



Allen-Bradley

On-Machine™ — On the Cutting Edge of Automation

Mission — Save Money with On-Machine™ Solutions.

*This paper examines the scope of
On-Machine™ solutions, outlines the key
benefits of this growing trend and highlights
examples where a distributed, On-Machine
architecture has been successful.*



Introduction

With the current squeeze on capital investments, companies are searching for ways to lower the cost of installing and maintaining automation systems. As a means to this end, they're finding that moving industrial controls and hardware closer to the application or directly onto the machine saves considerable time and money. This paper examines the scope of On-Machine™ solutions, outlines the key benefits of this growing trend and highlights examples where a distributed, On-Machine architecture has been successful.

Imagine this scenario. You're at work, in your office or cubicle, and instead of having your computer tower nuzzled under the desk, it's located 100 feet away in a room with dozens of others. A bundle of cables snakes from your monitor, mouse, and keyboard to the "computer room". In fact, a majority of the floor is covered with wires coming from or going to various workstations. Plus if you need a file off a floppy disk, want to burn a CD or have to troubleshoot a faulty keyboard, you make a trek to the room.

While this seems far-fetched today, it's similar to the setup many businesses employed during the mainframe era of computers — one massive, powerful machine with many tentacles. However, as technology advanced and prices dropped, the move to a distributed architecture, where a personal computer and its peripherals are together, made sense on several levels. It's a more flexible, cost-effective approach.

However when you step out of the office and on to the plant floor, you're transported back to the mainframe age. For decades, OEMs and end users have kept controllers and other automation hardware — drives, motor starters, etc. — in centralized cabinets. This equipment was connected to individual machines via lengthy runs of hard wire or, more recently, digital networks like DeviceNet™.

On-Machine Defined

On-Machine control is the placement of a new breed of automation components directly on a machine rather than housing them in a remote, central cabinet. While seemingly clear-cut, it's hardly an all-or-nothing concept. Some control components have always been located on the machine, but what's changing is the number of components moving from the panel closer to the point of application. Several factors are contributing to this trend, including the emergence of more modular, compact devices, plug-and-play connectivity, flexible communication networks, intelligent devices and a wide array of products with improved environmental ratings. (Figures 4, 5 and 6) On-Machine components can include everything from programmable controllers, motor starters, drives, sensors, contactors, network media, distribution boxes and I/O, as well as HMI devices.

Though the product categories are growing, the availability of these types of distributed On-Machine components are still somewhat limited. As the benefits of these solutions are more widely realized, the industrial sector will begin to see broader and more extensive hardware adaptations. Ultimately, some companies will evolve to an architecture where all components are placed on the machine without enclosures.

Many of today's control systems are becoming more integrated, meaning control functions — discrete, linear, process and motion — are combined into a single backplane. At the same time, the design of On-Machine products permits control devices to be distributed across a machine or process. While this may seem like a conflict, there are not many end users or OEMs who rely exclusively on one type of control deployment. They're using an optimized balance of both techniques.

To some extent, it may seem like some On-Machine control systems are more complex because they're fragmented and assigned to a variety of individual functions. But with the strength of today's plug-and-play products, as well as programming and networking tools, engineers can efficiently break up a control system over a variety of machine sections. As a result, it doesn't matter whether control functionality is centralized or distributed throughout the application.

On-Machine Benefits

Manufacturers and OEM machine builders need every competitive advantage they can find to implement flexible, high-performance production lines. On-Machine solutions provide reduced wiring and system costs, improved Mean Time to Repair (MTTR), enhanced control system reliability, increased productivity and greater flexibility. They accomplish this in a variety of ways, as discussed below.

Traditionally, engineers have built machines and control cabinets as separate units, which required massive amounts of wiring and manpower to interconnect the two. By using pre-tested wiring assemblies and placing automation equipment on the machine, OEMs and end users can reduce installation time. A recent study by a consortium of European manufacturers and machine tool technology groups concluded that On-Machine assembly costs are up to 30 percent less than conventional methods¹. This helps reduce both costs and time-to-market, making these OEM manufacturers extremely competitive.

