Resistance Spot Welding Gun with Force Amplification

New Potentials for Welding of AHSS with Air-Powered Welding Guns

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Challenges in Spot Welding of AHSS

- large welding forces
- tight weld window
- coatings
- need for higher current
- large impact of part tolerances on process
Mechanical Error Types of Spot Welding Guns

Elastic Error:
- machine deformation

C-Gun: unsymmetric
X-Gun: symmetric

Kinematic Error:
- gun balance

C-Gun: translatory movement
X-Gun: rotatory movement
Combining the Advantages: The XC-Gun

- Symmetric stiffness
- No bending-related tip errors
- Wide opening stroke

C-Type power stroke:
- Translatory motion
- No kinematic contact errors
- Simple concept of gun balance
Power Stroke Drive Mechanism

- Piston cylinder mounted in the rear
- Cam mechanism increases force
- Cam’s transfer function designed for constant force
- Mechanism mounted on roller bearings
Advantages of the Machine Concept

- simple gun balance
- no machine-induced contact errors
- bigger forces possible
- w/o high pressure supply
- less air consumption
- reduction of moved masses
### XC-Gun Prototype Ratings

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clamping Force</strong></td>
<td>8kN / 1800lbf</td>
</tr>
<tr>
<td><strong>Air Supply</strong></td>
<td>6bar / 90psi</td>
</tr>
<tr>
<td><strong>Throat Depth</strong></td>
<td>500mm / 20”</td>
</tr>
<tr>
<td><strong>Opening width</strong></td>
<td>265mm / 10.5”</td>
</tr>
<tr>
<td><strong>Power / Balance Stroke</strong></td>
<td>30mm / 1.2”</td>
</tr>
<tr>
<td><strong>Welding Current (DC)</strong></td>
<td>20kA</td>
</tr>
<tr>
<td><strong>Power Supply</strong></td>
<td>Inverter 10kHz</td>
</tr>
<tr>
<td><strong>Weight (w/o secondary circuit)</strong></td>
<td>145kg / 320lb</td>
</tr>
</tbody>
</table>
Test Rig
Machine Performance: Force Build-Up

- Fast, precise adjustment of force level
- Output $\approx 1.5$ kN/bar ($\approx 23$ lbf/psi)
Machine Performance: Stiffness

higher stiffness than many conventional X-Guns

tip deflection comparable to conventional X-Guns
Welding Example: Normal Weld

Quick force build-up without overshoot or bounce
Outstanding follow-up performance (force error ≈ 4%)
Welding Example: Spatter Behaviour

- Force drop: 0.51 kN
- th. Expansion: 180 μm
- Indentation: 350 μm
- Spatter travel: ≈390 μm

Excellent dynamic response on massive spatter force drop only ≈15%
Outlook

Further, detailed welding experiments
detailed investigations on the follow-up behaviour
cycle time optimization of the pneumatic drive
system
durability tests
identification of weight-reduction potentials
Summary

By means of a cam mechanism, air-powered welding guns can easily provide large welding forces needed for processing of AHSS.

The dynamic performance of the machine is apparently improved by the mechanism.

The XC-Concept is able to eliminate contact errors on the welding spot.
Thank you very much for your kind attention