieve their lean manufacturing goals.

MTI'S RESPONSE

To satisfy growing customer demands, MTI responded with SPARTAN. A line of standard Direct Drive Friction Welders, SPARTAN sticks to the basics to provide you with consistent, durable welds at a reduced cost. The SPARTAN is available as a 5-, 15-, 30-, and 45-ton machine.

A practical solution, this 'no-frills' product line is expertly engineered to handle a wide variety of applications. With the ability to create highly durable components for everything from commercial to personal-use vehicles, the SPARTAN line helps Tier 1 and Tier 2 manufacturers design flexible solutions for the ever-changing challenges of the automotive industry.

A Lean Manufacturing Solution

To keep up with the demands of the automotive industry, automotive suppliers have incorporated lean manufacturing concepts into their production processes. Lean manufacturing uses a combination of practices designed to carry out high-volume production using minimal inventories. The basis of lean production is to eliminate waste, and the SPARTAN product line does just that. Here's how:

- ***Cellular Manufacturing*** – Designed with automation in mind, the SPARTAN can seamlessly integrate into your existing production line or a fully automated production cell. When you choose a SPARTAN machine, we'll work on establishing the most efficient way to seamlessly automate the friction welding process to increase production rates and eliminate as many unnecessary steps and operations as feasible, all while maintaining time cycle goals. This leads to process repeatability, improved cycle times, increased production volume, and cost savings.
- ***Machine-controlled Process*** – Friction welding is a machine-controlled process that decreases variation to achieve repeatable welds. Taking human error out of the equation, SPARTAN's preemptive control system detects issues related to operator error, such as incorrectly loading parts before the welding process begins. When adding automation to SPARTAN, the accuracy in parts is increased because the machine is programmed to specific parameters, leading to less mistakes.
- ***Quality*** – Friction welding creates a 100% bond of the contact area, creating joints of forged quality. The weld properties are superior to welds created with fusion processes, such as MIG or TIG welding. With the SPARTAN line, we can add several operations into an automated cell, and the part will come out fully tested for length control, dimension control, and finished machining.
- ***Reduced Cycle Times*** – Friction welding is significantly faster than more conventional methods of welding. Weld cycle production times can be reduced, meaning more parts can be joined in less time. Just how much faster is SPARTAN than more conventional methods? That depends on the parts you're joining and a few other factors. For example, when you add automation, the SPARTAN machine will be programmed for a specific task and will work until the machine is stopped or reprogrammed, production cycle times can be managed to provide the most efficient and consistent process. Contact us to learn more.
- ***Simple Design*** – From its basic exterior to its intuitive operator interface, the SPARTAN product line offers straightforward machines. User-friendly and highly configurable, the operator interface stores weld history across different parameters and enables configurable reporting by job, part, operator, job status, and client. It also displays the weld parameters and diagnostics as well as real-time reports and much more.
- ***Selectable Options*** – To remain competitive in terms of cost while still delivering quality welds, this line of friction welders gives you only what you need. The SPARTAN line offers a high-quality standard base machine with a select number of optional features that can easily be configured to get the most out of your machine. Tailor these options to suit your application requirements without adding significant customized engineering requirements.
- ***Quick Changeover*** – For increased flexibility in response to changing customer demands, collet chucks allow for swift and seamless tool changes in as little as 30 seconds.

A LEAN MANUFACTURING SOLUTION

THREE ADDITIONAL WAYS SPARTAN ALIGNS WITH MANUFACTURING GOALS

The SPARTAN product line solves difficult manufacturing problems without sacrificing quality. Unlike other joining solutions, the SPARTAN line has multifaceted benefits that the user can leverage to increase productivity and lower costs.

5. ***Ability to join dissimilar metals*** – When you can join two dissimilar metals, also known as bimetallic parts, you can reduce the weight of the final vehicle, which is commonly referred to as "lightweighting." The ability to combine aluminum with other materials has become a critical aspect of automotive production, and the SPARTAN makes it possible. For example, a 5-ton direct drive friction welder – the SPARTAN 5 – can be used to join aluminum and copper for battery cables. This unique technology offers significant cost savings along the way.
6. ***Ecologically Friendly and Energy Efficient*** – Manufacturers are looking at their suppliers to adopt more sustainable practices. This is because stakeholders are holding automotive manufacturers accountable for the environmental impact of their products. SPARTAN is an ecologically friendly solution for suppliers because the direct drive friction welding process doesn't require any consumables, flux, filler material, or shielding gases to run. Plus, there's no weld splatter. It's also energy efficient because friction welding uses the least energy of all welding processes.
7. ***Backed by MTI's Standard Warranty*** – The automotive industry runs on Just-in-Time inventory, where materials or parts are produced or acquired only as demand requires. Suppliers cannot afford the production disruption that comes from machine downtime and must have a dependable technology in their production process. That's why we stand behind the quality of our machines. MTI has spent 90+ years supporting its customers and building its reputation by providing machines that perform as designed. Our machines stand up over time to rigorous production. The SPARTAN product line comes with MTI's standard one-year warranty and a one-year extended warranty option. In addition, our enhanced preventative maintenance package proactively identifies potential trouble spots and combats production downtimes.

CONCLUSION

Conclusion

A direct drive friction welder, SPARTAN creates a 100% bond of the contact area, creating joints of forged quality. The weld properties are superior to welds created with fusion processes, such as MIG or TIG welding. This results in a higher strength bond and greatly increased design flexibility of the part.

The SPARTAN product line delivers strong, consistent, and durable welds for the automotive industry without exceeding budget constraints. SPARTAN excels at high-volume production and is manufactured to the highest quality standards. By adding automation, you can get the most of your machine to achieve lean manufacturing goals.

An ideal joining solution, SPARTAN can be used for a wide variety of parts ranging from air conditioning compressor pistons to flanged axle shafts.

CONTACT INFORMATION

Contact Information

Talk to one of our experts to find out if our SPARTAN direct drive friction welding machine is right for your next project and how it could seamlessly integrate into your company's manufacturing cycle.

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About MTI

From our early days working for Studebaker Automotive to recent projects with Aerojet Rocketdyne and Federal-Mogul Powertrain, our extensive experience in automotive welding solutions is evident in the enormous variety of parts our machines produce. Those applications include air bag inflators, turbochargers, stabilizer bars, engine valves, pistons, drive shafts, transmission gears, bumper shocks, suspension components, steering components, water pumps, axles, camshafts, U-joints, and so many more. Friction welding may be fully integrated into automated production lines to handle this industry's high-volume demands.

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