¹ Installation Technology in Machine Tools (Distributed and Standardised Installation Technology (DESINA) working group). Available: www.desina.de.

Startup and commissioning time also are critical, and On-Machine solutions can reduce both considerably. Due to the modularity and simplified connectivity of components, On-Machine designs allow OEMs to more cost-efficiently build a machine at their site, pre-test it and then disassemble it for transport to an end user's plant. In fact, the installation process, in some cases is so simple less technical people can be utilized. Equally important for end users is the flexibility of being able to relocate equipment and make additions with relative ease. All of these reasons have proven to reduce overall cost and the number of breakdowns due to installation methodology.

In addition, On-Machine architectures eliminate the need for maintenance technicians and operators to access a control panel every time they have to check a connection or make an adjustment. This is not only a relief for plant floor personnel, but also a significant timesaver. End users can efficiently isolate problems and replace a starter or I/O locally, rather than sorting through a complex panel (which also may be a safety hazard). The result is significantly easier troubleshooting and shorter MTTR.

On-Machine solutions can minimize wiring errors as well because wiring is pre-manufactured with quick-disconnect features. And less wiring is involved, which means fewer points of failure. The decrease in errors associated with On-Machine wiring leads to an increase in the overall reliability of the control system. In the end, this helps boost a plant's productivity.

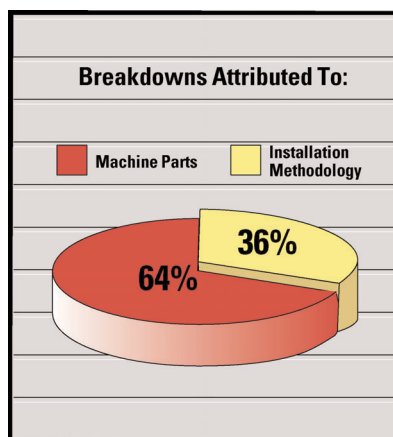


Figure 1 As this pie chart shows, a substantial amount of breakdowns and downtime in general is attributed to installation methodology, which can be reduced by utilizing the simplified On-Machine approach ².

² Installation Technology in Machine Tools (Distributed and Standardised Installation Technology (DESINA) working group). Available: www.desina.de.

The On-Machine approach also allows OEMs to provide standard product offerings once considered to be custom applications. In the material handling industry, for example, conveyors once sold as large customized systems can now be sold in standard ten-foot sections. This allows for reduced OEM engineering, quicker delivery times and increased flexibility for the end user.

Finally, there's the issue of maximizing available space. Control cabinets can occupy a substantial amount of the production floor, and an On-Machine approach frees that real estate, allowing companies to leverage more of their facility. This is particularly important in industries like semiconductor and pharmaceutical manufacturing which have seen the benefits for years, due to clean-room space being at a premium.

Justifying On-Machine Applications

Understanding the value of On-Machine architectures requires an acknowledgement that the cost for control hardware will most likely increase, because sealed devices, essential in rugged applications like automotive assembly, are more expensive than unsealed devices. Even so, the savings in designing, building, testing, and installing the machine offset this additional cost and, in most cases, lower the total system cost. In fact, the DESINA study stated that the overall cost of an On-Machine solution can be 17 percent less than systems built with standard, centralized control.

The way machine builders perceive this benefit, however, depends on how they calculate and weigh hardware and labor costs. For example, some companies base purchasing decisions largely on component costs. As a result, the labor savings is not part of the purchasing equation — although it does impact the bottom line. So the shift to On-Machine solutions will also require a shift in how companies calculate cost. More than anything, it will be an educational process.

Another challenge is manufacturers' natural resistance to change, especially in critical applications. When end users have a solution that's working effectively, they see no reason to experiment with a new concept. Until they have solid documentation and a cadre of proven benefits, there will be hesitation. In the automation world, the turning point for any trend is when the early adopters (usually OEMs) start saving money. Other companies then begin to gravitate to the new approach en masse. On-Machine solutions have not yet reached this point. As On-Machine benefits are well documented, end users will start pulling for these solutions, rather than being pushed by OEMs.

