CNZHENBO 臻博机械 | MP Sonic
Welding and cutting system

NO. MP220228001

Instruction

Super High Frequency Linear Vibration Welding

by CNZHENBO | MP Sonic

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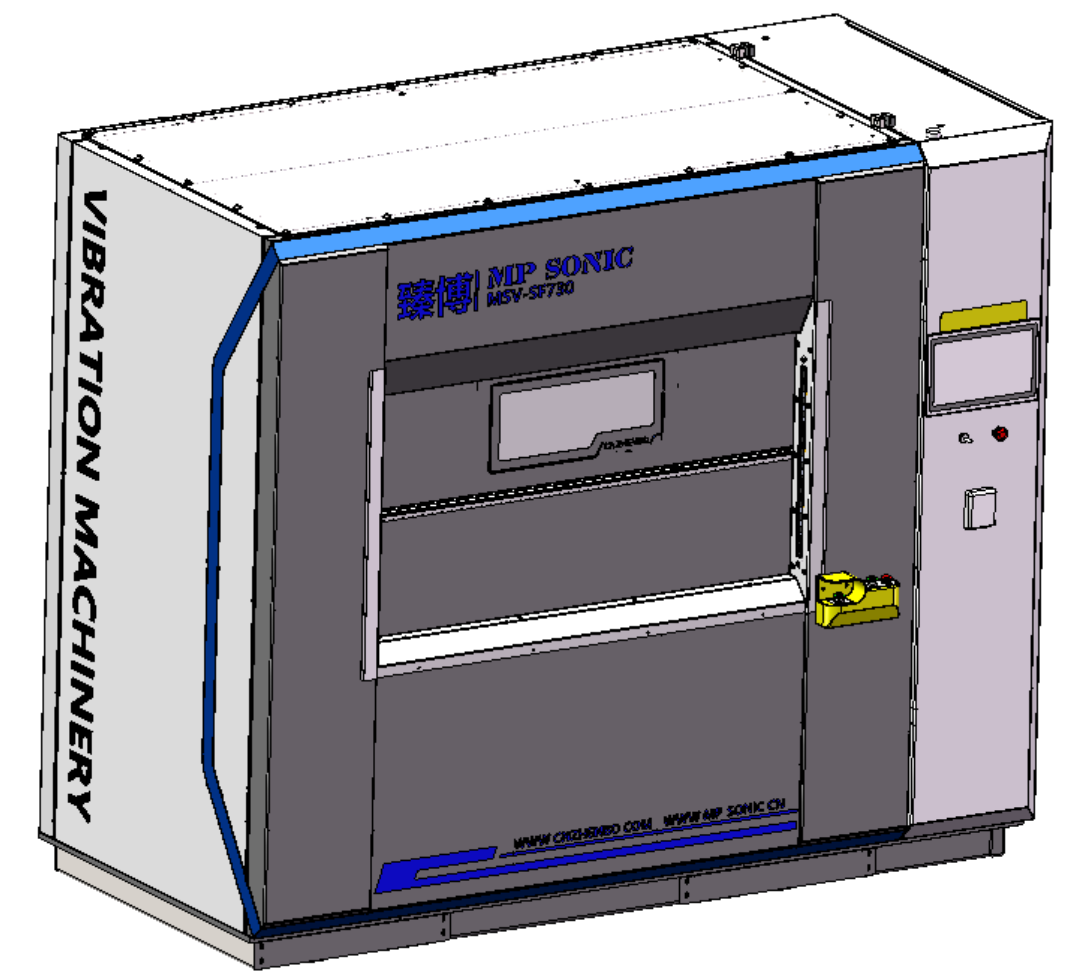
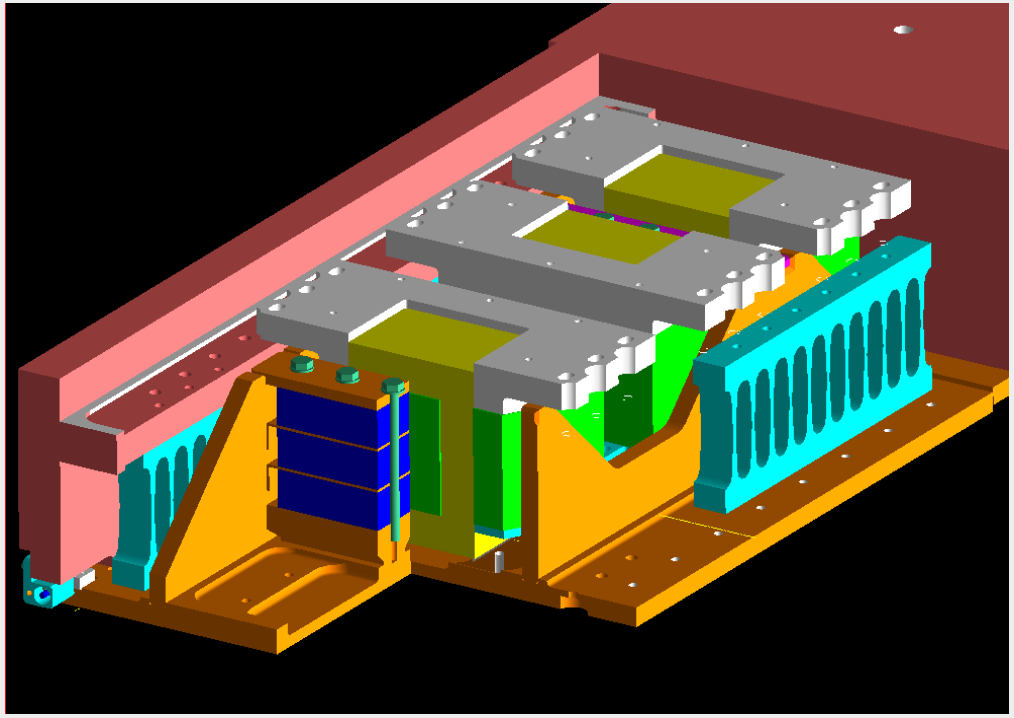
by Alex Lee

