COMPOSITE TOOLING FOR WIND TURBINE BLADES

Gurit Tooling is the largest independent manufacturer of plugs and moulds for wind turbine blades worldwide. Its scope of activity reaches beyond wind turbine blade moulds and also blade production assisting equipment, including automated devices. Gurit Tooling also makes highly engineered moulds for other industries like marine and such.

With over 650 skilled employees worldwide dedicated to the design, engineering, manufacture, and service of composite tooling; Gurit is a prime engineering and sourcing partner for quality moulds, wind blade production equipment, and global services delivered to client specification in short lead times and at very competitive prices worldwide.

A comprehensive solution:
- Design and manufacturing of master plugs and moulds
- Modular automatic mould turning system, also known as hinges
- Hydraulic Mould Clamping and Alignment Systems
- Modulated heating and process monitoring systems for blade processing, both in PCB and/or PLC format
- Wind blade production assisting equipment – jigs and fixtures
- Global maintenance services for global locations of our customers

MANUFACTURING AUTOMATION

Gurit leads the industry in blade manufacturing automation, providing consistent efficiency and reliability, making it the preferred choice for manufacturers of high-quality wind turbine blades.

Our vast experience working with blade manufacturers, worldwide, has given us specialized insight that helps blade builders solve their particular problems. Our services include:

■ Engineering Services
  - Mechanical Design (3D CAD)  - Structural Analysis (FEA)
  - Hydraulic System Design  - Automation (PLC and MicroController)

■ Manufacturing Services
  - Welding of Large and Small components  - CNC Machining

■ Technical Services
  - Installation and Commissioning  - Operator and Maintenance Training
  - Contracted maintenance services for mould system and related equipment
Composite materials open new avenues for the manufacture of lightweight, strong and durable structures of almost any conceivable form and shape. Independent of the chosen composite manufacturing process, plugs – a three-dimensional model of final part – and moulds – the forms used to actually manufacture a final part – define the accuracy of composite components. Gurit is globally the largest independent, fully integrated and highly specialised mould maker for large structures. Established in 2007 as Red Maple, in Taicang, China, Gurit Tooling has made a name for itself as the leading manufacturer of plugs and moulds for wind turbine blades. In 2016, Gurit opened an assembly and support facility in Poland as a European hub for our clients. In Montreal, Canada, Gurit operates a competence centre for hinges (PH Automation) and automation solutions.

Dedicated to the design, engineering, manufacture and service of composite tooling, Gurit is globally a prime engineering and sourcing partner for quality moulds, wind blade production equipment, and global services, delivered to client specification in short lead times and at very competitive prices – worldwide.

Short lead times

Gurit has the ability to manufacture large scale mould sets. International blade manufacturers worldwide choose Gurit as their primary supplier for prototyping and serial mould production.

As a highly specialised, industrial plug and mould maker with the latest technology at hand, Gurit controls the complete vertical production process. This allows Gurit to offer quality tools at unbeatable prices and even more importantly at very short lead-times - shipment, installation and commissioning included.
Covering the complete mould production process

Gurit's tooling makes a perfect match with the Group's other core offerings of structural design, composite materials manufacturing, composite processing know-how and composite component fabrication. This pairing enables fully industrialised, innovative, and cost-effective solutions for wind energy, marine, transport, and architectural markets. Gurit has specialised CNC engineers, operating 5-axis CNC machines, to build master plugs with extreme accuracy and speed. Gurit's plugs have successfully been used to make up to more than 25 perfect moulds. This means that all components, shear webs, spar caps and root inserts fit every time without costly adjustments or use of fillers. Gurit equips its moulds with hydraulic turn-over, closing and clamping systems, jigs and fixtures, and offers a choice of software controlled electric or liquid mould heating systems depending on the production process or the targeted precision.

Welded plugs, moulds and blade lifting systems, jigs and fixtures

Gurit's plug and mould surfaces are held by a very rigid steel support structure to ensure a tight, stable surface geometrical tolerance. All welding is done in-house following ISO standards, with CE certified welders and International Welding Engineers on-site, to ensure high levels of quality and safety. Over the past several years Gurit has worked with many high profile clients to design, develop, and manufacture key metal structures and tools to aid in the blade turning and turbine assembly process with high efficiency and accuracy. Whether it is new design, concept, build to print design, or prototypes, Gurit can work through all the phases of a project from design conception, design & validation, manufacturing, to delivery of the final parts with a competitive cost and time without compromise to quality.