On-Machine Applied — AEC

Of course, the best way to document the benefits of any strategy is through real-world examples. And AEC, the industry leader in producing plastics manufacturing equipment, is a poster child for the benefits of an On-Machine architecture. The company's most recent innovation in conveying and control systems is an On-Machine design using IP67 [see sidebar] machine-mounted I/O blocks — Allen-Bradley® ArmorBlock MaXum™ I/O (Figure 2) — and DeviceNet networks. "By developing an alternative to our traditional, chassis-based I/O, we have been able to reduce the installation time of our conveying systems by more than 50 percent," said Ron Newlun, engineering manager for AEC.

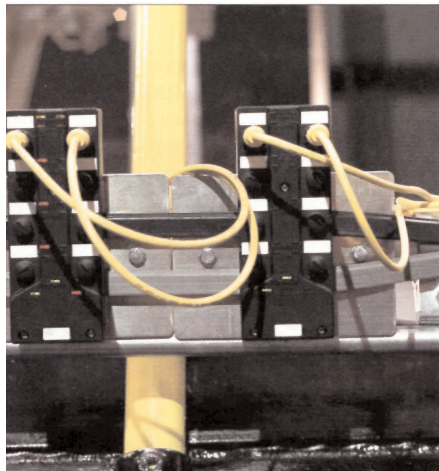


Figure 2

AEC's On-Machine™ design leverages Allen-Bradley® ArmorBlock MaXum™ I/O, which snaps onto DeviceNet™ KwikLink™ flat media and mounts directly on the vacuum line. With ArmorBlock MaXum I/O, the system requires no conduit, mechanical support structures or protective enclosures.

While reduced installation time is a key benefit for users, AEC also calculates the Total Cost of Ownership (TCO) of any new control solution. This takes into account acquisition, installation, long-term maintenance and system expansion costs. "While we have an excellent chassis-based I/O solution with a lower initial acquisition cost, our new distributed I/O solution ends up having a significantly lower TCO for mid-sized to large systems with plans of expansion," Newlun said.

For example, the AEC Vactrac™ vacuum material handling system distributes plastic pellets from large storage bins at an injection molding or extrusion plant to hoppers mounted above each press. Each hopper is now connected to a single Allen-Bradley SLC 5/04™ controller by a DeviceNet KwikLink™ flat media network cable and power trunk. ArmorBlock MaXum I/O snaps onto the flat media and mounts onto a bracket that is fastened directly onto the facility's pre-existing vacuum line. Because of this, the system requires no conduit or mechanical support structure and the I/O does not need protective enclosures.

“One of the most convenient features of the ArmorBlock MaXum I/O blocks is that they connect to the DeviceNet network by simply piercing the flat cable with their insulation displacement connectors,” said Nick Mercorella, Plant Engineer at Continental P.E.T. Technologies Inc., an AEC customer. “We were able to install our entire system without ever screwing a wire down, thus eliminating any potential miswiring and the system debugging costs associated with such problems.”

Since the basic application requirements of a hopper or a pump typically consist of just two inputs and two outputs, there is ample room on the I/O block for the many options that AEC has pre-engineered into the I/O system. Adding a filter cleaner to a hopper, for instance, is as simple as connecting a 12mm quick-disconnect cable to the connector on the block, and then enabling the option on the Allen-Bradley PanelView™ terminal. In the same vein, it is just as simple to add a remote proportioning valve which is used to efficiently integrate unused material with re-grind material for that particular hopper. “It is true plug and play, which is exactly what we need,” Mercorella said.

On-Machine Conclusion

The ideal On-Machine solution is an integrated-yet-distributed environment that allows different components of the system to be easily assembled and snapped in place with simple, reliable techniques. This requires forward-thinking product development strategies on how these methods can be accomplished in both standard and rugged environments. It also requires assuring some level of consistency in terms of mounting styles, dimensions and connection specifications.

The migration to the On-Machine approach, like most industrial innovations, will be driven by economics. In this regard, On-Machine solutions are largely an outgrowth of companies better understanding their true assembly and installation costs. OEMs and end users will see different cost advantages depending on their particular industry and equipment environment. Nonetheless, the ability of On-Machine solutions to reduce wiring and system costs, improve MTTR, enhance control system reliability, increase productivity and promote flexibility cannot be ignored.