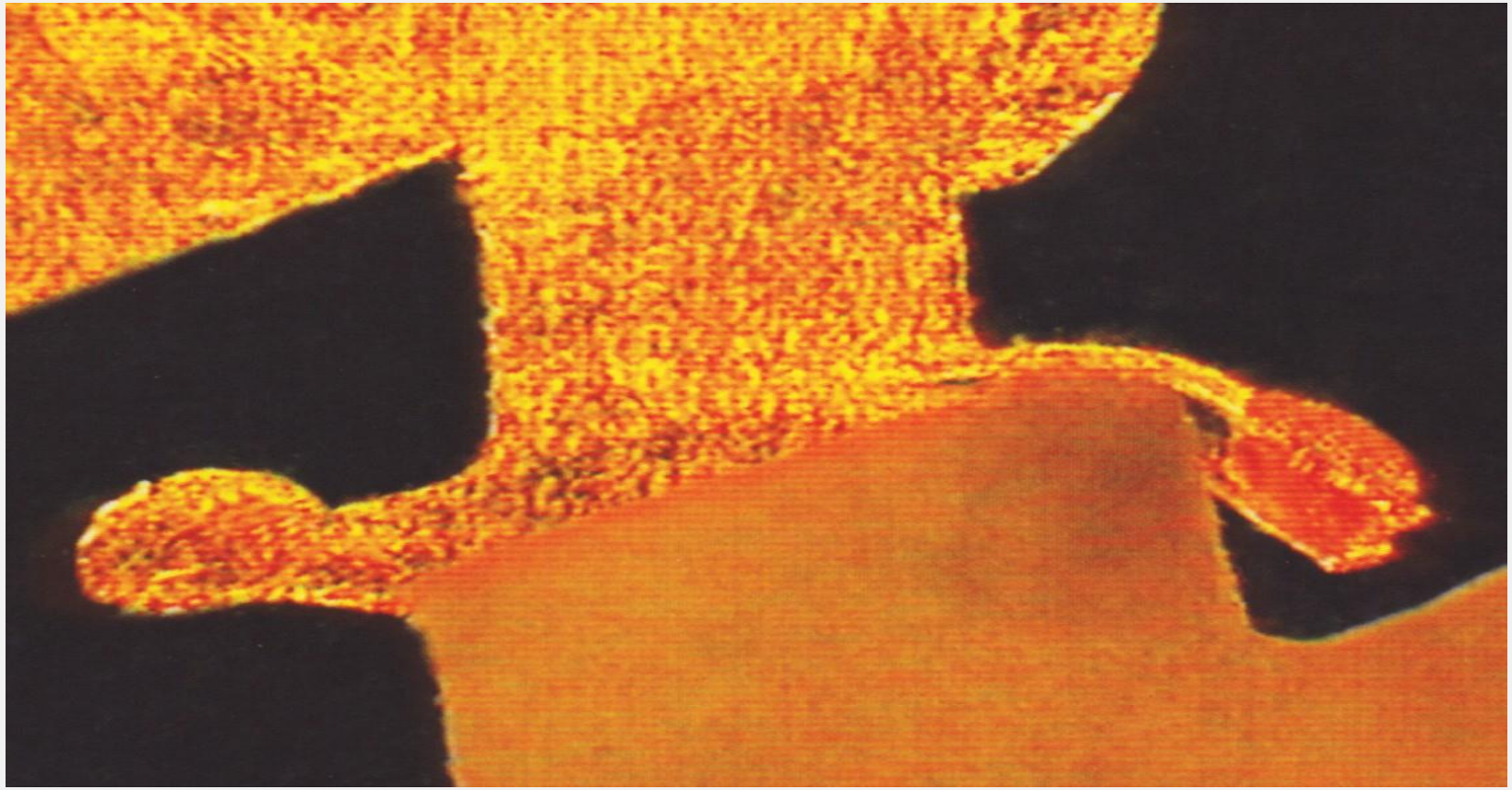
Liner vibration Working Modules





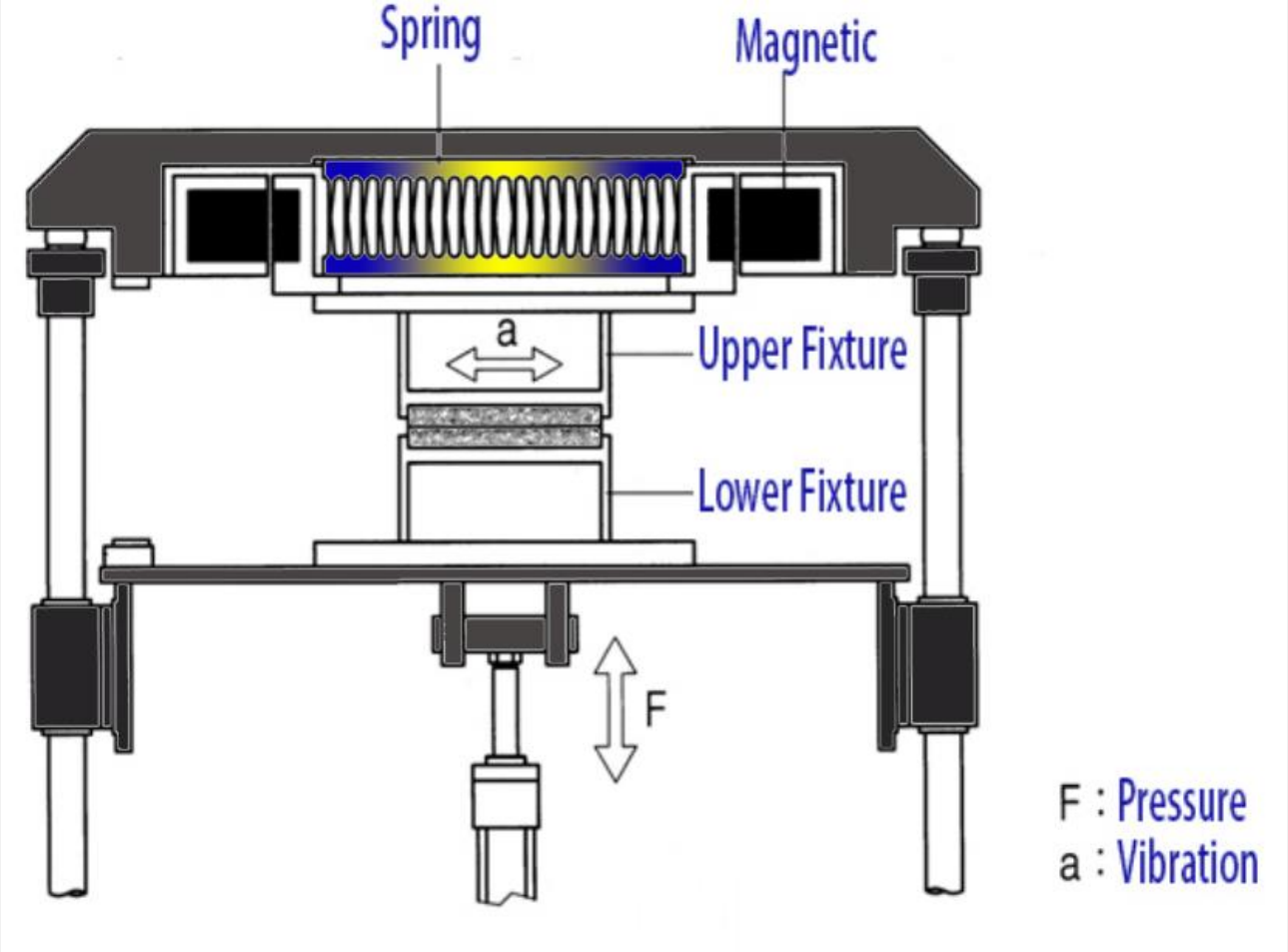
What is linear vibration welding

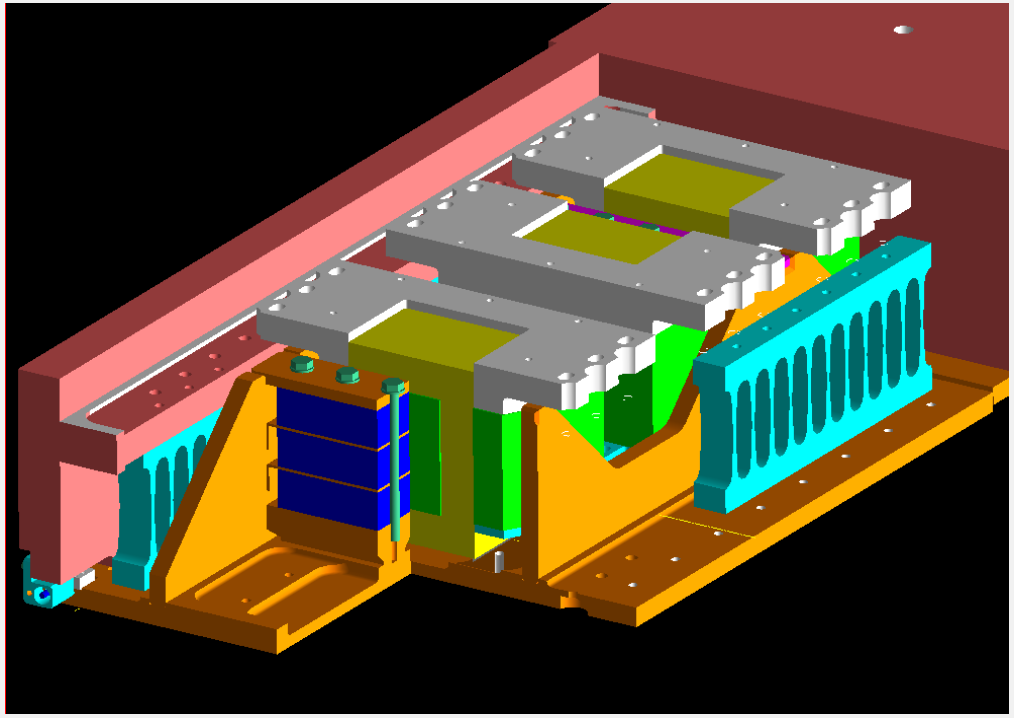
Linear vibration plastic welding is a kinds of friction plastic joining technology that one thermoplastic part half is hold with no moving while the other thermoplastic half is doing reciprocating motion (called as linear vibration) in fixed high frequency and vibration amplitude under pressure, through which heating energy is generated to melt thermoplastic material at the contacting surface. When the melting reach enough quantity, vibration stop and keep two plastic part halves together at the original relative position, until the molten thermoplastic material become resolidified and form joining.



