MECH 573 Mechanics of Robotic Systems

Term Project: The Path Planning of a Six-axis Robot for the Welding of Two Curved Surfaces

Assigned: Tuesday January 5th, 2010 Due: Tuesday April 13th, 2010

Attached is the data sheet of MOTOMAN-EA1400N, a six-axis robot for arc-welding. The robot architecture features an *offset wrist*, which sets it aside from other industrial robots, that bear a decoupled architecture. The latter is characterized by the concurrency of the last three axes at one common point, the centre of the wrist. In this vein, a closed-form solution of the MOTOMAN inverse kinematics is not possible.

The project involves the tasks below:

1. Find the set of postures of the robot at which its Jacobian matrix attains its minimum condition number, the value of this minimum, defined in the Frobenius norm, and the robot characteristic length. To this end, define a frame $\mathcal{F}_1$ fixed to the base, in such a way that its sagittal plane coincides with the Y_1-Z_1 plane of this frame at a given nominal reference posture. Also assume that the tip of the wire-feeder, at which the welding wire is delivered and at which the OP is defined, lies 250 mm below the flange of the end-link, on the axis of its bore.

2. The welding seam is defined as the intersection of the cylinder and the sphere of Fig. 11.4 of the textbook, with $R = 600$ mm, $r = 150$ mm and $d = 300$ mm. Decide on a convenient posture of the robot with respect to the seam, discussing the criteria on which you base your decision.

3. Define the pose of the end-effector at an arbitrary point of the seam such that the axis of the end-link bore lies on the binormal to the seam and the plane of the midcurve of the feeder coincides with the *normal plane* to the seam[1].

4. Produce plots of the six joint angles as functions of the arc length s along the seam. Use of Algorithm 11.5.2 is strongly recommended for this task.

5. Compute the maximum welding speed that the robot can produce in light of the maximum speeds of its motors.

The **Progress Report** should address item 1 above, the **Final Report** the remaining four items.

[1]Three planes are defined by the Frenet-Serret axes: the *normal plane*, perpendicular to the *tangent vector*; the *rectifying plane*, perpendicular to the *normal vector*; and the *osculating plane*, perpendicular to the *binormal vector*.

MOTOMAN-EA1400N

Integrated welding bundle

Benefits

- Increased cable durability
- Interference with peripheral jigs reduced
- Offline programming simplified

Compact wire feeder mount

Benefits

- Space saving design – high density welding layout possible
- Wire feeding trouble reduced
- Robot performance enhanced

In-line torch mount

Benefits

- Accessibility improved in difficult welding situations
- Circumferential welding simplified

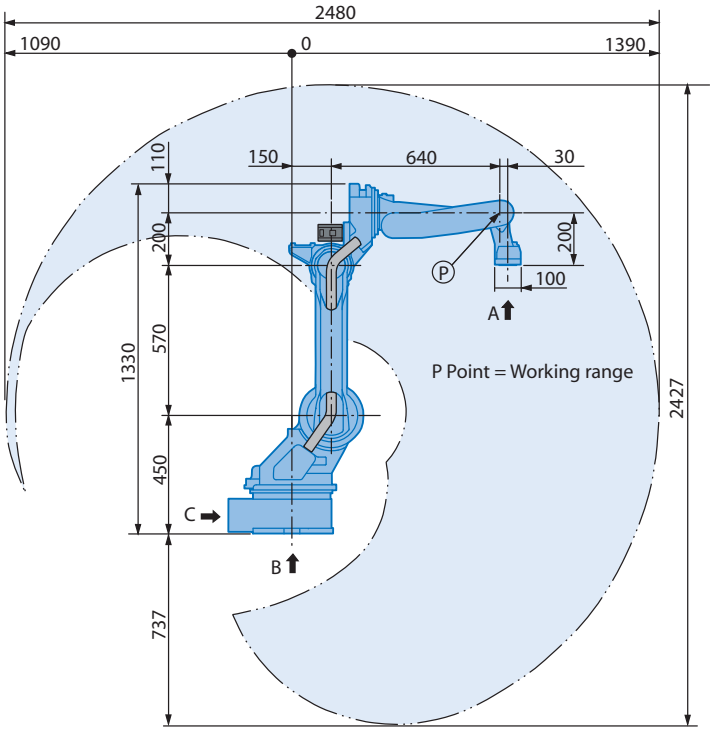
Application

Arc welding

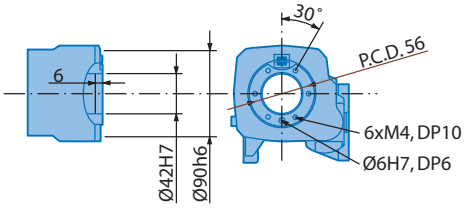
The EA1400N dedicated arc welding robot

The MOTOMAN-EA1400N is a robot dedicated for arc welding applications. The welding cable is integrated in the robot arm, which increases the cable durability and reduces potential interference with peripheral equipment. In addition, this feature also provides opportunities for production lines with high density layouts.

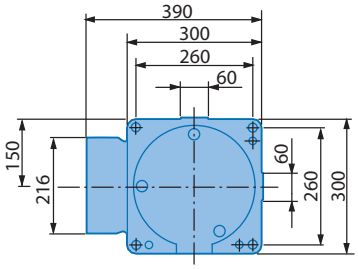
The welding torch is mounted in-line with the turning axis, which increases accessibility and improves performance when welding circumferentially. The position of the wire feeder combined with a short welding cable are important features for creating an overall compact build and trouble-free wire feeding.



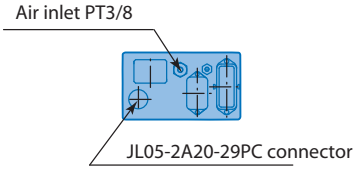
View A

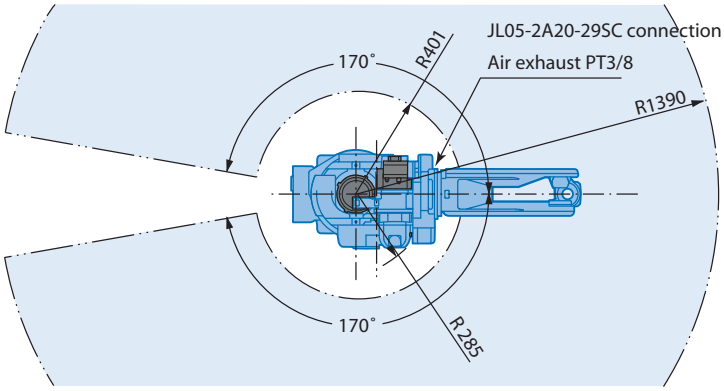


View B

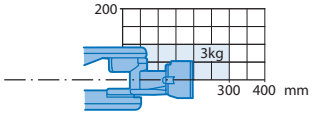


View C





Maximum payload



Note

These dimensions are for reference only.
Please request detail drawings for all design or engineering requirements.

Technical Specification for MOTOMAN-EA1400N

Robot type	Vertically articulated robot	Axis	Range of motion	Maximum speed
Controlled axis	6	S	±170°	150°/s
Payload	3 kg	L	+155°, -90°	160°/s
Repetability	±0.08 mm	U	+190°, -175°	170°/s
Weight	130 kg	R	±150°	340°/s
Power requirements	1.5 kVA	B	+180°, -45°	340°/s
Mounting positions	floor, wall and ceiling	T	±200°	520°/s