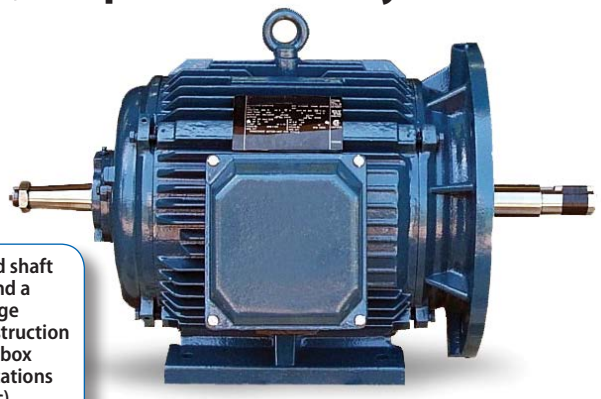
Can You Develop Your Own Custom Motor-and-Motion System?

Some of the ins-and-outs, ups-and-downs, of special-needs systems.

Jack McGuinn, Senior Editor



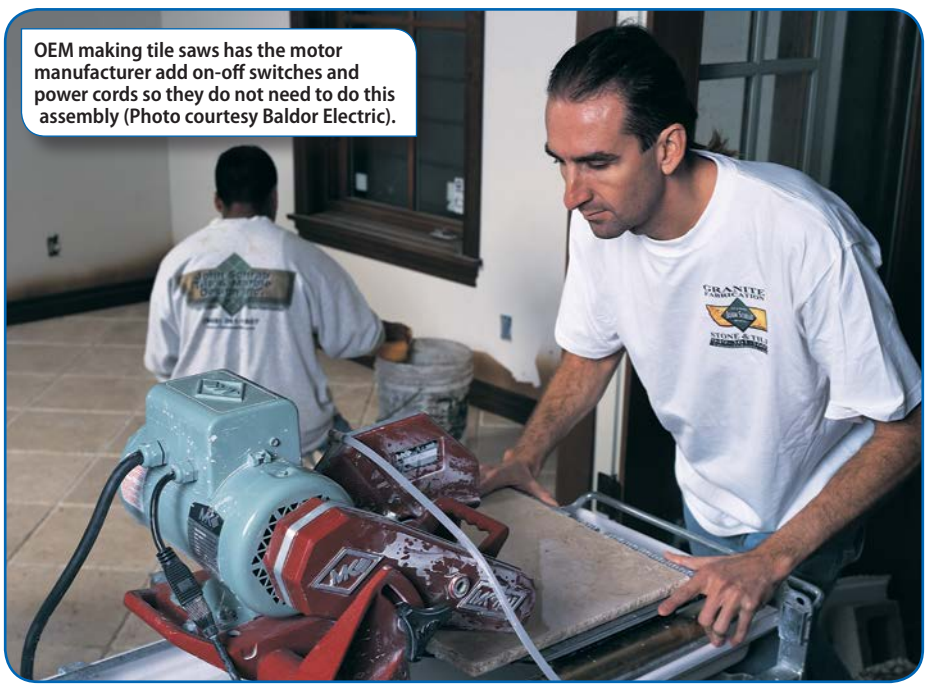
This motor has a special tapered shaft on the back end of the motor and a stepped down shaft on the flange mounted side. All cast iron construction including the base and conduit box to be used in severe duty applications (Photo courtesy Leeson Electric).

In this century's complex, ever-changing world of manufacturing, such capabilities as hardware and software expertise, effective location and distribution, business savvy and yes, even luck, are some of the cardinal requirements for running a successful business.

But another stands out, in a sense encompassing them all: how best to spend precious time — especially in a product's time-to-market context — and company resources.

This last "maxim" applies with great certitude for a company or a business that is tasked with a blank-paper assignment of designing, developing and manufacturing a custom electric motor-and-motion system — either for its own in-house operational needs or those of an OEM or end-user. It is often said you get what you pay for — but you know that is not always true. Indeed — when it comes to custom ***anything***, the buyer should not only beware; he should run like hell if, for example, he senses that he is being over-sold a package that is far beyond or below what in fact he truly wants or requires.