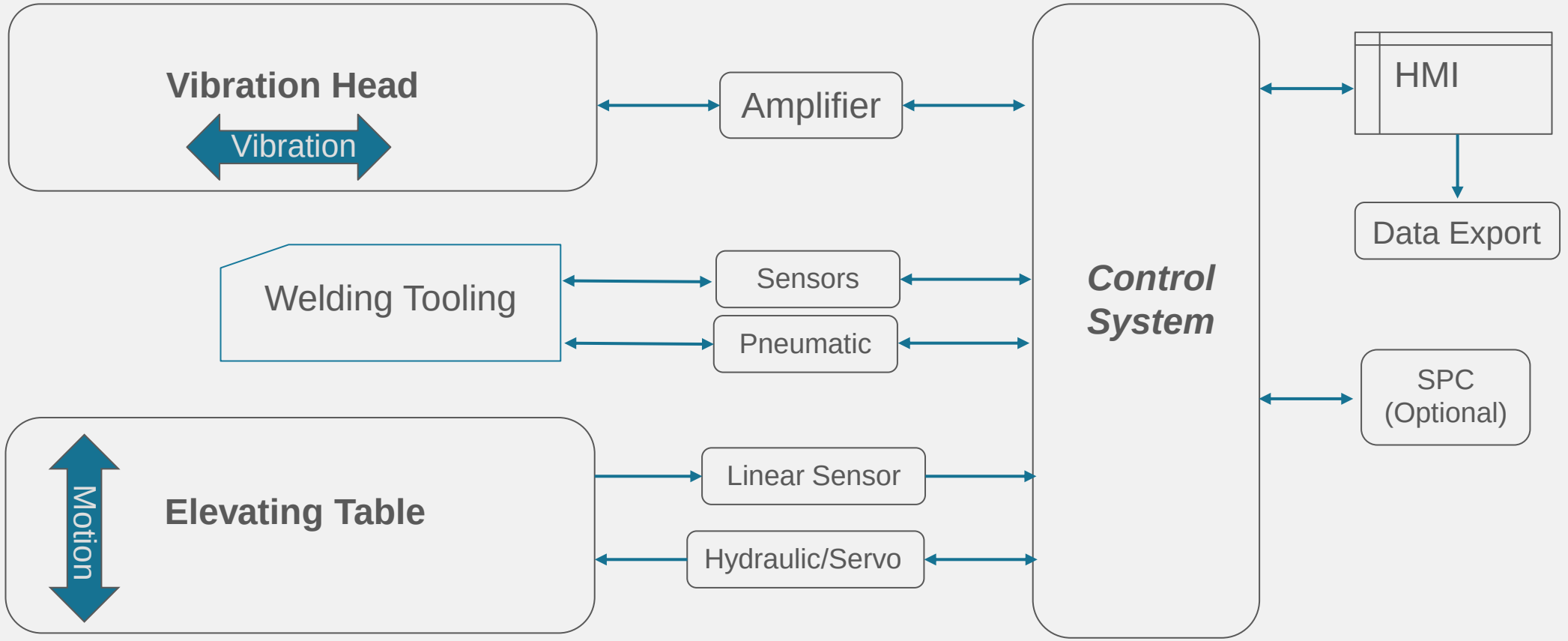
Linear Vibration Result

Liner vibration Working Modules

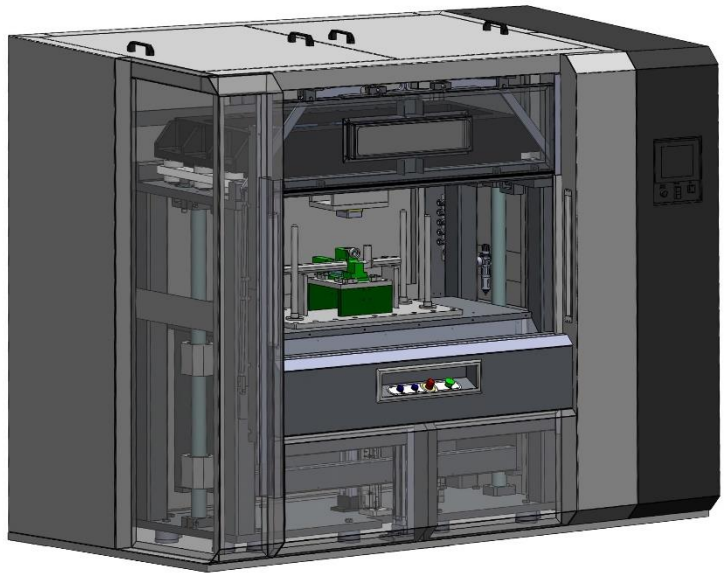


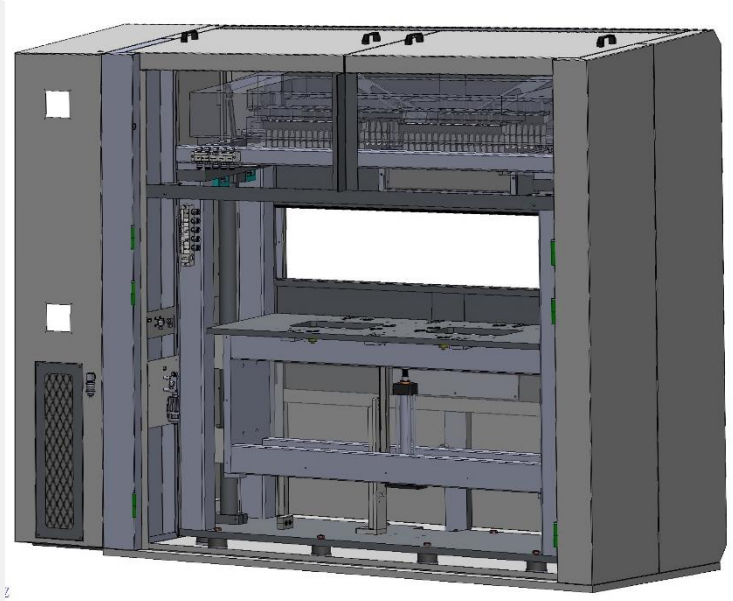


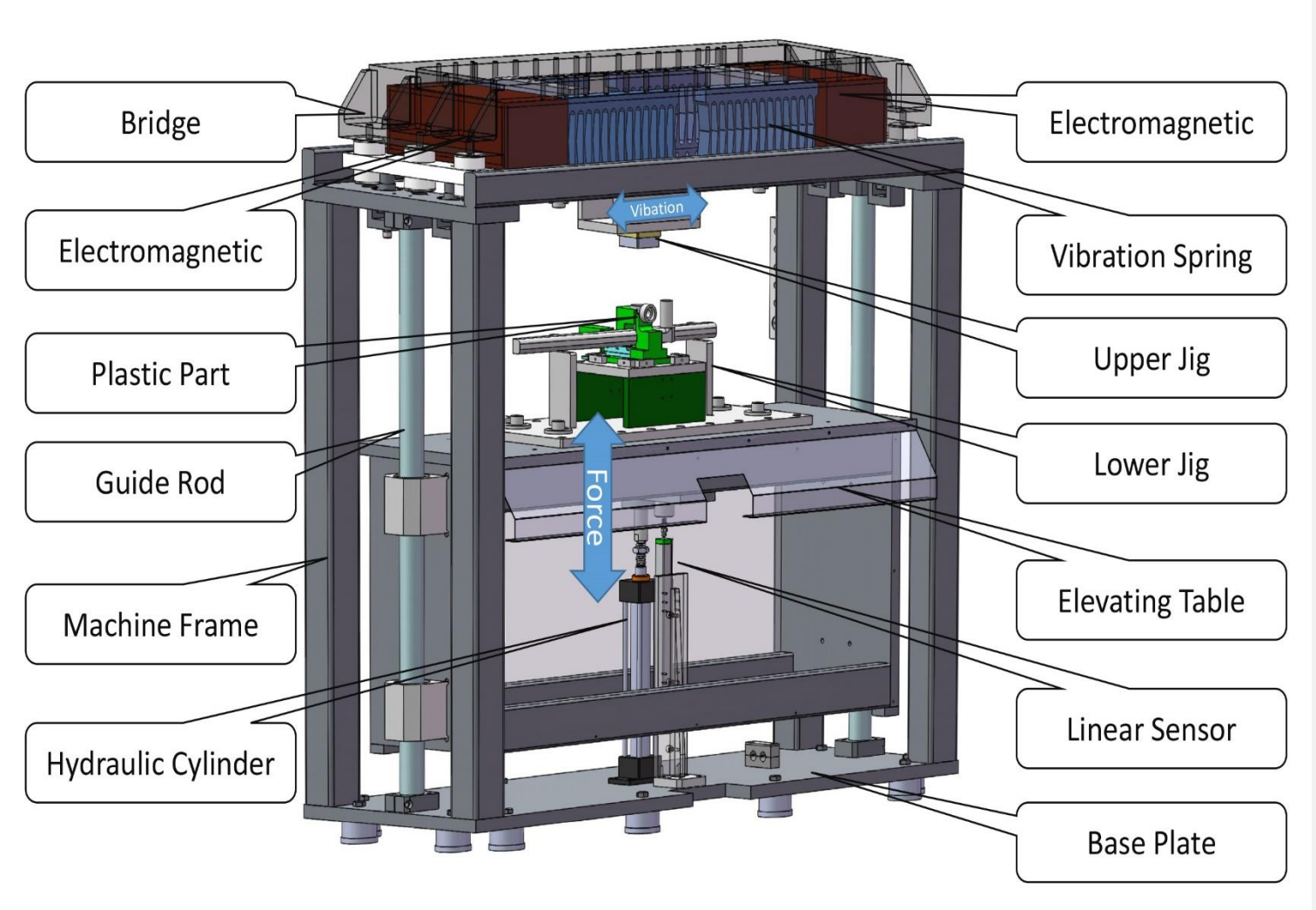
Liner vibration welding machine Working Principle



Liner vibration welding machine construction







1. Vibration System: Vibration Spring + Electromagnet + Amplifier

2. Forcing System: Servo Hydraulic System, or Pure Electrical Servo System

3. Control System: PLC+HMI+ETC

4. Pneumatic system: RFL, Solenoid valves, Vacuum, pressure gauges, etc

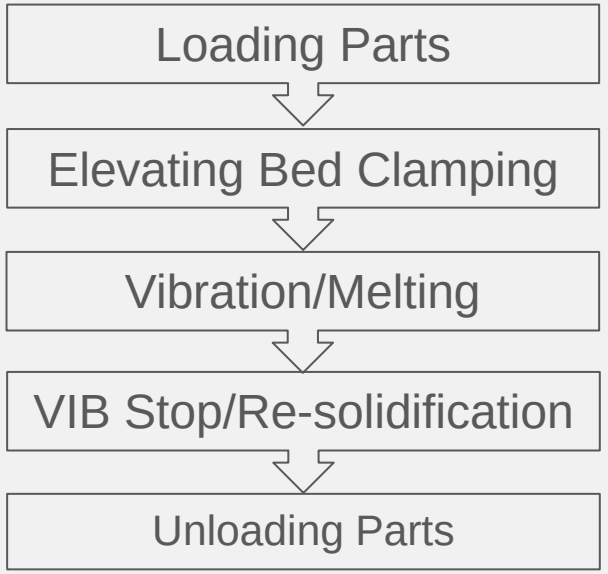
1. Consists of vibration springs and electromagnetics (E & I). When vibration thermoplastic welding operation, the spring reciprocating motion happens forced by the pulling energy from the electromagnets at two sides of the springs.

2. The Frequency of Mechanical Resonance: depends on the elasticity coefficient K & the total weight including that of the upper jig;

3. Vibration Frequency: depends on the AC current frequency to the electromagnetics at two sides.

Vibration welding operation process

1. Hold plastic parts by upper jig and lower jig;
2. Force plastic parts together by mechanical pressure;
