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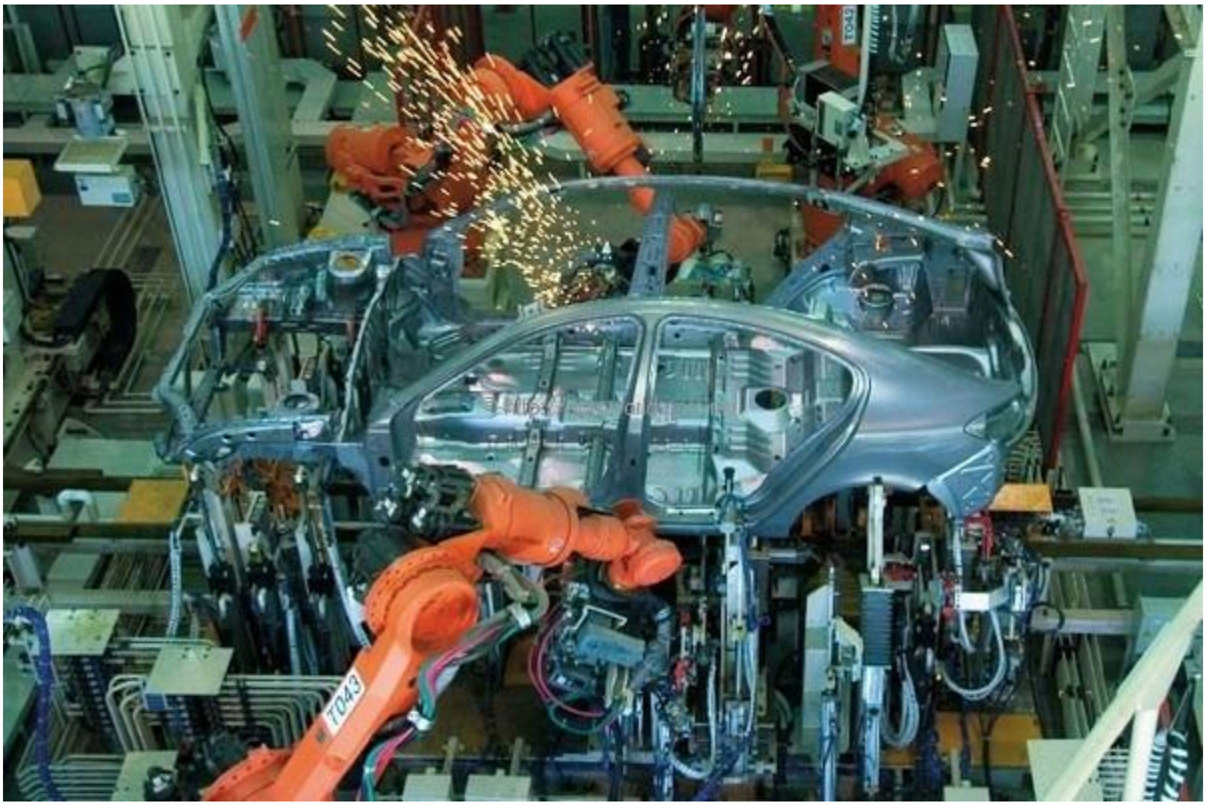

Automotive Industrial Robot - Selection Criteria for Body Assembly Application

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In automotive manufacturing processes especially at Body Shop, industrial robots are widely used to increase productivity while maintaining desired quality standard and design specification in production line. The application are mainly on welding (spot / arc welding), sealant / adhesive application and material handling. Therefore, the selection of the robot types and brand are crucial in order to get best fit to the application at minimum cost.

Depending on area of application to the automotive body structure, generally, there are 2 types of industrial robots - shelf and floor mounted types. The practical way in robot selection method is by determining the robot specification that meeting process specification and requirement, then, cost evaluation is done by using Total Cost of Ownership (TCO) method [1]. The following table shows the comparison of robot specifications, initial and operational cost for different robot's makers which gives general ideas on what to be taken into account during robot selection processes.

Brand		ABB	KUKA	Yaskawa
Picture				
Basic Specification	Model	IRB 6700 – 235	KR 210 R2700	MS 210
	Payload (Max)	235 kg	210 kg	210 kg
	Type	Floor mounted	Floor mounted	Floor mounted
	Controller	IRC 5	KR C2 Edition 2005	DX 200
	Power Supply	7.7 kVA	7.3 kVA	5.0 kVA
	Repeatability	± 0.06 mm	± 0.06 mm	± 0.2 mm
	Payload diagram, max COG range (Z-direction)	500mm	600mm	600mm
	Axis max speed, °/sec	126.7 (Avg)	108.0 (Avg)	140.3 (Avg)
	MTBF (Manufacturer claim)	40,000 hours	40,000 hours	36,000 hours
Initial Cost	Robot, Controller & Accessories	RM 124,367	RM 139,689	(Total 1 set)
	Dress Pack	RM 4,295 (3rd party - Leoni)	RM 4,295 (3rd party - Leoni)	↓
	Total, RM / unit	RM 128,662	RM 143,984	RM 155,000
Operation Cost	Power consumption, RM/unit/day (1 shift)	RM 6.06	RM 5.95	RM 5.72
	Spare part (ABB as reference), %	-	16.6% lower than ABB (Avg)	19.9% lower than ABB (Avg)
	Maintenance (Actual), RM / Unit / Year	RM 3,200	-	RM 725
	Downtime Cost (Actual), RM / Unit / Year	RM 8,780 (IRB 6640)	-	RM 1,718.75 (ES 200N)

Figure 1. Robot Specification Comparison

The robot's specifications as stated on the table are suitable for spot welding and material handling applications. First thing to consider is process requirement on position's accuracy. Process position's accuracy (tolerance) has to be matched with robot's repeatability. Then, other specifications such as maximum robot's payload and 'reach work space' to be considered during robot's selection process.