If you are looking to manufacture or self-install a custom electric motor-and-motion system, you ***are*** going to pay more. Basically, there exist four major types of electric motors — DC, AC synchronous, AC single-phase induction and AC three-phase induction — and each one can be customized to suit a special requirement.



OEM making tile saws has the motor manufacturer add on-off switches and power cords so they do not need to do this assembly (Photo courtesy Baldor Electric).

But stop and ask yourself — what exactly does "custom" mean — beyond higher price? Is it primarily design-based? Hardware-based? Both? Is it truly "unique" in its design or execution? And what precipitates the need for a custom-designed system? Don Labriola (P.E.), president of QuickSilver Controls, Inc., a custom design motion and control shop that works closely with like-minded motor builders, explains.

"Sometimes a custom design is needed to design around other constraints in a system that are pre-established; sometimes they are not as firm as they first appear, given the *costs/risks* of having to go custom. Other times, a key feature that is required that may be added to an existing design via software; i.e. — if the vendor is willing to customize. We have had a significant number of design-ins via flexible software and the ability to quickly add features."

Time to market and lost opportunity are costs often overlooked by design engineers. An internal design may save unit cost, but may add significant design costs that must be spread out over the unit cost, and a schedule slip may cause the product to completely miss their market. So time, resources — and especially risk — must be managed. Underestimating the challenge of a full custom design can (needlessly) sink a project.

From there it gets a bit trickier.

George Holling, chief technical officer for Rocky Mountain Technologies, points out, for instance, that customization is often *not* application-driven, as might be typically assumed.

"A manufacturer may want to promote a new technology that they conceive may give them an edge, i.e. — less heat, more reliable, less cost, etc.," he says. "Or they may want to get around patents by using something different or they may simply want to develop a new supply chain or in-house manufacturing."

And Mark Baake, director of sales at Leeson Electric, says "There are times when motors also need to meet specific efficiencies, national or international specifications and/or compliance to standards. Generally, the application dictates the majority of the motor features — space, power, torque, etc."

Just for good measure, Jesse Henson, Baldor Electric Company (ABB Group) director of motor sales and product management informs that there are "custom motors" existing in name only — especially in the OEM markets.

"Custom motors are often specified when special performance, features or mounting are required by the OEM. Such a motor does not necessarily mean it is a custom motor, as many special- and definite-purpose motors are stocked by motor manufacturers. Certain product families were specifically designed for OEM custom applications, but have moved into a stock product to address the need for similar motors from multiple OEMs and MRO business."

Having determined what requirements differentiate "custom" from "in-house," companies with a "blank sheet" project in front of them then need to decide if they are capable of doing the job alone or if they need outside help. It's a big "if" — one that could prove costly if not dealt with wisely or if bad choices are made.

"A big item in any engineering project is picking which areas you can easily buy and which ones are your core competencies," says Labriola. "Your core competencies are those that differentiate you from your competitors, and that you are willing to staff with sufficient depth to avoid losing the competency if a single key player were to no longer be available.

"The second item with core competencies is that they should be developed prior to needing to use them. Designing parachutes after leaving the plane is to be avoided, as are developing key technologies underpinning a product while trying to keep to a tight schedule. A prior manager referred to this as trying to schedule breakthroughs."

"This (optimizing in-house resources) is very true across many companies," says Baake, adding, "Resources over the years have been reduced and functions combined so you need to spend time on what is really needed."

Or, says Henson, "A custom motor could be optimized for the application in terms of performance, mounting, features and product life. For example, an OEM making tile saws has the motor manufacturer add on-off switches and power cords so they do not need to do this assembly in their plant. It is really about providing more value to

the OEM."

Of course, given that 21st century motor/controller development requires a fair range of skills, e.g. — regulatory for emissions and safety circuit design; control algorithms; communications; HW/SW interfaces; test benches for testing; and hard real-time software — why would generalist-type shops even think they can build a custom motor on their own? Well, they usually don't.