3. vibration system starts working, friction happens between plastic parts at contacting area (welding area） generating heat;
4. Plastic parts is molten at welding area by vibration friction;
5. Vibration stop when plastic welding is ready, two plastic parts move back to its original position in precision of ±0.1mm;
6. Keep two parts pressed together under pressure, the molten material of two parts infiltrate to each other and re-solidified;
7. Welding finished, manual unload the welded part.



Initial Operation Process

Step 1. Connect electric source and air source

Step 2. Turn on the air valve (the doors should be close at this moment)

Step 3. Turn on the breaker inside the electric control cabinet

Step 4. Turn the master power switch (Key Power Switch) clockwise to turn on machine control power

Step 5. Turn on the hydraulic system on manual page

Step 6. Load jigs (refer to “Jig loading instruction”)

Step 7. Open the front door on manual page

Step 8. Ascend the jig bed on manual page

Step 9. Auto frequency tuning

Step 10. Set welding parameters

Step 11. Trial welding in Auto Mode

Step 12. Trial welding to get the best welding parameters for a part

Step 13. Store the parameters (formula)

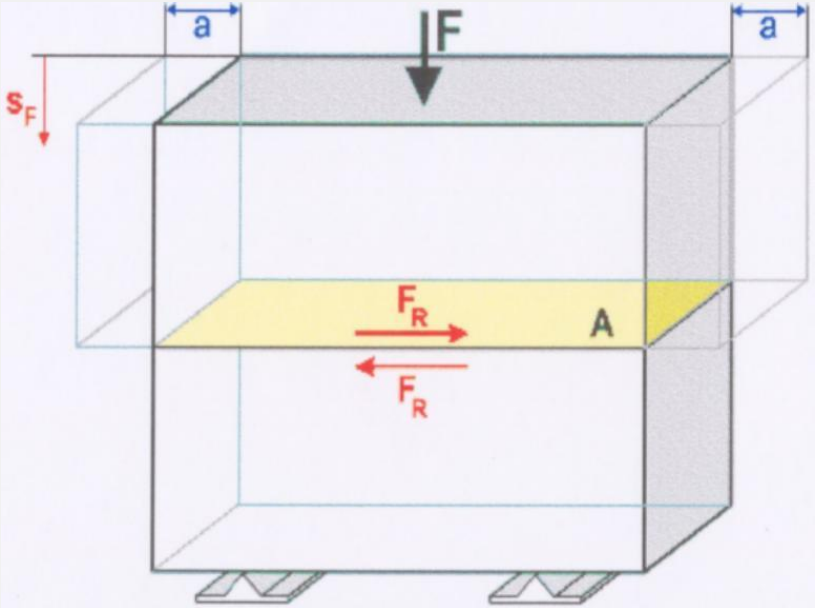
Step 14. Do welding production by the best welding parameters