From a hardware and software perspective, the evolution to On-Machine solutions is a matter of balance. Suppliers need to offer a range of On-Machine and in-panel equipment because most manufacturers have a need for both — now and in the foreseeable future. As new On-Machine control products emerge and companies become more comfortable with this concept, On-Machine solutions will be a common strategy for reducing costs and increasing reliability of both OEM and end user control systems.

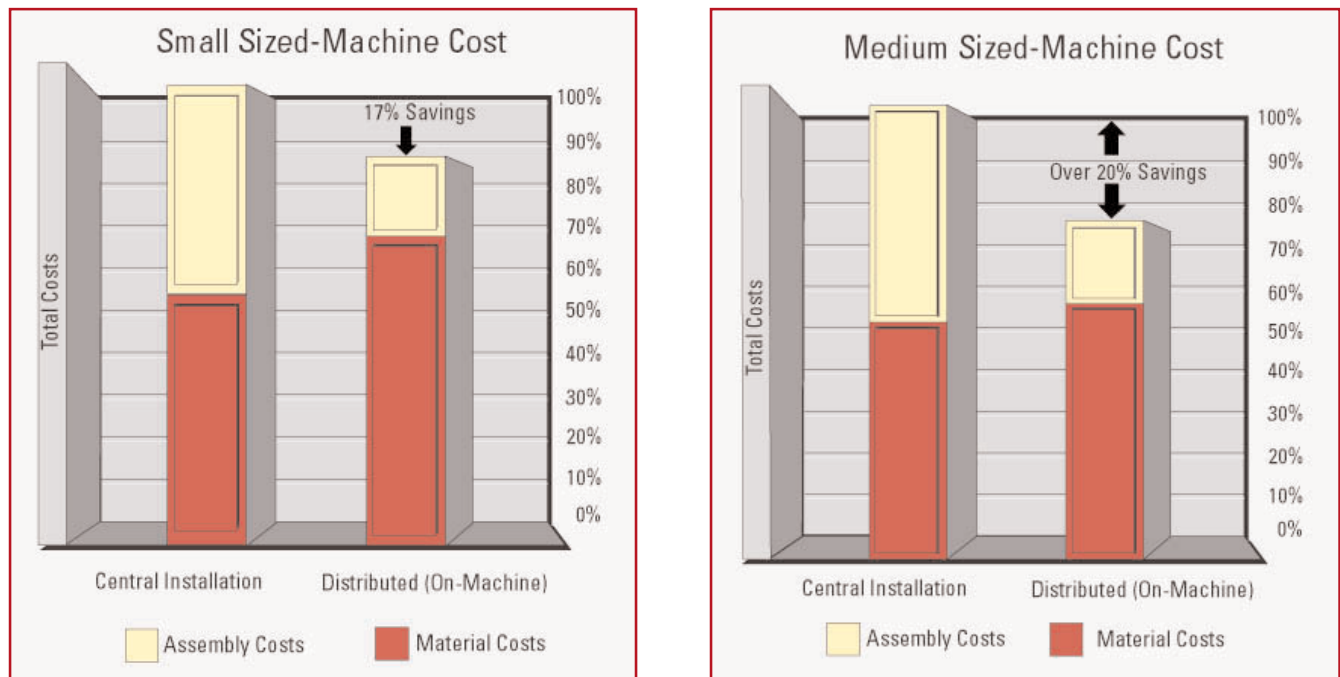


Figure 3

Although the cost of individual components used in On-Machine solutions can be more than those used in In-Cabinet applications, the savings in assembly and material costs of wire and cabinetry make the overall cost of the machine less.

Will that be an IP20 or IP67?

As automation equipment migrates from centralized cabinets to the machine, OEMs and end users have to pay closer attention to environmental hazards — splashing liquids, corrosive agents, etc. This is especially true in On-Machine applications where components are not in any sort of enclosure. However, finding the appropriate hardware for an application can be confusing.