"With global efficiency regulations, capital investments required, and registration, an OEM would find it difficult to build their own motors,' says Henson. "They would need to use very few models with extremely high volume to justify the massive investment. To add the design of adjustable speed drives on top of motors, it would take significant investments for start-up and a wide range of design and production engineers. If one looks at the companies making motors and drives, there has been much global consolidation over the last decade and not too many new start-ups."

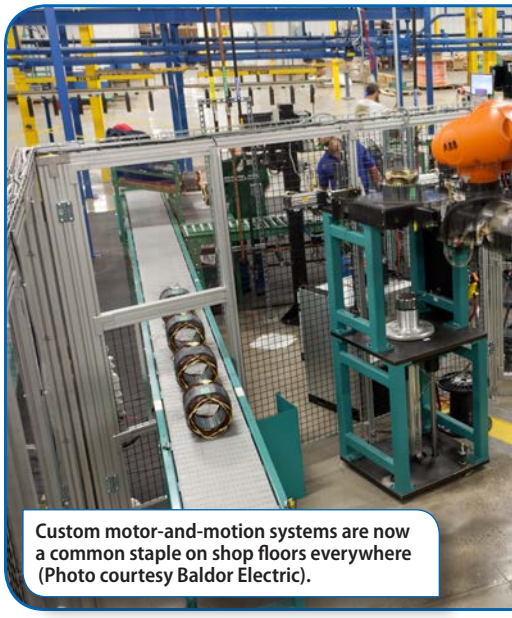
Indeed, Holling declares: "The good old days of trial and error are gone. (Our company) uses $50-$100k design tools, but some designers still simply scale and come up with sub-optimal solutions at best (too much cost), or designs that do not perform and then we often get involved. Vendors, especially in the chip industry, make it sound so simple to build a controller. The problem is they use PhDs (I have one of those — so I can say this) to design 'sample drives' that may work on a bench under very confined conditions. But some of those will not hold up in an industrial environment. A few succeed and many will give up."

"A well designed system looks simple," Labriola allows. "Component count makes it look like a "quick engineering project" could save on the total cost. The reality is that many man-years are invested in the algorithms and code. High-frequency, high-power circuitry in proximity to logic-level DSPs requires very careful design, with intuition gleaned from many iterations and sometimes significant experimentation. Simple, open loop steppers are fairly easy to implement; jumping into higher power, higher speeds, and well behaved motions is not the small step it may appear.

One wonders about scenarios where a shop has overestimated its skill, underestimated the degree of difficulty to complete the motor project, and had to bring in outside help to get things back on track. It happens more often than one might think — and even then there can still be problems if an unwise choice of an outside consultant has been made.

"Quite a few (occurrences) come to mind," says Holling. "Two recent cases where customers used outside consultants; in one case the consultant was an electronic trying to use a uP to switch a power device and things kept blowing up. They did not have the expertise or the equipment to analyze the failure. We successfully redesigned the controller and they are in production now (three years later). In another case the motor was a magnet graveyard (lack of magnetic design expertise or tools) with no torque, and that project is ongoing."

"Fortunately, (for us), yes!" says Labriola regarding customer fires that need quick extinguishing. "I have also seen others that got about 60% of the way there and then stalled and never made it. I usually quote that the first 90% of the project takes 90% of the time, and the next 10% of the project takes 90% of the time, thus projects are often late. Again, fortunately, we have


Custom motor-and-motion systems are now a common staple on shop floors everywhere (Photo courtesy Baldor Electric).

had a lot of shops that have started with our product for a prototype and just decided to keep it for the final design." Adds Baake, "We do see it occasionally and as long as the shop is a customer we help to provide them what is needed because in the end their customer is also ours."

Looking at it from a strictly OEM's perspective, Henson explains that "Most motor and drive manufacturers have previously supplied systems for the same or similar applications and have knowledge of what works and what doesn't. If it is new, the OEM should select a supplier with problem-solving engineering resources.