MANUFACTURING AUTOMATION FOR CYCLE TIME REDUCTION

Gurit Tooling leads its class for blade manufacturing automation, providing consistent efficiency and reliability, making it the preferred choice for manufacturers of high-quality wind turbine blades.

Our vast experience working with blade manufacturers, worldwide, has given us specialized insight that helps blade builders solve their particular problems. Our aim is to be a full system provider for our wind blade manufacturers.
BLADE MANUFACTURING TURNKEY AUTOMATION

1. Mould turning

Gurit offers a full range of hinges with different capacities and arm sizes catered to blade mould sizes from 50 to 150 m. The turning system can precisely close the two halves of the mould and control angular positions.

Gurit’s hinge portfolio includes arms with sizes and torque capacities ranging from 320 to 800 kNm. Latest hinge generations are modular what enables a fast and low-cost installation, providing the ability to expand and reconfigure the system.

Hinge portfolio:
- V58: Advanced sensing enabling industry 4.0 solutions
- GTT-200: Widest used hinge in moulds <80M long
- GTT-258 Hinge of choice for moulds >80M long

### Specification

<table>
<thead>
<tr>
<th>Specification</th>
<th>V58</th>
<th>GTT200</th>
<th>GTT258</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
<td>340-480</td>
<td></td>
<td></td>
<td>V (3ph)</td>
</tr>
<tr>
<td>Frequency</td>
<td>50/60</td>
<td></td>
<td></td>
<td>Hz</td>
</tr>
<tr>
<td>Torque capacity per hinge</td>
<td>367</td>
<td>550</td>
<td>800</td>
<td>kNm</td>
</tr>
<tr>
<td>Number of hinges per mold</td>
<td>10</td>
<td>12.5</td>
<td>18.75</td>
<td>Ton</td>
</tr>
<tr>
<td>Weight capacity per hinge</td>
<td>Acc. to spec.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hinge Maximum working pressure</td>
<td>280</td>
<td>320</td>
<td>320</td>
<td>Bar</td>
</tr>
<tr>
<td>Rotation time</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>Min</td>
</tr>
<tr>
<td>Number of jacks</td>
<td>Acc. to spec.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jack maximum lifting force per jack</td>
<td>85</td>
<td>98</td>
<td>98</td>
<td>kN</td>
</tr>
<tr>
<td>Jack maximum working pressure</td>
<td>280</td>
<td>320</td>
<td>320</td>
<td>Bar</td>
</tr>
</tbody>
</table>
2. Automated blade assembly

Gurit offers a broad range of tools to precisely assemble prefabs onto a blade shell mould. The automated solutions aid to securely holding and precisely locating the inner components of a blade. Gurit’s gantry system is designed with optimal strength and stability, while respecting the wind blade industry’s increasingly tight tolerances and increasingly large blades.

<table>
<thead>
<tr>
<th>Production stage</th>
<th>De-moulding tool</th>
<th>De-moulding &amp; auto flip tool</th>
<th>Assembly tool</th>
<th>Gantry</th>
</tr>
</thead>
<tbody>
<tr>
<td>De-mould</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flip &amp; rotate 90°</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Assembly: Install spacers</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Store finished part set</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Place on mould</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Dry fit</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Bond webs on shells</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Disengage from mould</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Park</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Apply gelcoat</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>
3. **Modular webs positioning device gantry ("Galactica")**

The webs gantry system allows for easy lifting, bonding and positioning of the webs parts during blade assembly. The system includes a loading station for the gantry structure. The gantry is positioned on the mould's suction or pressure sides without requiring external actuators other than Gurit’s mould jacks & clamps.

The webs gantry system main truss is modularized and of variable height to minimize overhead gantry hook height requirements. The main truss can be disassembled into segments and fully containerized for efficient transportation. The gantry system minimizes capital investment by using the hydraulic lifting and clamping system already available in the mould. The system’s operation time is minimized with most mounted components having full rough adjustment possibility.

