3 PATHS TO FLEXIBLE TRANSFORMER MANUFACTURING

An equipment strategy based on staged investment offers future-proof scalability when working with forward-thinking machine builders

Navigating changing markets and business goals is tough — especially without a roadmap for equipment investments. Keeping older, less efficient technology on the shop floor reduces your overall competitiveness.

That's why our team at Micro Tool & Machine Ltd. (MTM) developed a flexible deployment strategy for intelligent, automated machines. As a custom machine design firm focused on the transformer industry, MTM's staged-investment approach delivers upgradeable winding machines. So, our manufacturing customers across the globe can harness core machine functionality immediately while ensuring expandability in the future.

A strategy of **incremental upgrades** to winding equipment empowers transformer manufacturers to realign existing machines by integrating add-on technologies — from winding mandrels, wire flatteners and cold welders to laser welding. This applies to both new machines and retrofits. While this article focuses on winding lines, the strategy fits other production areas.

Let's examine three common upgrade paths for coil manufacturing equipment. Then we'll highlight a case study, along with some initial recommendations to get started.

Figure 1: Layout of a combined foil and wire winding machine – a versatile platform that can be incrementally upgraded.

Photo: Micro Tool & Machine

Upgrade Path 1: Portable Add-on Modules

Add-on systems offer a quick win to enhance coil winding capabilities, quality, and efficiency. MTM's portable or retrofittable modules often offer a low price point but yield significant performance improvements. Below are a few add-on options.

Wire Flattening Attachments

Wire flattening devices lightly compress round magnet wire (usually used for high-voltage coils) to create a more rectangular cross-section. This tool's benefits include tighter coil packing, lower core losses, reduced electrical stress, better short-circuit strength, and smaller, cheaper coils — often cutting total costs by 5–10 percentage. In a staged deployment, a manufacturer might install the flattener as volume or product requirements demand the improved performance.

Figure 2: Retrofit wire flattener installed on a coil winding machine to improve winding packing and performance.

Cold Welding Systems

Also known as pressure winding, a cold welding system creates joints faster and cleaner, with no cooling time and fewer quality issues. Cold welding joins two metal parts — copper-to-copper, copper-to-aluminum, or aluminum-to-aluminum — through high-pressure deformation without filler material or heat.

MTM can implement add-on cold welding equipment either through direct integration into the winding machine or as a portable unit, often resembling a small hydraulic press or clamp system mounted on a cart. This mobility is advantageous for factories with multiple winding bays.

Photo: Micro Tool & Machine

Figure 3: Portable cold-welding unit for transformer coil leads and terminals.

Bending Fixtures

Forming leads or bus bars typically entails making connections to other windings or external bushings. Traditionally, operators bend heavy copper leads or aluminum bars manually or with simple tools. Here, a portable bending fixture from MTM helps manufacturers achieve more consistent connector geometry and reduce manual labor.

As a staged investment, a company might start with manual bending and later introduce a semi-automatic bending tool as production ramps up. MTM's custom equipment portfolio often includes coil lead bending jigs or small hydraulic benders, increasing throughput and quality without needing a completely automated assembly line from day one.

Figure 4: Integrated coil lead processing station combining cold welding and lead bending operations.

These modular, add-on upgrades in Upgrade Path 1 require a relatively low investment and set the stage for the next level of upgrades.

Upgrade Path 2: Multi-Coil Manufacturing Capabilities

As transformer demand grows, manufacturers must increase coil output without necessarily buying new winding machines. The second path is to upgrade existing MTM machines to wind multiple coils simultaneously or to deploy multi-coil configurations in the production line. We anticipate this need by designing base machines specifically to be expandable, or by offering additional modular multi-coil systems when required.

A common entry point is a combination winder that handles both LV foil and HV wire, initially set up for single-coil operation. This lowers complexity and cost. Once production ramps up, a machine upgrade can add more winding heads or parallel stations to enable simultaneous multi-coil winding.

In a dual- or triple-coil setup, the winder uses multiple wire payoffs and tension units to create identical coils side-by-side. Each mandrel rotation produces a preselected number of coils, significantly boosting throughput. A dual-coil setup nearly doubles output, while triple-coil winding can reduce per-coil time by up to 60%, depending on the coil design. Multi-coil machines can replace several single-coil units, improving productivity and saving floor space.

Since HV coils take far longer to wind than LV, multi-coil HV winders help eliminate idle time and better balance production flow. MTM has implemented production cell strategies around this: for instance, a dual-machine cell with a multi-coil HV winder and a flexible LV/HV machine working in tandem. This balances coil flow and reduces idle time, improving daily coil output by up to 20%.