"Today many OEMs look at the entire power drive system consisting of motor, drive, mechanical power transmission devices (gearboxes, pulleys, etc.), as well as using the best practice for the driven load. There are only a few companies that can supply the complete package and service it in the end."

Earlier on we alluded to "unique" as a quality inherent in custom manufacture. Define unique as it pertains to custom motors and motion systems, you say? Let's let our experts handle that.

Cautions Holling: "Unique means there is only *one*, so most likely it will probably be a lie. But there would be some features that would single a motor out: a special magnetic design — i.e. transverse flux; a configuration with significantly reduced PM material; a special pole/slot/winding configuration; or special components such as soft magnetic composites, very high-temperature materials, etc.

Labriola adds that "We worked with our motor vendor to add a slot to a stator that enabled us to add a sensor coil strip that turned the motor into its own resolver (we call the combination a Mosolver). The PWM drive serves as the excitation and the rotor and stator as the magnetics. We are applying this to a couple of different motor types."

It is Baake's sense that "Many times the unique features are developed based on the 'voice of customer.' Unique features could be special shafts, bearings, machined or cast flanges or feet, but could also include special rotor/stator assemblies to develop custom power characteristics of the motor so it starts/operates as needed for a specific application."

As for Baldor's Henson, "Unique could be in terms of specialized mounting and shafts designed to be part of the OEM equipment. Motor performance, speed, torque and duty cycle can also be uniquely designed for the specific application.

"An example of this could be a totally enclosed air-over motor designed for a direct-drive, fan-on-shaft, HVAC application that is also cooled by the air over the motor as it drives the fan. In such an application lower starting torques are allowed and the OEM will want to minimize the use of active material in the motor. Testing of temperature rise and thermal protection performance on the application may take a few weeks."

So let us say the customer has reconsidered and has decided to call for "back-up" — enter the custom system consultant/supplier. (*FYI, the four companies included in this article are all hands-on producers and suppliers — not merely consultancies.*) What next? Does the customer typically know what they want and need, even if they *really* don't know how to build it?

"The customer generally has a benchmark design in mind," says Leeson's Baake. "But upon reviewing the specifications and asking additional questions in order to provide value-added benefit, motor designs or features can change significantly."

From Rocky Mountain Technologies' Holling's way of looking at it, there are the, shall we say less-than-informed customers and those customers that actually do their homework—which of course leads to choosing a custom house supplier.

"In many cases, (clients) just use a buzzword (e.g., brushless) because that is what everyone else uses. There is a lot of 'inertia' in the motion industry. Some of the more sophisticated customers will actually do an analysis of their needs and make a conscious technology choice that includes performance, price and marketing. These customers will also be the ones that will most rely on outside experts."

But in Labrilola's experience, it's mostly complex, application-driven—and about the customer knowing where to go for help. "Most of the customers I have worked with come from the application need side; e.g.—size, weight, torque and power. And even more commonly, what protocols does the controller support, ability to handle an application space (i.e., a winder that needed electronic gearing with seven places behind the decimal point in the gearing to cause the different self-supporting, bobbin winding configurations needed by their customers).

Again addressing a larger-scale manufacturing (OEM) base, Henson says "(Baldor customers) usually know the input voltage, speed, horsepower, enclosure and mounting needed. Technology selection is often pretty advanced to deviate from an AC induction motor. A special reason would be discussed."