The system includes an automated vacuum system with suction cups. The truss frame is built with seamless pipe that acts as an accumulator to aid in the holding force in the instance of any leaks or short duration power loss. Electro clamps or UPS for the vacuum pump are available as upgrades.
<table>
<thead>
<tr>
<th>Sample configuration</th>
<th>Modular truss</th>
<th>Adj. legs</th>
<th>Swing arms</th>
<th>End clamps</th>
<th>Suction Cups</th>
<th>Align devices</th>
<th>Load station</th>
</tr>
</thead>
<tbody>
<tr>
<td>Featured</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Vacuum pump</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>According to requirement</td>
</tr>
<tr>
<td>Suction cups</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>According to requirement</td>
</tr>
<tr>
<td>Power outage protection option 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Manual lifting slings</td>
</tr>
<tr>
<td>Power outage protection option 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Automatic mechanical clamp</td>
</tr>
<tr>
<td>Power outage protection option 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Vacuum beam accumulator</td>
</tr>
<tr>
<td>Power outage protection option 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>UPS</td>
</tr>
<tr>
<td>Support legs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fitted to mould hydraulic jack &amp; clamp system or Shear web alignment clamping (SWAC)</td>
</tr>
<tr>
<td>Alignment devices</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mating metal blocks fitted to the mould frame</td>
</tr>
<tr>
<td>Accuracy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Height: +/- 100 mm / Length: +/- 50 mm / Chordwise: +/- 30mm</td>
</tr>
<tr>
<td>Operation time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;15 min (Loading, bonding and disengagement)</td>
</tr>
<tr>
<td>Weight</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>19300 Kg.</td>
</tr>
<tr>
<td>WLL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1500 Kg.</td>
</tr>
<tr>
<td>Crane requirement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2x 10000 Kg. overhead cranes</td>
</tr>
<tr>
<td>Min. Crane hook height</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8M</td>
</tr>
</tbody>
</table>
| Sample process flow  |              |           |            |            |              |               | #1: Load from station  
|                      |              |           |            |            |              |               | #2: Place on mould  
|                      |              |           |            |            |              |               | #3: Dry fit  
|                      |              |           |            |            |              |               | #4: Bond webs  
|                      |              |           |            |            |              |               | #5: Disengage from mould  
|                      |              |           |            |            |              |               | #6: Park |
4. **Shear web alignment clamping**

The SWAC System is designed with optimal strength and stability to raise and lower the shear web gantry and other components, while respecting the wind blade industry’s increasingly tight tolerances. The SWAC system greatly reduces production time by precisely positioning the shear web gantry within seconds, at the push of a button.

- **Remotely Controlled**
  The SWAC system is installed onto the shear web gantry and allows for remotely raising and lowering of the gantry.

- **Alignment Precision**
  The SWAC ensures repeatable chord-wise and span-wise alignment between the shear web and a mould half.

- **Optimal strength**
  The SWAC is designed with optimal strength, respecting the wind blade industry’s increasingly tight tolerances and increasingly large blades.

### System specifications

<table>
<thead>
<tr>
<th></th>
<th>SWAC</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated force per actuator (vertical installation)</td>
<td>2000</td>
<td>kgF</td>
</tr>
<tr>
<td>Linear travel</td>
<td>250</td>
<td>mm</td>
</tr>
<tr>
<td>Rated power per actuator</td>
<td>0.37</td>
<td>kW</td>
</tr>
<tr>
<td>Maximum power per actuator</td>
<td>0.44</td>
<td>kW</td>
</tr>
<tr>
<td>System supply voltage</td>
<td>380-480</td>
<td>V AC</td>
</tr>
<tr>
<td>System supply frequency</td>
<td>50-60</td>
<td>Hz</td>
</tr>
<tr>
<td>Individual actuator supply current</td>
<td>5</td>
<td>A</td>
</tr>
<tr>
<td>Locating tolerance (standard pin)</td>
<td>X:± 0.5; Y: ± 0.5; Z: N/A</td>
<td>mm</td>
</tr>
<tr>
<td>Locating tolerance (centering pin)</td>
<td>X:± 0.5 ; Y: ±0.5 ; Z: ± 0.5</td>
<td>mm</td>
</tr>
<tr>
<td>Actuator dimensions</td>
<td>1.05 x 0.23 x 0.2</td>
<td>m</td>
</tr>
<tr>
<td>Actuator weight (each)</td>
<td>50</td>
<td>kg</td>
</tr>
<tr>
<td>Gantry weight</td>
<td>13,000</td>
<td>kg</td>
</tr>
</tbody>
</table>
5. **Automated blade finishing and sanding**