Implementing multi-coil capability often involves adding hardware — extra winding heads, payoffs, etc. — and updating control software to manage multiple axes. The MTM team designs machines with these future upgrades in mind, so the transition can be made with minimal disruption. If expansion isn't feasible on the original machine, a new multi-coil unit can be added to the cell instead.

In MTM's scalable approach, Upgrade Path 2 helps transformer manufacturers expand output, shorten delivery times, and delay capital purchases while flexibly adding capacity later.

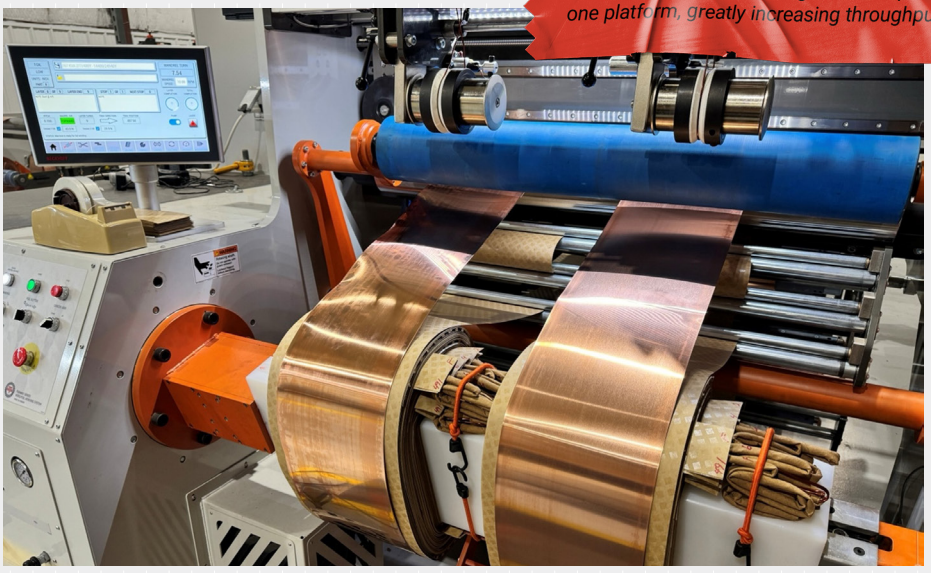


Figure 5: Example of a multi-coil winding machine setup, with three coils being wound in parallel on one platform, greatly increasing throughput.

Photo: Micro Tool & Machine

Upgrade Path 3: Integrated Laser Welding for Internal Busbar Connections

The third upgrade path extends the machine's functionality into the precise joining of internal busbar connections within the transformer coil. By integrating laser welding technology, manufacturers can automate the fabrication of heavy conductor joints inside the coil structure.

In many modern distribution and medium-sized power transformers, the coils' internal connections are manually assembled. These crossovers, tap leads, or interlayer busbars handle high currents and mechanical stresses. Integrating laser welding capabilities for a seamless, automated flow from winding through completion.

Laser welding delivers precise, localized energy with minimal heat spread, ensuring strong, repeatable welds without damaging nearby insulation or conductor materials. Unlike traditional arc welding processes, laser welding allows for:

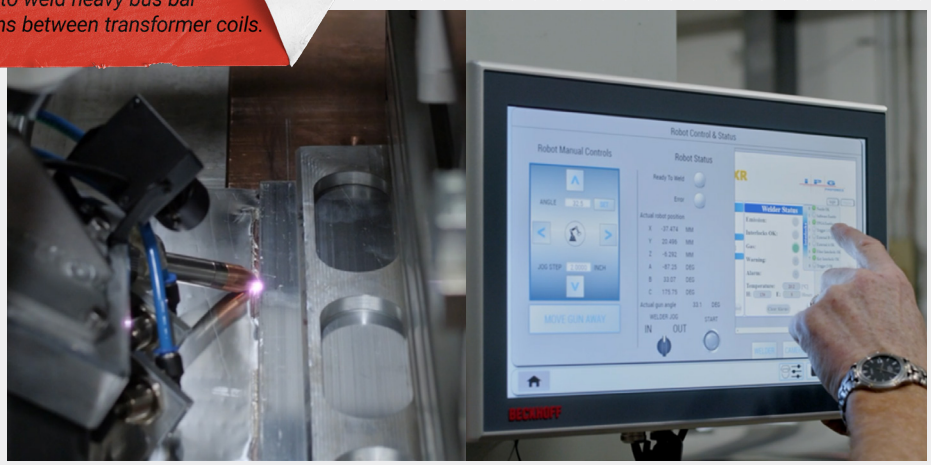
- Clean, reliable connections between conductors or foil stacks.
- Minimal distortion of delicate coil windings during joining.
- High repeatability and reduced manual labor.