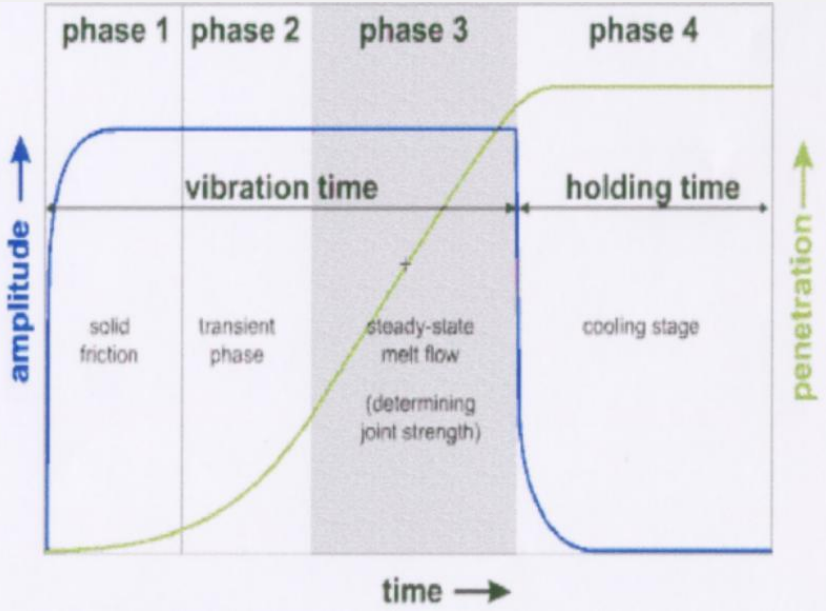
Phase 1. Dry friction: Friction starts to melt material;

Phase 2. Melt generation: molten material begins flashing out;

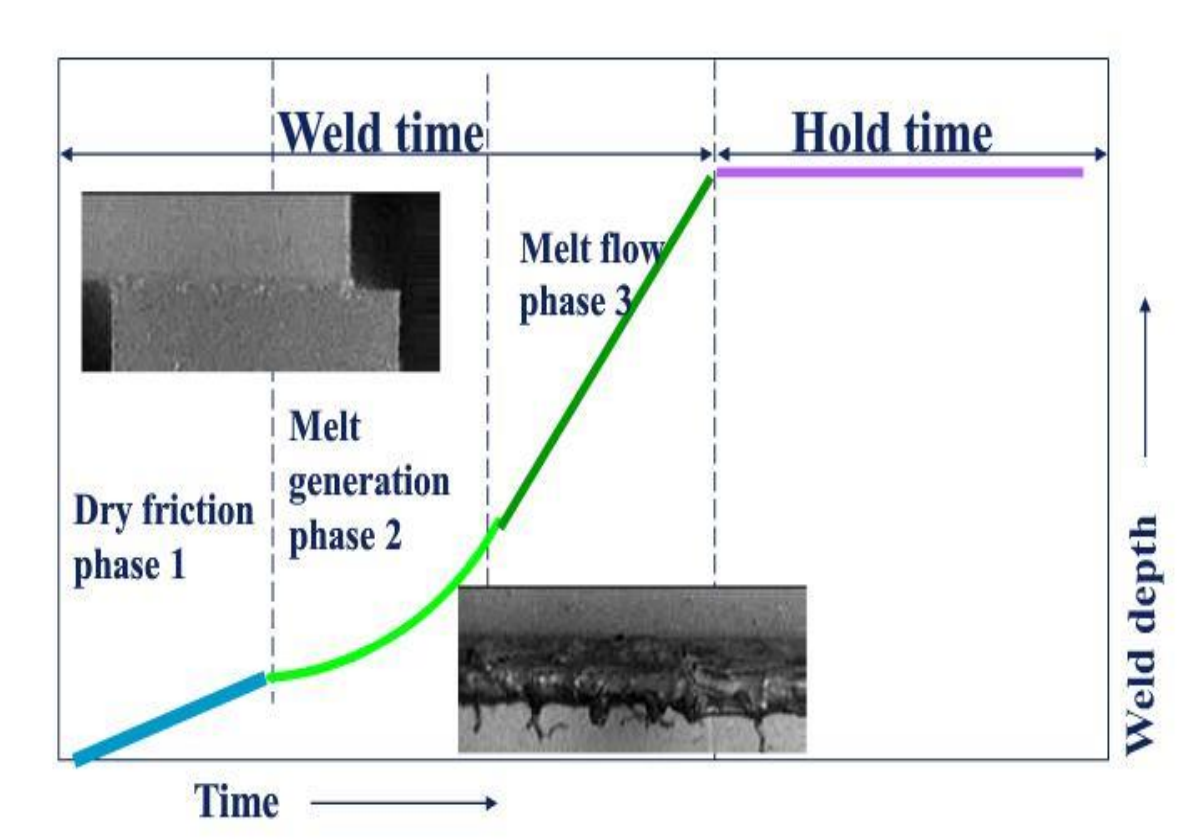
Phase 3. Steady-state Melt Flow: melt quantity is even with flow quantity. It determines the joining strength;

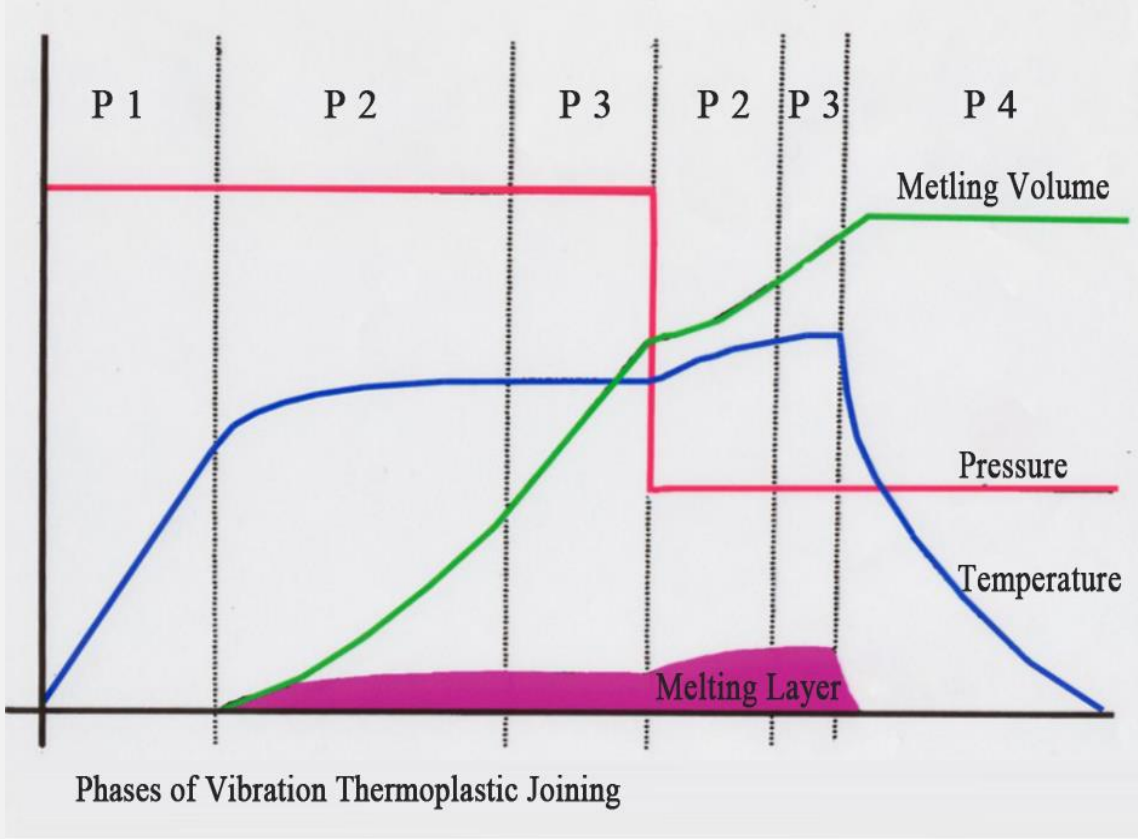
Phase 4. Holding: vibration stop and hold thermoplastic parts keeping they pressed together under high pressure until it become re-solidified at the joining surface.