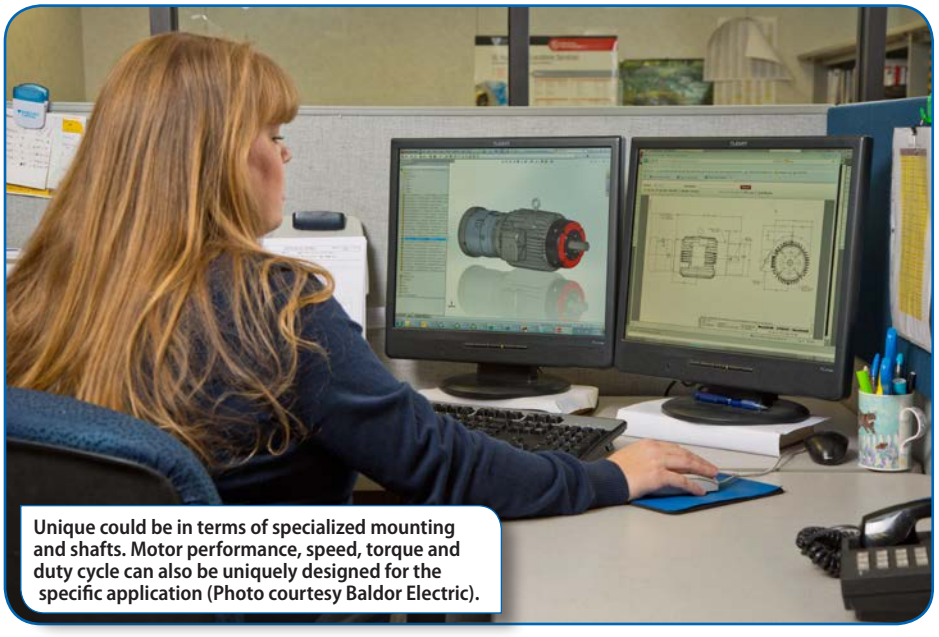
With all the parameters to be addressed and choices to be made, is there one most difficult type of custom motor system to design, build and deliver? Of course there is; and the difficulty presents in different ways.

"Time killers are those projects that really do not know what they need," Labriola says. "This shows up in motor power changing by a factor of up to 30 over the course of the project. If the package size or other requirements get set before the motion needs have been determined, it can put the whole project in peril."

Henson believes that "Some requirements from customers go outside the scope of a motor manufacturer's standard designs. When this occurs it's important to select the right motor manufacturer that can support the customer's designs with strong engineering expertise and flexible manufacturing capabilities."

Leeson's Baacke provides two examples:

"Two types of applications come to mind. First is a vibratory application which has high shock loads to the motor frame bolts and bearings. Second is a centrifuge application; in this application the motor may decide to begin rotating 380 seconds after the power is applied to the motor. Therefore, long



Unique could be in terms of specialized mounting and shafts. Motor performance, speed, torque and duty cycle can also be uniquely designed for the specific application (Photo courtesy Baldor Electric).

start-up/acceleration times, and large load inertias to move/rotate the motor (are required).

Holling points out that while "Industrial is typically easy, (it) may require very quick turnaround. (While) appliance has a focus on cost and automotive has impossible specs at no cost. Military is often the most difficult, but at least cost is a secondary issue. The new motor design needed to meet high torque requirements, yet maintain low running amps to allow for use in household applications. The motor also required a unique metric mounting flange."

Given how manufacturing economic reports are all over the map (literally) these days, a final question begged asking—Is it a good time to be in the custom motor-and-motion industry today?

"We currently enjoy a nice mix," says Labriola. "Some DoD, some medical, multiple smaller OEMs; keeps one area going down from being a disaster."

But at Rocky Mountain Technologies, "Right now is probably not a great time," Holling says. "Our consulting business is doing well (not saying we turn down orders but we are probably upper price end) so we are probably siding towards a recession. DoD is the toughest place—very hard to make money. We have a sister company that does all of our government business. If we tried DoD in a commercial company we would go broke on government contracts.

"Large OEMs are easier to work with but harder to sign up than smaller ones that are typically higher maintenance and have often unrealistic budget expectation but they will find the funds required if they are in a bind and then they want everything done overnight, which is not always possible as everything takes time."

Meanwhile, at Leeson, "The motor business as a whole is a strong market," Baake enthuses. "The sweet spot would be Distribution, Integrators, Assemblers, OEM's and end-users. Large motors can quickly support a business once they have been spec'd in (qualified) at the OEM or end user. This helps gain more of a foothold into the business and opens the doors for other motor sales that are not easily obtained." **PTE**

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