APPLICATION BRIEF:
FDM for Robotic End of Arm Tooling

OVERVIEW
Robots are used to perform tasks such as sorting, transporting, palletizing, inspecting and machining. A robot’s end of arm tool (EOAT), also called an end-effector, is selected based on the operation it will perform, such as gripping or welding, and is specific to the part or tool that the robot manipulates (Figures 1 and 2). Although there are standard, off-the-shelf EOATs, robot integrators and end-users often need customized solutions to engage uniquely shaped objects, optimize operations and improve productivity.

Because of the low-volume nature of custom EOATs, many are machined from metal. They are combined with stock components such as vacuum cups, actuators, framing components and quick changers. However, the time, cost and effort to machine custom EOATs can be prohibitive, which is why end-users may settle for non-customized, stock solutions.

BENEFITS OF FDM
Average lead time savings:
• 70% - 85%
Average cost savings:
• 75% - 85%
Greater design freedom:
• Internal vacuum channels
• Consolidated assemblies
• Complex geometry
• Integrated components
Greater performance:
• Lightweight/low mass
• Optimized designs
• Impact dampening
• Non-marring
• Increased velocity
• Extended preventative maintenance cycles
Rapid response:
• In-house fabrication
• Redesign as needed
• Reduced downtime

Typical time and cost savings derived from numerous end-user analysis, testimonials and feedback. Actual savings may vary based upon numerous factors, including traditional time/cost, part geometry and utilized technology.

FDM IS A BEST FIT
Size:
• 25 mm (1 in) to 400 mm (16 in)
Quantity:
• 1 to 100s
Design:
• Complex/organic shapes
• Lightweight
Materials:
• Thermoplastics are acceptable
Tolerance:
• ± 0.13 mm (0.005 in)
Fabrication:
• In-house needed
Revisions:
• Frequent changes or replacements
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APPLICATION OUTLINE
FDM® technology provides an alternative method for producing EOATs that can provide dramatic time and cost savings while optimizing performance. FDM is an additive manufacturing (3D printing) process that builds plastic parts layer by layer using data from 3D computer-aided design (CAD) files. With FDM, EOATs can be customized and tailored to a specific application while often accelerating implementation on the production floor.

FDM technology and materials make EOATs that result in many performance advantages for robots. FDM EOATs are lighter than those made with metal, which means that robots can move faster or carry larger payloads. Weight reduction also improves motor efficiency and reduces component wear, extending the time between preventive maintenance (PM) cycles. FDM technology easily makes hollow internal structures and the thermoplastic materials are lightweight, yet durable. When combined, weight reductions of ninety percent or more are possible (Figure 3).

Plastics have two additional advantages: they won’t scratch the products they grip, and they dampen impact forces so that a tool crash is less
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likely to damage the robot. An FDM EOAT can also have components like magnets and sensors embedded during the FDM build process. Fully encased, the components are protected and won’t mar the parts that come in contact with the EOAT.

FDM EOATs can be as simple or complex as needed, which gives designers the freedom to create tooling solely for its specific function. For example, EOATs can have integrated vacuum channels, assemblies consolidated to a single part, or organic shapes that conform to the object being manipulated by the robot (Figure 4). This design flexibility provides a unique opportunity to optimize robot performance and with FDM technology, design complexity doesn’t increase cost.

FDM EOAT manufacturing is responsive, efficient and straightforward, turning EOAT design projects into simple tasks. If a design needs to change, FDM can produce a new tool in as little as one day. New or revised designs and replacement EOATs are delivered and mounted on the robot quickly, regardless of complexity. During robot testing and validation, a quick response avoids delays in starting up a production line. Once FDM EOATs are operating in production, rapid revisions keep the line running at peak performance.

Figure 4: Integrated vacuum channels in the EOAT’s arms eliminated numerous external vacuum hoses (ABS Yellow).

Figure 5: Genesis Systems’ robotic waterjet cutter (ULTEM® 9085 resin Tan).

Figure 6: The Genesis FDM vacuum gripper has internal vacuum channels and weighs just three pounds (ULTEM 9085 resin Tan).
CUSTOMER STORY

Genesis Systems Group, headquartered in Davenport, Iowa, designs, builds and implements robotic tooling for work cells used in assembly automation, material handling and processing, non-destructive inspection and welding. One of Genesis’ specialties is building robotic, waterjet cutting systems used to trim composite parts.

Genesis pioneered a safer approach for waterjet cutting. Instead of using a robotic arm to move the waterjet cutter, it keeps the waterjet fixed and uses the robot to move the part (Figure 5). However, this approach posed a challenge because each unique part required a custom gripper to hold and manipulate it. Genesis found that outsourcing for CNC machined custom grippers was adequate but each tool cost nearly $8,000 and took 20 days to make.

For a better solution, Genesis turned to FDM for a faster, lighter and less expensive EOAT to replace conventionally fabricated metal grippers (Figure 6). Engineers began by redesigning the EOAT to include internal vacuum channels, which was cost prohibitive with CNC machining. Using FDM simplified the assembly and removed external vacuum hoses that would be damaged during waterjet cutting. “FDM grippers offer major advantages over metal grippers and conventional fixtures. Using FDM gives us tools that are quick, cheap, easy, durable and repeatable for the waterjet application.” said Doug Huston, process engineer for Genesis Systems Group.

The redesigned tool, made with lightweight FDM plastic, also reduced the EOAT’s weight from 35 pounds to just 3 pounds. Huston noted that the weight reduction made it possible to use smaller, less expensive robots.

“Switching to FDM dramatically reduced the cost of building grippers. Delivery time was substantially reduced too, which is important because if a gripper is destroyed in a crash, production may have to be shut down until the replacement gripper is built.” said Huston.
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HOW DOES FDM COMPARE TO TRADITIONAL METHODS FOR GENESIS SYSTEMS GROUP?

<table>
<thead>
<tr>
<th>METHOD</th>
<th>TIME</th>
<th>WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNC Machining</td>
<td>20 days</td>
<td>15.9 kg (35 lbs)</td>
</tr>
<tr>
<td>FDM</td>
<td>3 days</td>
<td>1.4 kg (3 lbs)</td>
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<tr>
<td>SAVINGS</td>
<td>17 days (85%)</td>
<td>14.5 kg (91%)</td>
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</tbody>
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Application compatibility:
(0 – N/A, 1 – Low, 5 – High)
- FDM: Idea (3), Design (3), Production (5)
- PolyJet™: Design (3), Production (3)

Companion and reference materials:
- Technical application guide
  - Document
- Application brief
  - Document
- Video
  - Commercial
  - Success story
  - How It’s Used
- Case study
  - Genesis Systems Group
  - Robai Corporation

CANDIDATE PROFILE

Companies:
- Manufacturers, custom molders and foundries
- Robotic system integrators and accessory suppliers

Departments:
- Manufacturing, assembly
- Quality assurance
- Packaging and inventory control

Applications:
- Robot testing and validation
- Low, medium and high-volume production runs

Characteristics:
- Require custom EOAT solutions
- Want to optimize robot performance
- Need quick delivery or replacement

Traditional technology obstacles:
- Machining is cost or time prohibitive
- Machine shop is backlogged
- EOAT functionality limited by machining constraints

REPRESENTATIVE COMPANIES

- NASA
- Thogus
- RoadNarrows
- Genesis Systems Group, LLC
- DM Digital Mechanics
- ROBAI
CONTACT:
To obtain more information on this application, contact:

Stratasys Application Engineering
www.stratasys.com/solutions-applications