Kawasaki Robotics (USA), Inc.

Corporate Headquarters for Americas
28140 Lakeview Drive, Wixom, MI 48393, U.S.A.
Phone: +1-248-446-4100 Fax: +1-248-446-4200

Global Network

Kawasaki Heavy Industries, Ltd.
Tokyo Head Office/Robot Division
1-14-5, Kaigan, Minato-ku, Tokyo 105-8315, Japan
Phone: +81-3-3435-6852 Fax: +81-3-3437-9880

Kawasaki Heavy Industries, Ltd.
Akashi Works/Robot Division
1-1, Kawasaki-cho, Akashi, Hyogo 673-8666, Japan
Phone: +81-78-921-2946 Fax: +81-78-923-6548

Kawasaki Robotics (UK), Ltd.
Unit 4 Easter Court, Europa Boulevard, Westbrook Warrington
Cheshire, WA5 7ZB, United Kingdom
Phone: +44-1925-71-3000 Fax: +44-1925-71-3001

Kawasaki Robotics GmbH
Im Taubental 32, 41468 Neuss, Germany
Phone: +49-2131-3426-0 Fax: +49-2131-3426-22

Kawasaki Robotics Korea, Ltd.
43, Namdong-daero 215beon-gil, Namdong-gu
Incheon, 21633, Korea
Phone: +82-32-821-6941 Fax: +82-32-821-6947

Kawasaki Robotics (Tianjin) Co., Ltd.
Bldg 3, No.16, Xiang'an Road, TEDA, Tianjin 300457, China
Phone: +86-22-5983-1888 Fax: +86-22-5983-1889

Kawasaki Motors Enterprise (Thailand) Co., Ltd.
Rayong Robot Center
119/10 Moo 4 T. Pluak Daeng, A. Pluak Daeng, Rayong 21140, Thailand
Phone: +66-38-955-040-58 Fax: +66-38-955-145

KawasakiRobotics.com

Kawasaki Robot

CAUTIONS TO BE TAKEN TO ENSURE SAFETY

- For those persons involved with the operation / service of your system, including Kawasaki Robot, they must strictly observe all safety regulations at all times. They should carefully read the Manuals and other related safety documents.
- Products described in this catalogue are general industrial robots. Therefore, if a customer wishes to use the Robot for special purposes, which might endanger operators or if the Robot has any problems, please contact us. We will be pleased to help you.
- Be careful as Photographs illustrated in this catalogue are frequently taken after removing safety fences and other safety devices stipulated in the safety regulations from the Robot operation system.

QUALITY SYSTEM CERTIFICATION DNV·GL ISO 9001

ENVIRONMENTAL SYSTEM CERTIFICATION DNV·GL ISO 14001

ISO certified in Wixom, Michigan U.S.A.