Multi-robot grinding system for wind blade. Capable of reducing cycle time and man-power requirements while providing better surface quality and improved surface finish. The system features a dust extraction and a quick grinding head exchange mechanisms.

6. **Mould Heating**

The mould heating system used by Gurit is customized for each mould. Gurit offers two types of heating systems with an option of different types of controllers.

- **Electric heating system:**

  The wind blade mould is normally divided up to 450 zones depending upon the blade structure design. Each zone includes two temperature sensors, two overheating safety switches and one heating resistance.

  Gurit Tooling offers the following two types of controllers for its mould heating system:
  
  - Integrated Heating System
  - PLC Heating System

  The in-house developed software package provides full control and supervision over an Ethernet network. It is also available with an integrated touch screen computer system to simplify the heating control system.

- **Liquid heating system**

  The patented liquid heating systems from Gurit are designed for further accuracy in the production cycle. Allowing for higher temperatures with a more uniform distribution, this design ensures an even cure on all parts.

  Advantages include: easy maintenance when compared to electric heating, quick replacement equipment change-out, surface cooling, and ability to use prepreg materials.

  An integrated touch screen computer system helps to simplify the heating control system.
7. **Industry 4.0 – Smart Moulds**

A number of sensors, smart features and software options:

- **Gurit’s advanced production tools** enable significant cost and time savings. This through real time decision of the cure cycle; detection of unexpected events; online reporting and mobile push notifications.

- **Gurit’s proprietary temperature control software** is deployed globally and installed in the platforms of the top 3 blade OEM’s.

- **Heat transfer** through: air, electrical resistance or liquid.

- **Cooling systems** capable of reducing cycle times by up to 60 minutes through cooling ramps of up to 0.4 C/min.

- **Gurit’s production software** main features include:
  
  a. Surface vacuum ESCADA with automatic drop tests and vacuum level control
  
  b. Surface thermocouple ESCADA with reporting and automatic TG test.
     
     Critical areas of the part are monitored to estimate their cure percentage.
  
  c. Online curing profile adjustment
  
  d. Remote /central data warehouse
  
  e. Mobile push notifications
  
  f. Customizable quality control reports
  
  g. Localized composite repair control system
  
  h. RFID controlled access
Installation Service and Technical Support

Gurit Tooling is the only company which provides local to local customer services globally. Our team is present in America, Europe and Asia, ready to provide fast support both on site, and on call. Our services include the commissioning and decommissioning of moulds, periodical maintenance, and the training of operation and maintenance personnel.

Our highly skilled team is always prepared to support customers with automation equipment, precision measurement with laser tracker, composite materials, welding, machining, and more.

Engineering Design and Support

Our engineering team has over a decade of experience in providing customers with complete design solutions, working closely with clients to fully understand their needs. We can quickly integrate our products with client’s systems, as well as provide customized structural, mechanical, control and automation solutions.
8. Contacts

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About Gurit

Gurit develops and manufactures advanced composite materials, composite tooling equipment, blade manufacturing automation and provides core kitting services. The product range comprises, structural core materials, fibre reinforced prepregs, formulated products including coatings, resins and adhesives as well as structural composite engineering. Gurit supplies global growth markets such as the wind turbine industry, aerospace, marine, rail and many more. Gurit operates production sites and offices in Canada, China, Denmark, Ecuador, Germany, Indonesia, India, Italy, New Zealand, Poland, Spain, Switzerland, Turkey, United Kingdom and the United States.

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