Phases of Vibration Welding

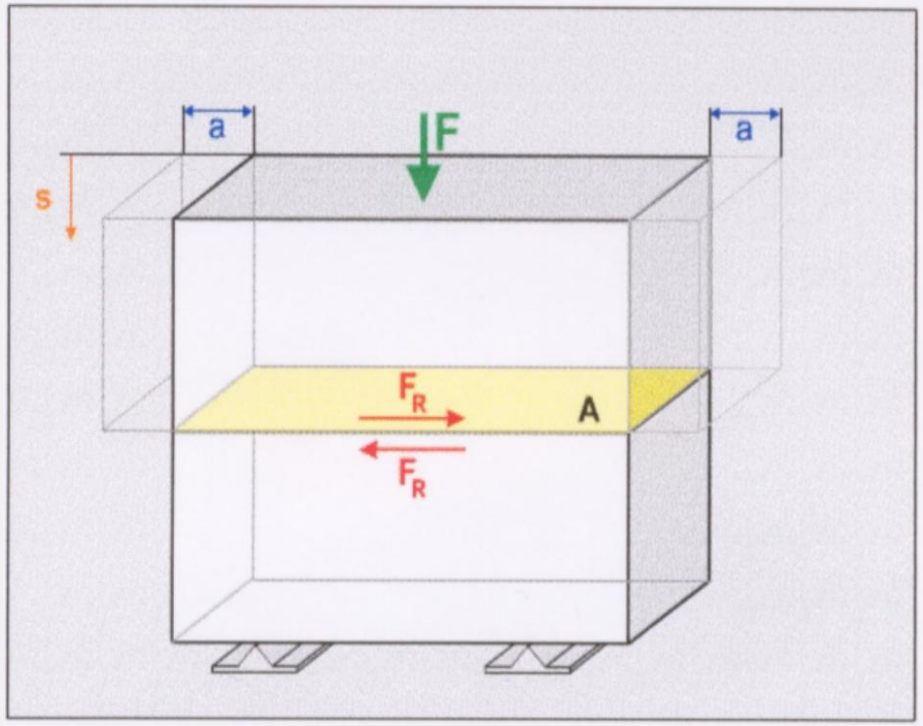




Phases of Vibration Thermoplastic Joining

Liner vibration welding parameters

* E = P(N/㎡)・V(m/min)・T (Sec)・Cosθ
  P : Pressure
  V : Friction Speed
* V = 4.45・a・f
  V : Friction Speed(mm/Sec)
  a : amplitude(mm)
  f : Frequency(Hz)



- Variable Machine Parameters:
  Joining force--F
  Amplitude--A
  Frequency--Fr
  Vibration Time--Tv (Time control)
  Welding Penetration--Ss (Penetration Control)
  Holding Time—Th

- Resulting Process Parameters:
  Joining Pressure--p=F/A (Interface A)
  Friction force--Fr
  Penetration—s resp. welding time tF

To gain a good vibration welding result with scientific operation, physical modelling is essential. To make final decision, it necessary to consider the vibration welding machine parameters and resulting process parameters.

Liner vibration welding operation parameters

* Time: 1. Vibration Time
  2. Holding Time
* Pressure: 1. Vibration Pressure
  2. Holding Pressure
* Vibration Amplitude
* Vibration Frequency
* Welding Depth

Liner vibration welding operation parameters--Amplitude

- it can reduce vibration time if apply higher amplitude, but the time choice points to gain the perfect welding performance will be reduced relatively;
- High amplitude is not good for some material such as PBT,NORYL, etc;
- It requests high amplitude if the vibration direction is along with shorter side of plastic parts;
- Over-high amplitude will result in weak welding strength;
- When melting reach stable, it should reduce amplitude to gain high welding strength.

Liner vibration welding operation parameters--Frequency

Vibration frequency should be set according to material and geometric shape of plastic parts;

- Low frequency (90~120Hz)
  -Amplitude: 2~4mm(P - P)
  -For parts in big size, big length or thin parts;

- High frequency(210~280Hz)
  -Amplitude: 0.6 ~2mm(P-P)
  -It is suitable for welding requests small tolerance and less flash;
  -It can do the welding of different plastic material, and save welding time.

- Super high frequency (300~365Hz)
  -Amplitude: 0.3~1.2mm
  -For challenging welding requirement including clean welding and parts with big bevel angle, limited space for amplitude and challenging material.
  -High precision control, high efficiency, high stability & low consumption.

There is no big effect to welding strength by different frequency.

Liner vibration welding operation parameters—Time & Depth

- Time of vibration;
- Concerned to productive;
- Affect the thickness of melting layer (affect strength);
- It is a time length for X direction and Y direction of vibration surface synchronously reach the highest welding strength;
- Vibration time will be reduced if plastic parts has been added with strengthening material;
- To gain the highest welding strength in the shortest vibration time.

- Welding depth affects welding strength deeply;
- It can judge the welding result according to the depths graphics of the welding chart;
- For welding between two different material, it should set big welding depth.

Liner vibration welding operation parameters--Pressure

Welding pressure is a critical factor affecting welding strength and precision. Mutiple-phases pressure adjustment affects crystalline resin

1) Friction Pressure: the pressure for the beginning of vibration (high pressure);

2) Welding Pressure: the pressure when even condition (1/2 of the friction pressure value). It affect welding strength much;

3) Fusing Pressure: to ensure enough melting layer, it should apply low pressure. High pressure resulting in sharp decreasing of welding strength.

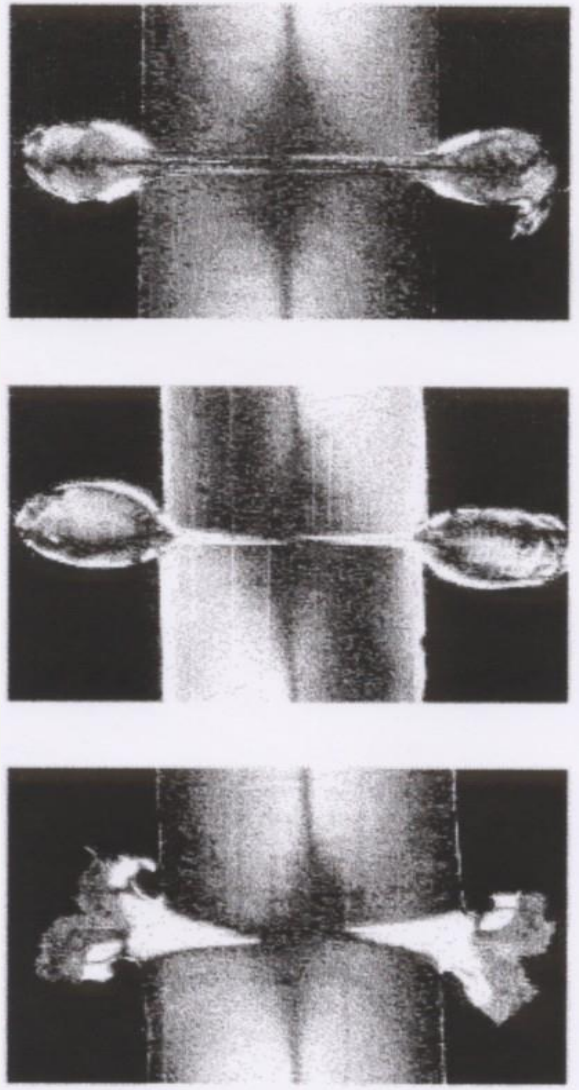
4) If water is consisted in Lynon material, the welding pressure should be higher than the vapor pressure.

5)the wider welding line is, the higher pressure is requested, while, the bigger the welding line height is, the higher the pressure is requested.

* Lower welding pressure: suitable for material in lower melting point;
* High welding pressure: it can reduce welding time, suitable for welding engineering plastic;
* Increase pressure: will generate much flash and reduce welding strength;
* Down adjust pressure in time after melting: can ensure thick melting layer and welding strength (provide enough space for vertical flow direction for material molecule).