Cat. No. FSJ1807 Ⓜ

Kawasaki
Powering your potential

Friction Spot Joining

50th ANNIVERSARY
Kawasaki Robotics

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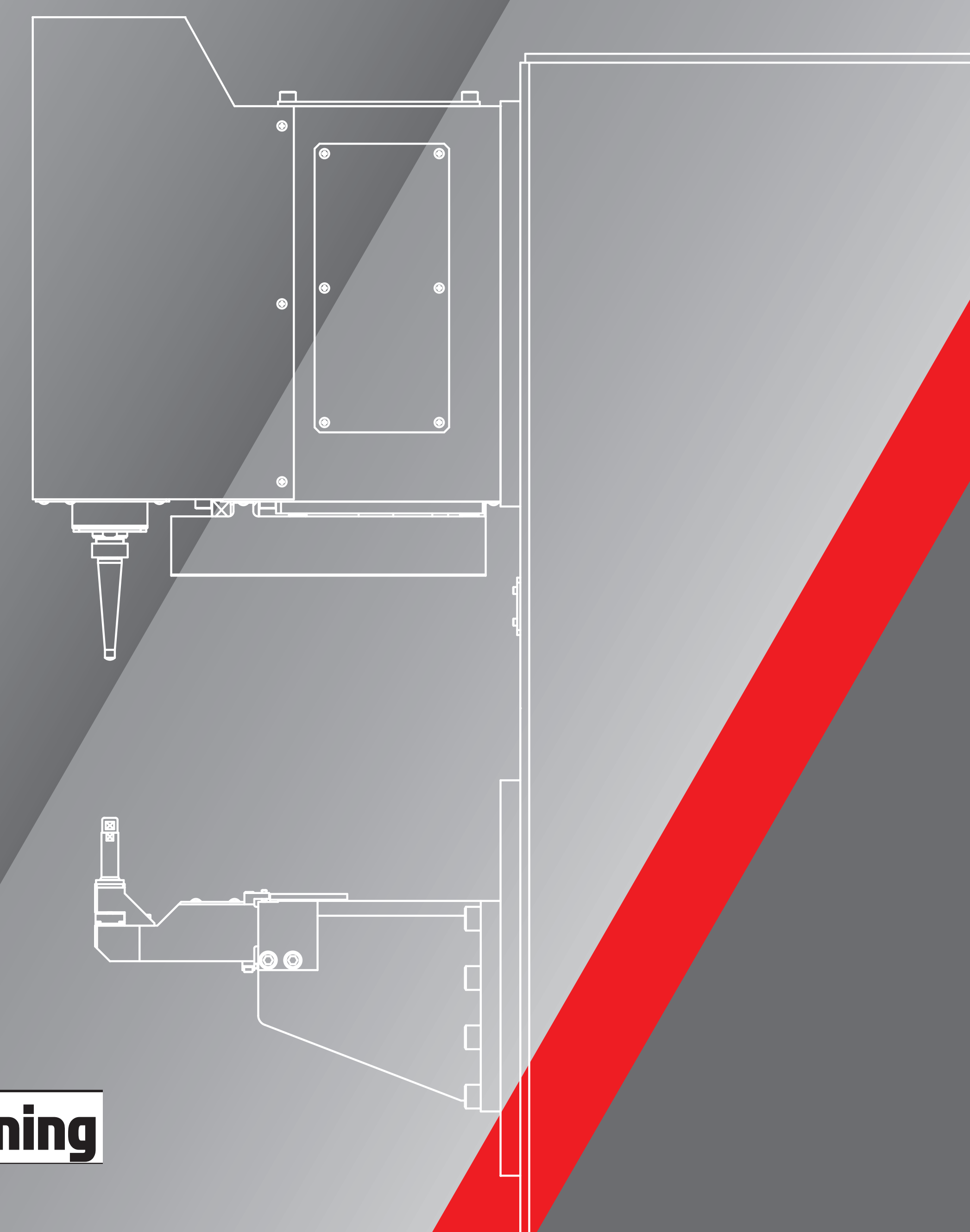
A new method for light alloy joining

Friction Spot Joining



Friction Spot Joining

A revolutionary joining method, based on an innovative concept, opens the way for new opportunities in the light alloy world.

A simple joining mechanism consisting of plunging, stirring and withdrawal

Friction Spot Joining is an entirely new joining method developed and offered by Kawasaki Heavy Industries which is used on lap joints of aluminum, magnesium and other light metals.

The process is extremely simple. A cylindrical joining tool, with a small projection at the tip, known as the pin (pin tool), rotates while plunging and then withdrawing from the material creating a metallurgical bond.

The rotation of the tool first softens the material by means of frictional heat creating a plastic flow effect in the rotary and axial directions in the periphery of the pin, thereby stirring and joining the upper and lower plates. The whole process is completed within a matter of seconds. The material then maintains a solid state without any melting.