While some laser welding capabilities should be specified prior to a machine purchase, standalone or modular laser welding stations can often be added later. The initial machine simply must include basic integration points, such as communication links and footprint, to ensure scalability as production volume or product complexity increases. Laser welding delivers repeatable joints, boosts efficiency by running in parallel with other tasks, and improves safety by moving welding into an enclosed, automated space.

Upgrade Path 3 often represents the culmination of the flexible deployment journey. At this stage, the manufacturer transitions from basic coil fabrication to a fully integrated coil manufacturing system that includes winding, lead preparation, and internal connection assembly — all managed within a coordinated production cell.

The key is to plan for flexibility early. The staged investment approach exemplifies the essence of a flexible machine deployment strategy: invest progressively, scale capabilities in line with demand, and maintain technical leadership in a rapidly evolving transformer market.

Figure 6: Robotic TIG welding station integrated into a coil production line, used here to weld heavy bus bar connections between transformer coils.



Case Study: Phased Upgrades in Practice

How do upgrade paths work in the real world? Consider AlphaTransformers, a mid-sized distribution transformer manufacturer that that is looking to partner with MTM on a flexible machine deployment strategy.

In year one, they modernized using a combined LV/HV winder from MTM with basic features — avoiding the need to buy multiple machines. This replaced two older winders and allowed operators to wind LV and HV coils back-to-back, reducing material handling and inventory.

Following a successful year, AlphaTransformers followed Upgrade Path 1: a wire flattener and portable cold welding unit. The flattener, easily mounted due to MTM's modular design, produced more compact HV coils with fewer layers, and improved surge withstand performance. The cold welder enabled copper-to-aluminum lead transitions in-process, eliminating brazing. This boosted production and quality with nearly zero internal joint failures in impulse testing.

By year three, growth in small kVA transformer demand created a bottleneck. To address it, AlphaTransformers upgraded went down Upgrade Path 2: adding a second winding head to create a dual-coil winder. With MTM's guidance, the upgrade was completed during a planned shutdown. This reduced HV coil winding time per unit by 45%. AlphaTransformers reconfigured its workflow into a mini production cell. The new machine handled HV coils and urgent LV jobs while a refurbished foil winder handled standard LV production, increasing throughput and utilization.

Encouraged by this progress, the company proceeded to Upgrade Path 3: a semi-automated TIG bus bar welding cell. Previously, manual brazing of bus bar connections caused delays. The new setup used a six-axis robot to weld preformed copper bus bars directly to coil leads. Operators loaded the bars, while the robot performed precise, repeatable welds. This optimized assembly time and format changes by updating programs rather than retraining welders.

Using a flexible machine deployment strategy, AlphaTransformers transformed in phases. Each upgrade built on the original machine's platform. By aligning investment with growth and giving staff time to adapt, the company boosted quality, output, and flexibility with minimal disruption.

Photo: Micro Tool & Machine

Getting Started with a Flexible Machine Deployment Strategy

A flexible deployment strategy scales investment with need, reducing risk and unlocking value in phases. So where should you start? Transformer manufacturers that want to align their capital outlay with future growth while staying on the cutting edge of production technology should consider these aspects:

- Start with a Modular Platform: Choose winding machines designed for future upgrades. MTM's combination HV/LV winders can be expanded later with add-ons, enabling smooth scaling over time.
- Prioritize High-ROI Upgrades: Early investments in compact coil tech can reduce costs and improve reliability. These low-cost, low-disruption retrofits offer quick quality and efficiency gains.
- Scale with Demand: Track coil hours and machine utilization to time capacity upgrades. When volume nears single-coil limits, consider multi-coil machines or cells to cut winding time per coil by up to 60% and eliminate process idle time.
- Automate Strategically: After output grows, target manual steps like lead welding for automation. TIG welding integration, for example, boosts consistency and reduces labor when justified by scale.

This staged equipment investment philosophy dovetails with continuous improvement philosophies: each upgrade stage brings a focused improvement, whether it's quality, speed, or automation. By partnering with equipment suppliers like MTM who embrace modular design and future-ready engineering, manufacturers can ensure that today's machine purchase offers a roadmap to meet tomorrow's production requirement.

Gord Atamanchuk is the President and CEO of Micro Tool & Machine Ltd. (MTM) in Winnipeg, Canada. He has over 17 years of experience in designing custom automation and machine tools for the electrical transformer manufacturing industry. Gord specializes in developing intelligent winding systems and has led MTM's initiatives in modular machine design and staged investment implementations for transformer OEMs worldwide.

Ready to get on the right path to upgrade or purchase machines using a flexible deployment strategy? Contact Gord Atamanchuk at gord@mtmmachines.ca for more information.