There are some robot's specifications that are usually neglected but quite important especially when it comes into productivity and cost effective point of view. For example, for better productivity, faster robot axis speed is required to complete the process. The following tables shows the comparison of maximum robot axis speed for 3 different robot makers.

	Brand	Yaskawa	ABB	KUKA
	Picture			
Max Axis Speed, °/sec	Axis 1	120	100	86
	Axis 2	97	90	84
	Axis 3	115	90	84
	Axis 4	145	170	100
	Axis 5	145	120	110
	Axis 6	220	190	184
	Average	140.3	126.7	108.0

Figure 2. Robot Axis Speed Comparison

For cost effective point of view, maximum center of gravity (COG) range in robot payload diagram also quite important. The following table shows the comparison of robot payload diagram for 3 different robot makers.

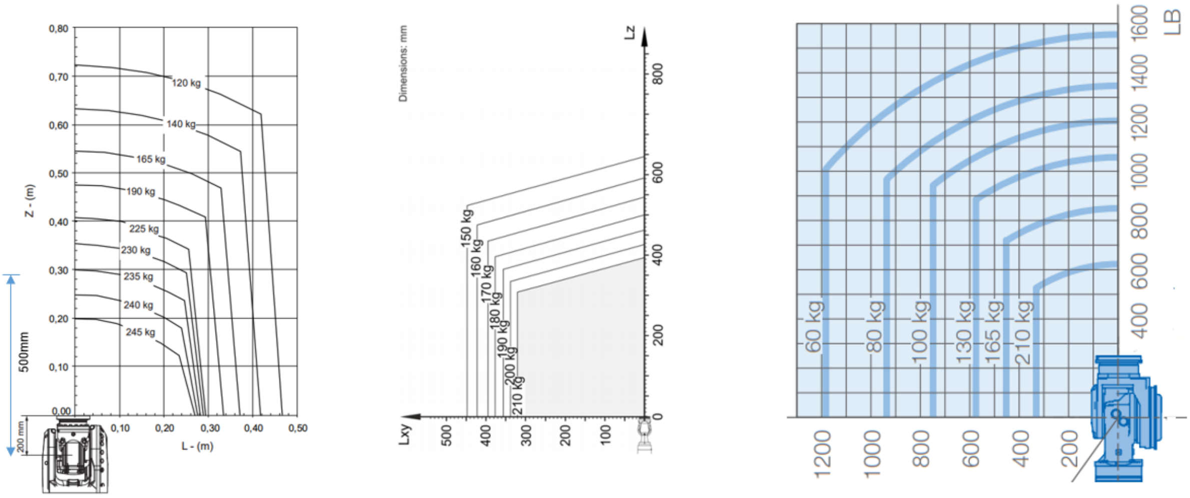

ABB – IRB 6700 -235/2.65
*Effective range – 500mm on Z direction

KUKA – KR 210
*Effective range – 600mm on Z direction

Motoman – MS 210
*Effective range – 600mm on Z direction

Figure 3. Robot Payload Diagram Comparison

Farther the effective range of allowable maximum payload in robot payload diagram, better the tool's design flexibility and cheaper the tool's material cost. For example, if the designed tool's weight exceed allowable effective range in robot payload diagram, there are 2 options available for designer, either to select higher robot payload spec or to use lightweight material for tool's fabrication. Both options may increase the robot initial or purchase cost [2].

Estimating the operational cost of a robot is quite difficult but possible and usually neglected during robot selection processes. Other than robot mean time between failure (MTBF) value and spare part cost, robot power consumption during operation also can be estimated. The following tables shows the estimated robot power consumption comparison for 3 different robot makers.

Robot Power Consumption	Max Rating/ Capacity, kVA	Rated Capacity, kW		
		Playback (Robot Moving)	Servo On (Robot Standby)	Servo Off (Power for Control)
Yaskawa	5.0	1.97	1.09	0.28
ABB	7.7	2.7	0.71	0.16
KUKA	7.3	2.5	0.7	0.22

*Power consumption data taken from robot's specification for each brand

Robot	Working Day	Working hours	Idle Hours		Movement type			Shift	Working Cost, RM/robot/day	Idle Cost, RM/robot/day	Total Cost, RM/robot/day	Total Cost, RM/robot/month
			Day	Night	Playback	Standby (Servo On)	Standby (Servo Off)					
ABB	22	8	4	12	60%	40%	0%	1	RM5.41	RM0.65	RM6.06	RM133.21
Yaskawa	22	8	4	12	60%	40%	0%	1	RM4.59	RM1.13	RM5.72	RM125.78
KUKA	22	8	4	12	60%	40%	0%	1	RM5.06	RM0.89	RM5.95	RM130.81

*Utilities cost (electricity) is calculated based on 1 shift (day) operation
*Movement type details:
- Playback – Robot move to spot point location / position
- Standby (Servo On) – Robot's position on hold, welding gun perform spot welding operation or at home position
- Standby (Servo Off) – Robot idle, no activities (after working hours)

Figure 4. Robot Operational Cost Comparison

In conclusion, it is easier to select robot that suit to the process requirement. But, when considering productivity and cost effectiveness, a lot of elements need to be considered during robot selection processes. It is recommended to evaluate robot total cost of ownership (TCO) before finalizing robot selection to get clear picture of overall cost that need to be spent in robotic production line.

References

1. https://en.wikipedia.org/wiki/Total_cost_of_ownership.
2. https://blog.robotiq.com/bid/70408/How-to-Choosethe-Right-Industrial-Robot.

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