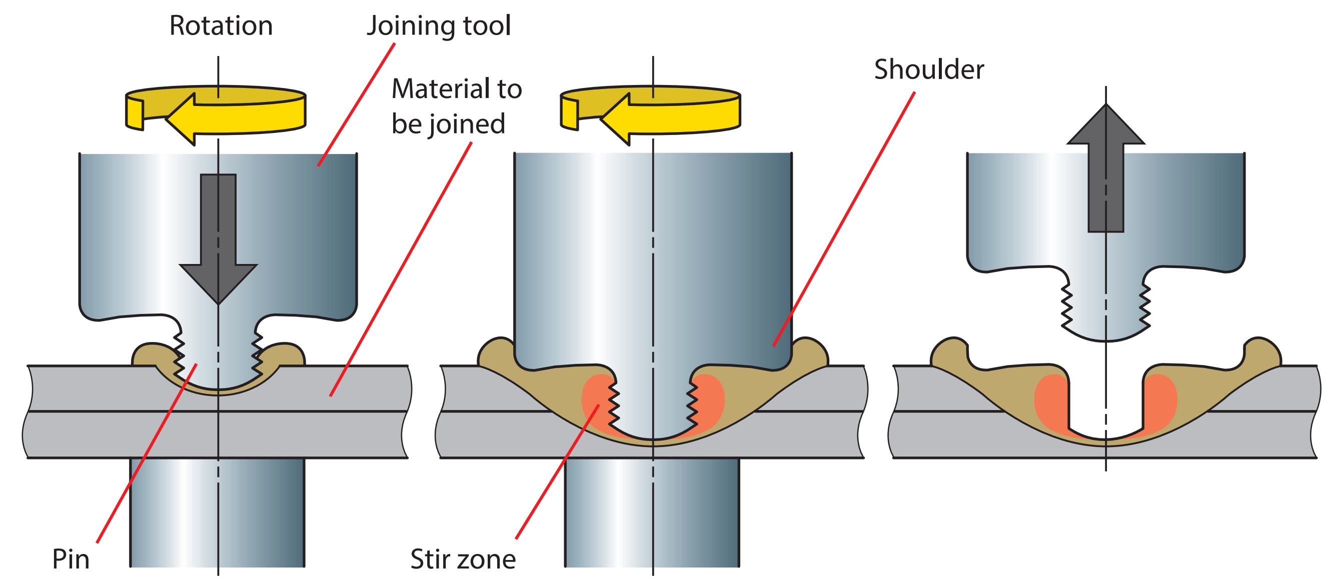
Joining process

The joining process is carried out in the following three stages:

❶ Plunging The joining tool, while rotating, is forced against the workpiece with a specified amount of pressure. This pressure creates frictional heat between the workpiece and the pin on the tip of the tool softening the metal and allowing the pin to plunge into the workpiece.

❷ Joining The pin becomes completely embedded in the workpiece and the press force on the tool is maintained for a given interval even after the shoulder on the outer edge of the tool comes in contact with the work piece (refer to the drawing below for the joining mechanism).

❸ Withdrawal The tool and the pin are withdrawn after the joining is completed.



❶ Plunging ❷ Joining ❸ Withdrawal

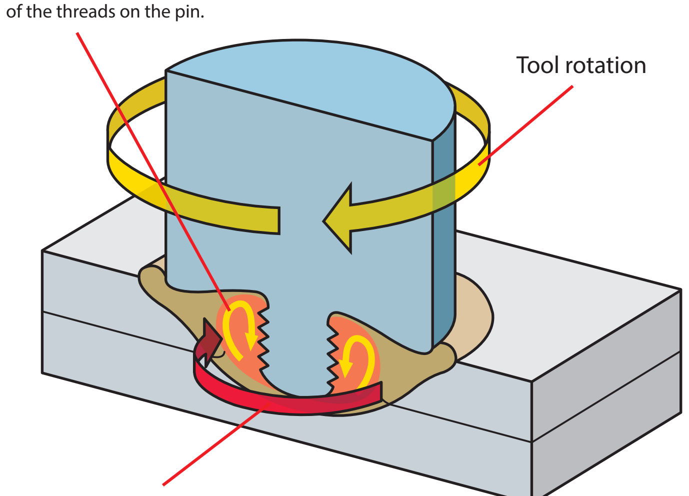
Joining tool

The joining tool has a small threaded projection (pin) at the tip. The outer edge (shoulder) of the tool is convex creating a pocket in the material where the stirring is performed. This convex shape leaves a saucer-shaped dimple on one side on the joining area.
Various tool configurations and dimensions can be utilized depending on the joining conditions and the desired strength.