Welding pressure for different material & result by different pressure

Material	Pressure (N/mm^2)
ABS	1~2
PA6	0.5~3
PA66	0.5~3
PE-HD	0.5~8
PMMA	1~2
POM	1~4
PP-H	0.5~4
PPE+SB	2~6
PS	1~4
SAN	1~2



- Moisture absorbing material should be dried enough before welding, and it should be welded under high pressure to offset the pressure of water vapor;

- If two different kinds of material welding, the difference of melting points between two machine should be no bigger than 38℃, and the two material molecular structure should be similar;

- Over-deep welding line design will affect melting layer and will increase the time spent in melting & resolidifying.

Factors affecting welding result

1) Construction Design of plastic part

2) Melting Temperature of material

3) Strength of thermoplastic part

4) Characteristics of different material

5) Humidity of thermoplastic material

6) Fluidity of molten thermoplastic material

7) Resin additive to thermoplastic material

1. Available to weld plastic parts in complex geometric shape design;
2. Ability for thermoplastic joining in big measurement which is over than ultrasonic welding ability;
3. High welding strength and airtightness resulted from vibration welding, the welding is reliable;
4. Two or more cavities welding per stroke is available;
5. No request of additional agent for plastic parts welding assembly;
6. No fumes, emissions or consumables generated during vibration thermoplastic weld, no pollution to environment;
7. Perfect welding performance to damped thermoplastic material or that with high percentage of additive;
8. Low power consumption: Only power consumption when vibration oscillation;
9. Short welding cycle time, high operation efficiency;
10. Easy achieve welding phases control, the setting is easy;
11. Vibration welding is available to most thermoplastic material;
12. Low tooling manufacturing cost.

Liner vibration welding operation parameters

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Hot Platen Welding
Long melting time
High power consumption
Melton material sticking on hot platen
Easy case metamorphism to plastic material under high temperature
Pollution cased

Spin Friction Welding
Low machine & tooling cost
Limited by plastic parts geometric design
Difficult in positioning
Can weld only one parts in one welding cycle;

Ultrasonic Welding
short welding cycle time
low cost
Limited in material range
Limited in thermoplastic parts geometric design and measurement

Laser Welding
High cost in equipment
High cost of maintenance
Limit to material
Pollution cased

Stick by Glue or Other Solvent
Long process time
Difficulty in carrying & process
Pollution cased to environment
Requests spent in problem of prescription, space taken up and spar parts, etc.

Factors limit to vibration welding

- Bevel angle at welding surface at vibration oscillation direction, normally can not bigger than 10 degree for traditional VW technique and 45 degree to super-high frequency VW;
- Requests high hardness to holdout the oscillation strength of vibration welding;
- Melting flow impact the welding outlook, and scrap easily generated, especially exist welding result by traditional VW.

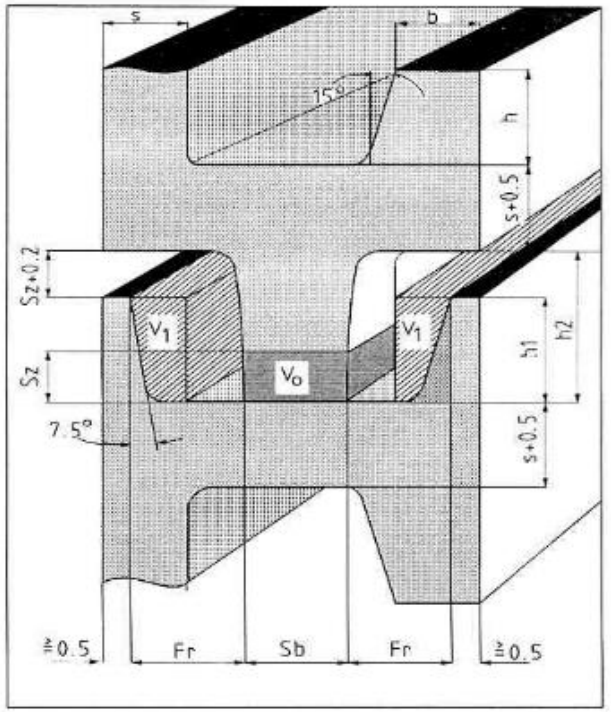
- Measurement of welding line;
- The parts holding design at vibration oscillation direction;
- At least 1/2 width of joining area should be supported by vibration welding fixture;
- At least 0.8mm space for the moving distance of oscillation (120Hz:1.8mm);
- Reinforcement at vibration direction:(0.8mm * 2) + α(above2mm)
  Side: aobve1mm;
  Reinforcement for 120Hz welding : about twice of that for 240Hz welding;
- Space for melting flow: melting volume*20~30%。
- Design angle reinforcement to avoid shake at vibration direction;
- Consider the deformation after molding;
- Ensure that the surface slope at vibration direction no over than 10 degree.