To ensure a suitable match, most companies rely on two key rating systems: Ingress Protection (IP), a globally recognized standard defined by the International Electrotechnical Commission (IEC), and a U.S.-based system created by the National Electrical Manufacturers Association (NEMA). IPC IP and NEMA ratings, given to products after they are run through a battery of tests, are used to specify the environmental protection of enclosures around electronic equipment.

The following figures explain both rating systems in detail. Figure 4 is an overview of the IP classifications. Figure 5 details the NEMA enclosure ratings. And Figure 6 provides a comparison between the two.

In addition to the IP and NEMA marks, companies must also consider washdown (calculated in pounds per square inch (PSI)) and weld field immunity requirements when specifying equipment. Further, various chemical and other environmental conditions may not be reflected in standard testing.

On-Machine is a trademark of Rockwell Automation, Inc.

Figure 4

IP Enclosure Ratings	
The Degree of Protection is indicated by two letters (IP) and two numerals (see Example below). International Standard IEC 529 contains descriptions and associated test requirements that define the degree of protection each numeral specifies. The following table indicates the general Degree of Protection.	
First Numeral ¹	Second Numeral ¹
Protection of persons against access to hazardous parts and protection against penetration of solid foreign objects	Protection against ingress of water under test conditions specified in IEC 529
0 Nonprotected	0 Nonprotected
1 Back of hand; objects greater than 50mm in diameter	1 Vertically falling drops of water
2 Finger; objects greater than 12.5mm in diameter	2 Vertically falling drops of water with enclosure tilted 15 degrees
3 Tools or objects greater than 2.5mm in diameter	3 Spraying water
4 Tools or objects greater than 1.0mm in diameter	4 Splashing water
5 Dust-protected (dust may enter during specified test but must not interfere with operation of the equipment or impair safety)	5 Water jet
6 Dusttight (no dust observable inside enclosure at end of test)	7 Powerful water jets
	8 Continuous submersion
Example: IP64 describes an enclosure that is designed to protect against the entry of tools or objects greater than 1mm in diameter and to protect against vertically dripping water under specified test conditions. Note: All first numerals and second numerals up to and including characteristic numeral 6, imply compliance also with the requirements for all lower characteristic numerals in their respective series (first or second). Second numerals 7 and 8 do not imply suitability for exposure to water jets (second characteristic numeral 5 or 6) unless dual coded, e.g., IP_5IP_7. ¹ The IEC standard permits use of certain supplementary letters with the characteristic numerals. If such letters are used, refer to IEC 529 for the explanation.	

Figure 6

IP/NEMA Comparison	
IP	NEMA
10	1
11	2
14	3R
30	1
31	2
32	3R
52	5
52	12 & 12K3
54	3S
54	13
54	4 & 4X
56	3
64	12, 12K and 13
65	4 and 4X
66	6 & 6P
67	

This chart shows the relative comparisons between the IP and NEMA ratings. Some of the testing for the individual ratings are different, so to secure the rating in each organization, full testing must be done.

Figure 5

NEMA Indoor Rating	
Environmental Conditions	Enclosure Type
	1* 2* 4 4X 5 6 6P 7 9 12 12K 13
Incidental contact with the enclosure equipment	X X X X X X X X X X X X
Falling dirt	X X X X X X X X X X X X
Falling liquids and light splashing	X X X X X X X X X X X X
Circulating airborne dust, lint, fibers, and flying**	X X X X X X X X X X X X
Settling airborne dust, lint, fibers, and flying**	X X X X X X X X X X X X
Hose down and splashing waters	X X X X X X X X X X X X
Oil and coolant seepage	X X X X X X X X X X X X
Oil or coolant spraying and splashing	X X X X X X X X X X X X
Corrosive agents	X X X X X X X X X X X X
Occasional temporary submersion	X X X X X X X X X X X X
Occasional prolonged submersion	X X X X X X X X X X X X
Hazardous location, Class I, Div I Groups A, B, C, D	X X X X X X X X X X X X
Hazardous location, Class II, Div I Groups E, F, G	X X X X X X X X X X X X

* These enclosures may be ventilated.
 ** These fibers and flyings are nonhazardous materials and are not considered Class III type ignitable fibers or combustible flyings.

The NEMA indoor rating includes oils, coolants, corrosives and hazardous locations.