Joining mechanism

Plastic flow in the axial direction

The material in the periphery of the pin flows in the axial direction (through-thickness direction) due to the rotation of the threads on the pin.

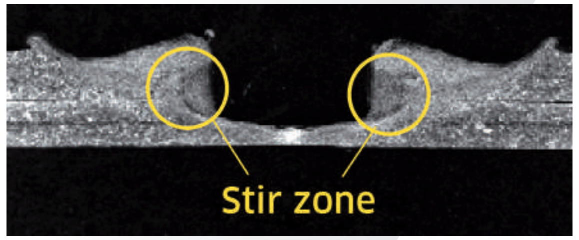


Plastic flow in the rotational direction

The material flows as if dragged by the rotation of the tool.

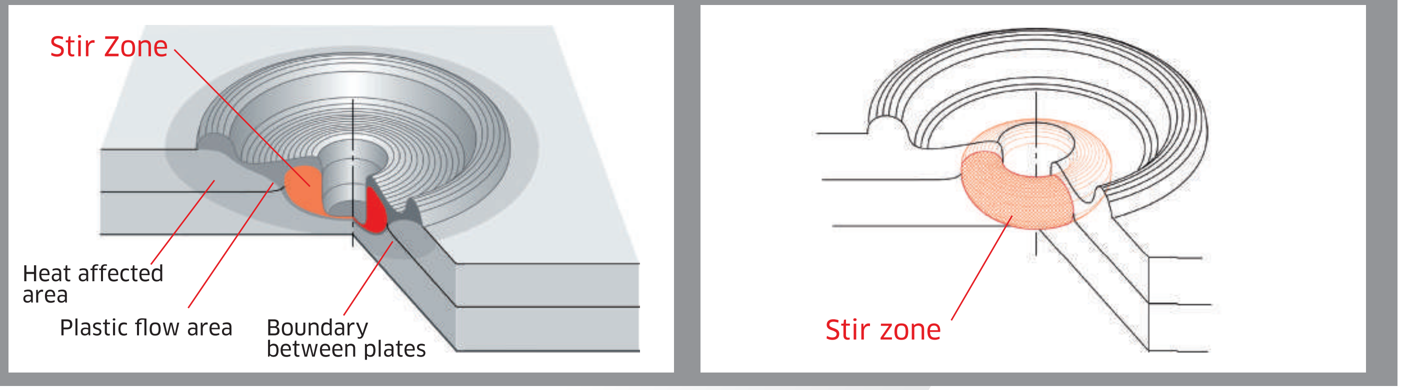
Both tensile strength and fatigue strength are comparable to welds created with resistance spot welding

A donut-shaped stir zone, comprised of re-crystalized material, is formed in the periphery of the pin from the high-temperature frictional heat and the plastic flow effect. The plastic flow occurs in both the rotational and axial directions due to the rotary action and shape of the tool.
This zone is characterized by high strength and outstanding ductility, providing FSJ joint with excellent mechanical properties. The results of tensile shear strength, pealing strength, tensile shear fatigue strength, and other tests confirm that this method offers the strength equivalent to that of resistance spot welding.