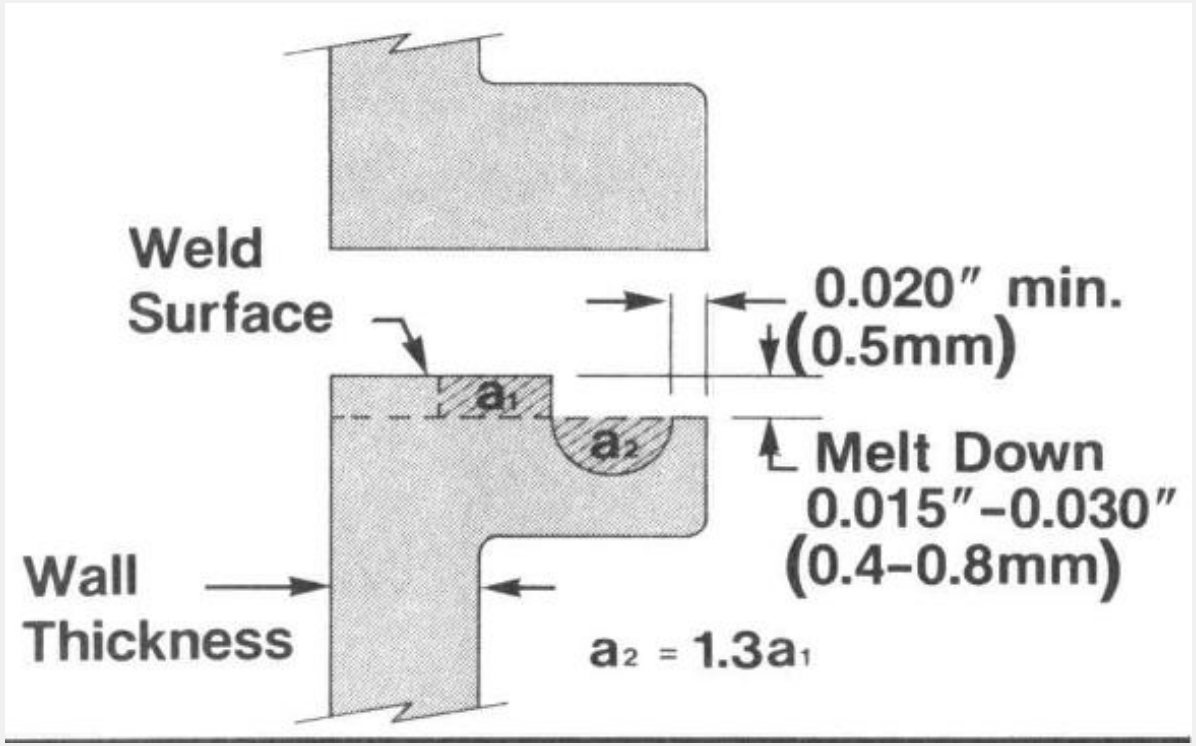
Welding design concept--Construction

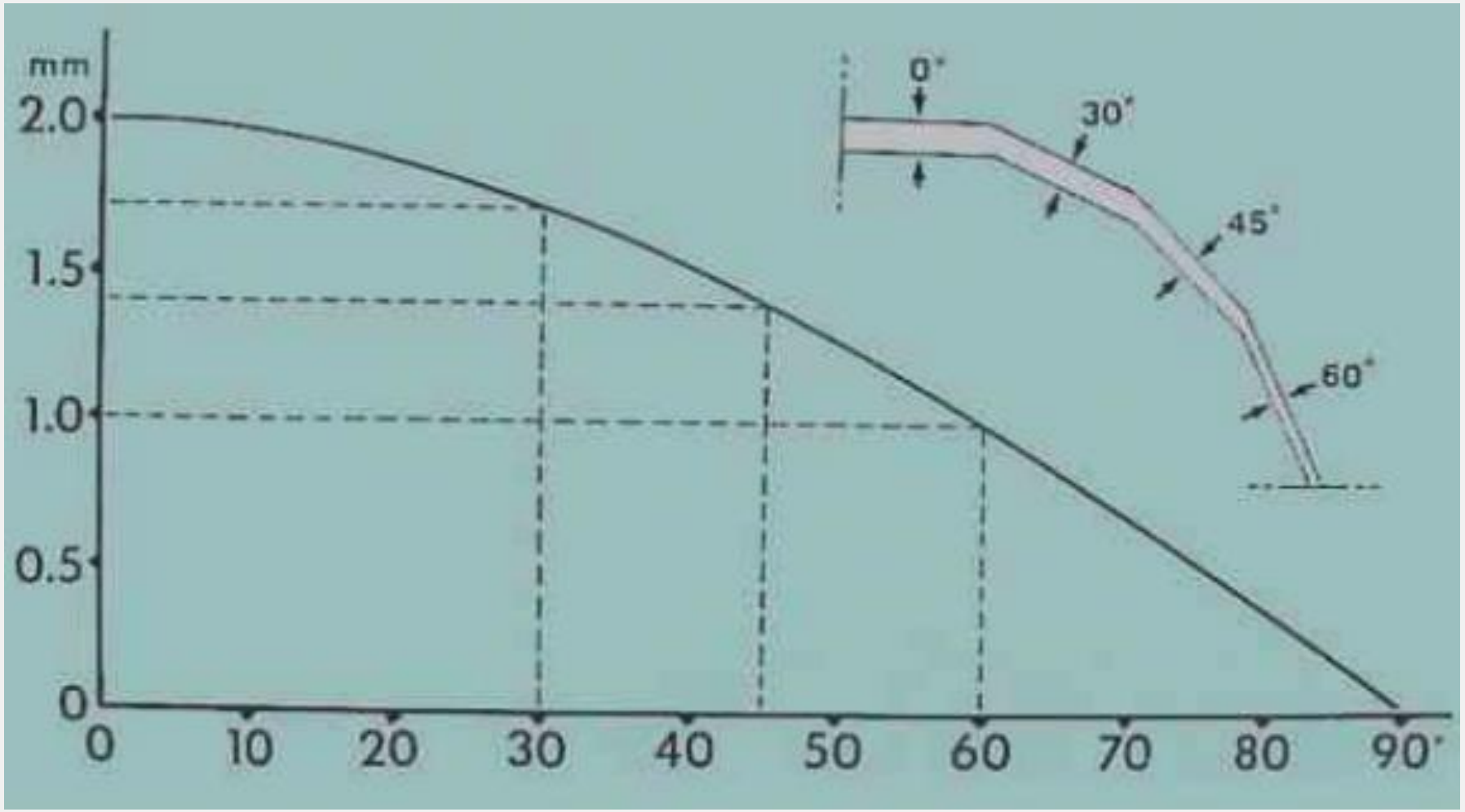
4.2.4 Exemplary design of a modified butt joint in the vibratory direction

This weld joint design is intended to cover up flash and debris by means of appropriate flash traps.

- S = Wall thickness
- S_z = Weld allowance about 0.5 – 1.5 mm
- h = Height of the retaining lugs
- h_1 = Groove depth about 2 mm
- h_2 = $h_1 + S_z + 0.2$ mm
- b = Width of retaining lugs about 1.2 mm
- V_1 = Flash section $\frac{V_o}{2}$
- V_o = Weld section
- Fr = Flash trap = V_1+20%







Amplitude

Bevel Angle

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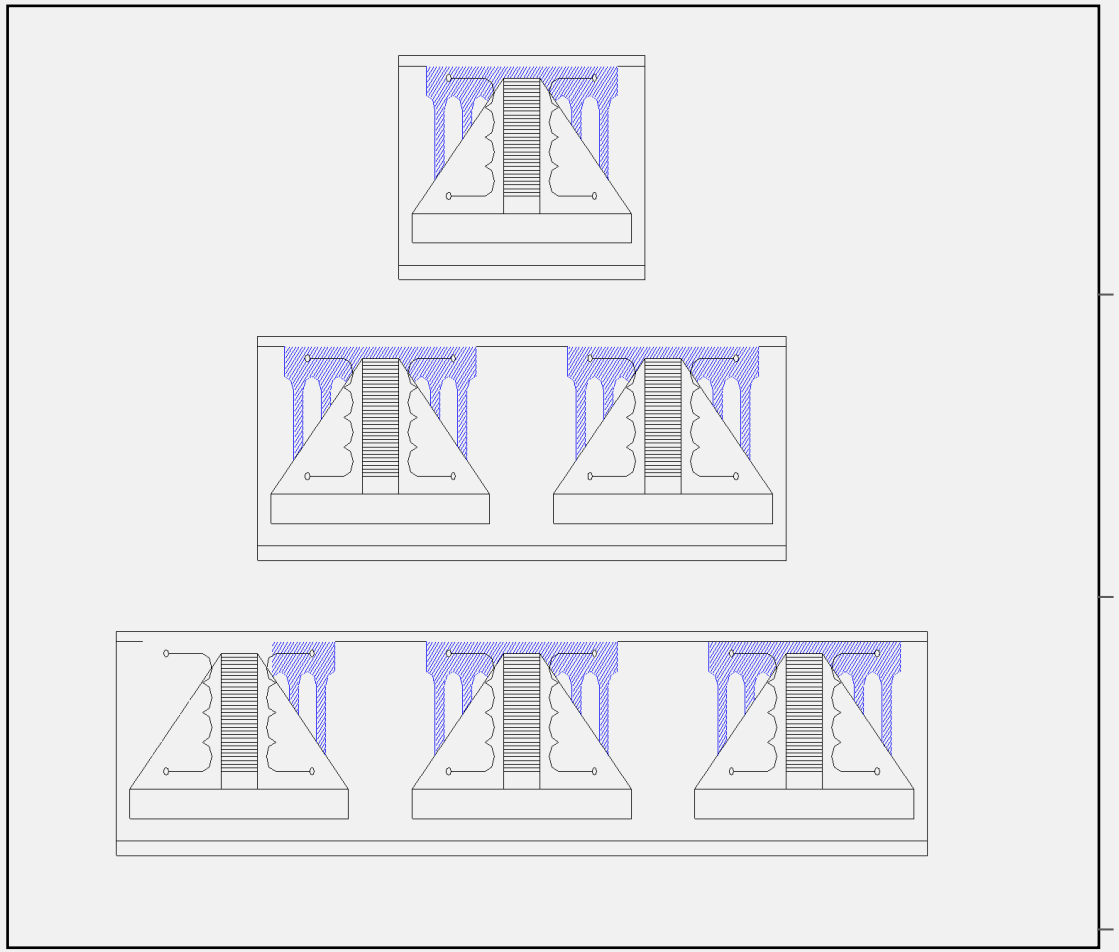
Frequency：90-360 Hz



25 kg. (1) x 25 Kg.	
50 kg. (2) x 25 Kg.	
50 kg. (3) x 25 Kg.	

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Thanks

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