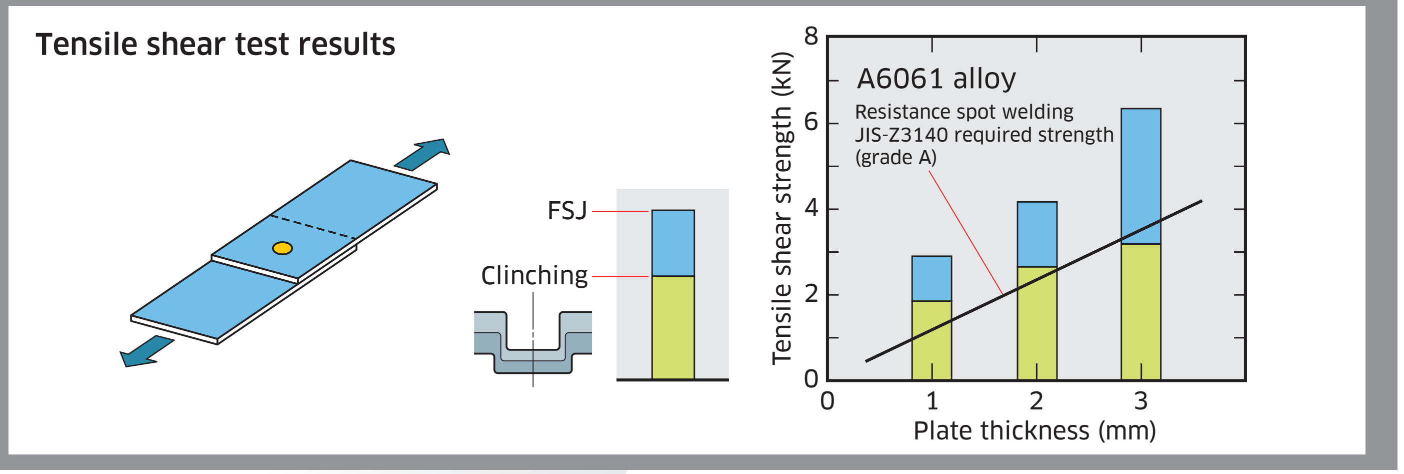


Example of the microstructure of the joining area

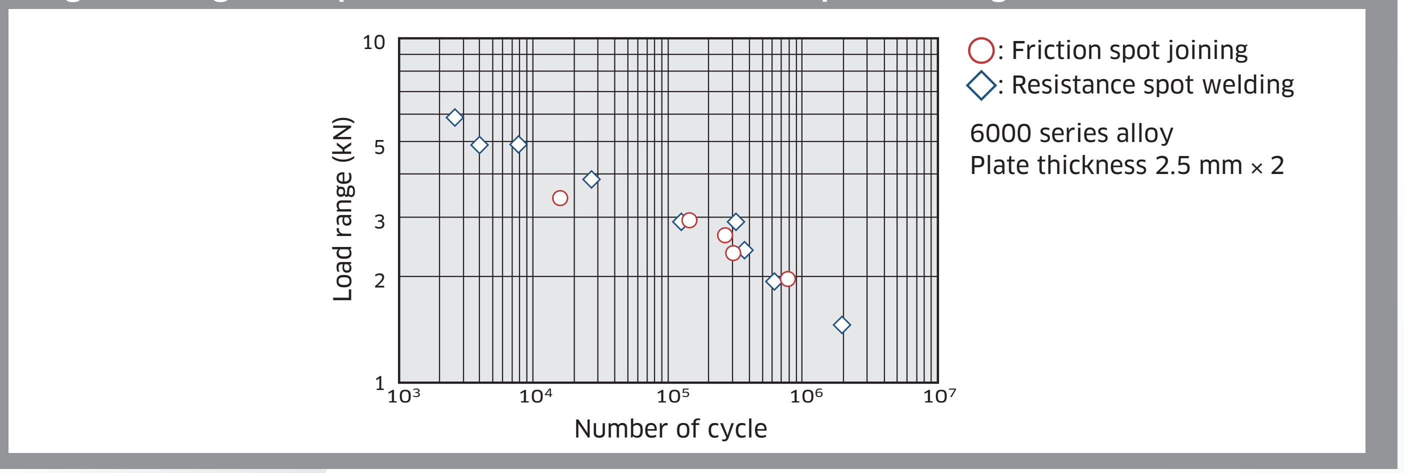
Stir zone formation



Tensile strength comparison FSJ with clinching (6000 series alloy)



Fatigue strength comparison – FSJ with resistance spot welding



Instant solution to the problems of resistance spot welding and riveting

Features of the FSJ system

1. High quality and high strength

The FSJ process does not require the materials to become molten. Heat from the joining process is kept low, resulting in less heat deformation than resistance spot welding while the achieving outstanding strength characteristics.

2. Conserves energy and reduces operating costs

The energy consumed by the FSJ method is no more than the electrical power required by the two servomotors that manipulate the joining tool. In fact, the FSJ system uses less than 1/20th the power consumed by resistance spot welding equipment. In addition, there is no need for large-capacity power supply equipment, resulting in a reduction in overall equipment costs.

3. A simple and economical system

The system mechanics are very simplistic with no need for auxiliary equipment as required by the resistance spot welding process. Neither cooling water nor compressed air are required which allows for broad reductions in both equipment and running cost.

4. Joining tool with a long lifespan

The joining tool, used in the FSJ system, is not susceptible to wear and tear when used with aluminum alloys. Users have reported no tip wear during production, even after several hundred thousand spot joins.

5. Clean workplace environment

With no dust or fumes to worry about and no need for a large electrical current, the FSJ process is clean and does not generate any electromagnetic noise.

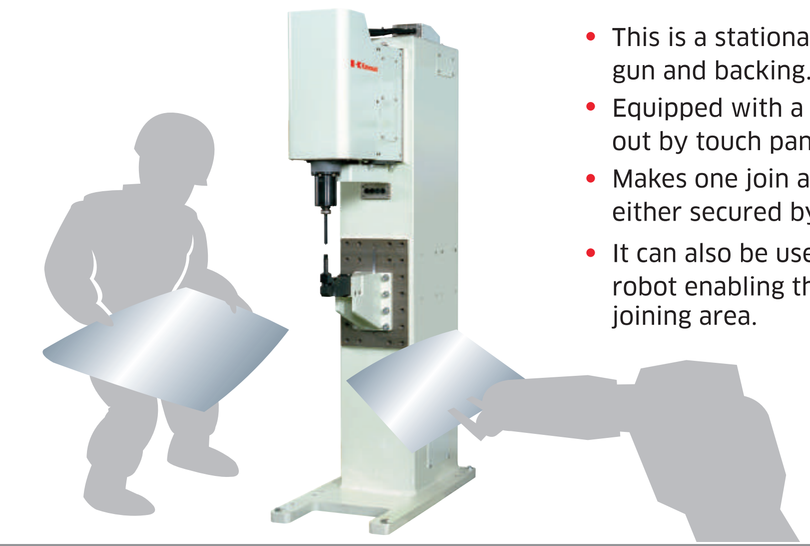
Comparison of problems and advantages of various joining methods

		Riveting	Self-piercing riveting	Resistance spot welding	Clinching	Friction Spot Joining
Joined area performance	Strength	◎	◎	○	× Strength limitations	○ Adequate strength can be achieved
	Quality disparities	◎	◎	△ Not uniform in strength	△ Not uniform in strength	◎ Consistent qualities
	Deformation (heat warping)	◎	◎	× Excessive heat warping	◎	○ Very little heat warping
	Looseness / Separation	○	○	○	× Looseness due to vibration, etc	○ No looseness or separation
Economic viability	Facility costs	× Equipment is expensive	× Equipment is expensive	× Requires primary power source, cooling water and air supply	○ No need for primary power source, cooling water or air supply	○ No need for primary power source, cooling water or air supply
	Cost of electrical power	◎	◎	× Welding current 30kA	○	◎ Energy required only for servomotors, less than 1/20th of that required for resistance spot welding
	Cost of supplementary materials	× Rivetsa	× Rivetsa	○ Not required	○ Not required	○ Not required
	Maintenance	△ Requires maintenance of rivet supply equipment	△ Requires maintenance of rivet supply equipment	× Requires tip dressing after every few dozen welds	◎	◎ Maintenance free for several thousand cycles
Workability	Pre-treatment	× Requires hole boring	○ Only requires alignment of upper and lower plate	○ Only requires alignment of upper and lower plate	○ Only requires alignment of upper and lower plate	○ Only requires alignment of upper and lower plate
	Operational efficiency	× 0+ seconds	○ Within a few seconds	○ Within a few seconds	○ Within a few seconds	○ Within a few seconds
	Multi-spot operation	○	○	× Not possible (shunt current)	○	○ Multiple (clustered) joins possible
Environment	Workplace environment	○	○	× Generates fumes and dust	○	○ Quiet with no dust or fumes

Even greater benefits can be realized when combining the FSJ system with a Kawasaki multi-axis robot!

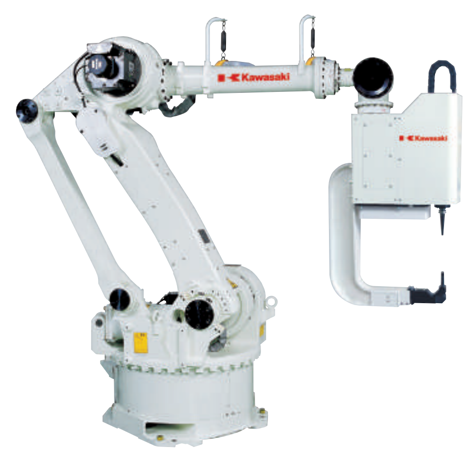
Kawasaki Heavy Industries has developed a special FSJ gun to take advantage of the outstanding characteristics of this process of joining light alloys. KHI has achieved success and world-wide recognition for developing and perfecting stationary FSJ systems as well as flexible joining systems utilizing the Kawasaki articulated robots.

Stationary FSJ System



- This is a stationary system featuring a special mount for the gun and backing.
- Equipped with a special control device, operation is carried out by touch panel and push buttons.
- Makes one join at a time by foot switch with the workpiece either secured by jigs or held by the operator.
- It can also be used in combination with a material handling robot enabling the workpiece to be manipulated to each joining area.

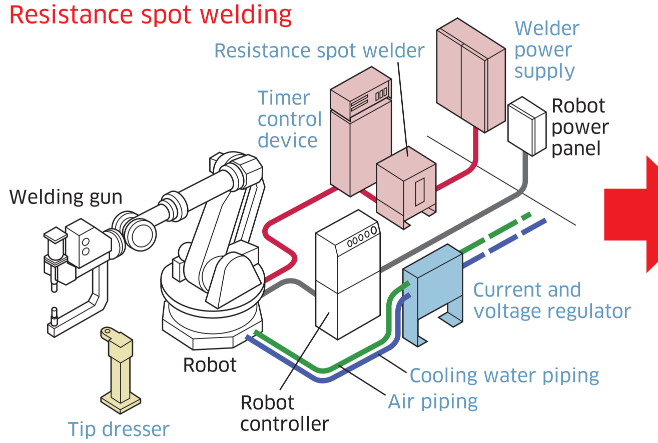
FSJ Robot System



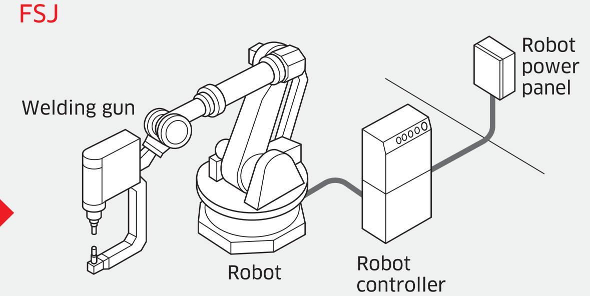
- The gun with C-frame backing is mounted on the articulated robot.
- The gun is equipped with 2 servo motors, one for the tool rotation and one for axial movement.
- The gun motors can be controlled by the robot controller as external drives, eliminating the need for additional control devices or operating panels.
- The robot manipulator can be selected to accommodate the workpiece shape and dimensions as well as the required operating range.

Example comparison of resistance spot welding and friction spot joining systems

Resistance spot welding



FSJ



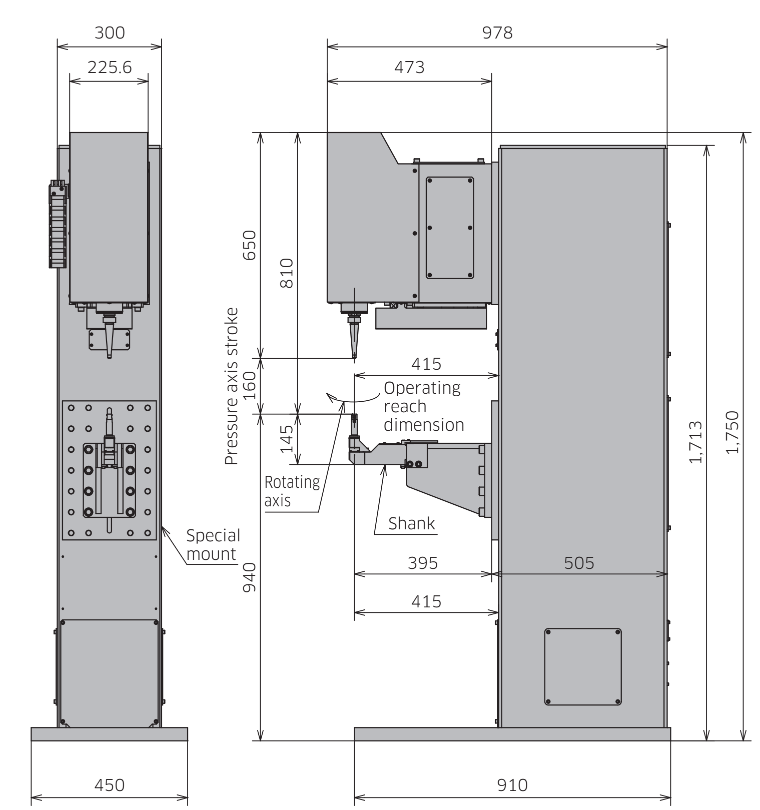
The FSJ robot system is based on very simple mechanics and operation.
For example, it has no need for the various peripheral devices required for resistance spot welding.

FSJ system specifications

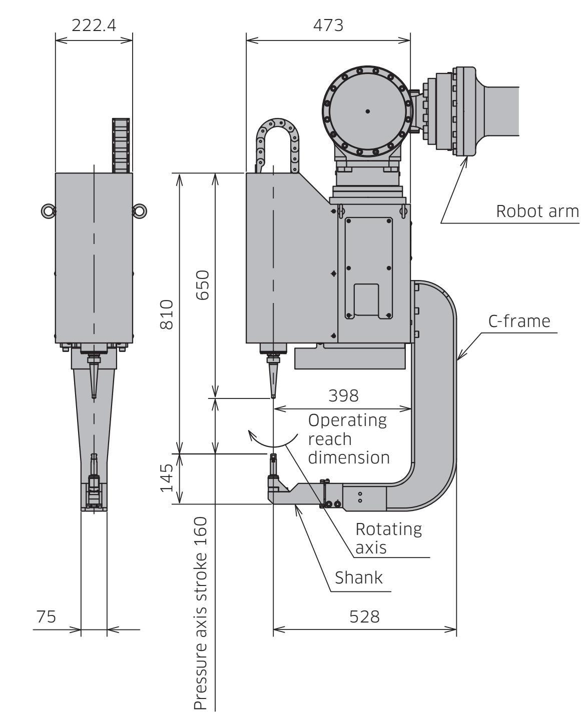
		Stationary system	Robot system
Gun mounting		Special mount	6 axes articulating arm
Control device		Robot control device	
Gun specifications	Drive method	AC servomotor drive (pressure axis & rotating axis)	
	Pressure range (N (kgf))	1,470 – 5,880 (150 – 600)	
	RPM range (rpm)	0 – 3,000	
	Pressure shaft stroke (mm)	Max. 160	
	External dimensions (mm)	(Refer to FSJ Gun External appearance & dimensions below)	
	Mass (kg)	Approx. 105	
Standard accessories		Processing tool, Pressure measuring device	
Options		Spot position irradiation device, Tool cooling device	Piping for tool cooling
Required power supply (kVA)		JIS: AC200/220V ±10%, 3-phase, 50/60Hz CE: AC380/400/415/440V ±10%, 3-phase, 50Hz UL: AC460/480/515/575V ±10%, 3-phase, 60Hz	
		11	
Mass (kg)		Approx. 500 (including gun) Robot controller: Approx. 95	Robot arm (including gun): Approx. 1,500 Robot controller: Approx. 95

External appearance & dimensions

Stationary system



Robot system gun



* The required shank dimensions, shape and the operating reach dimensions can be altered as required.

(mm)