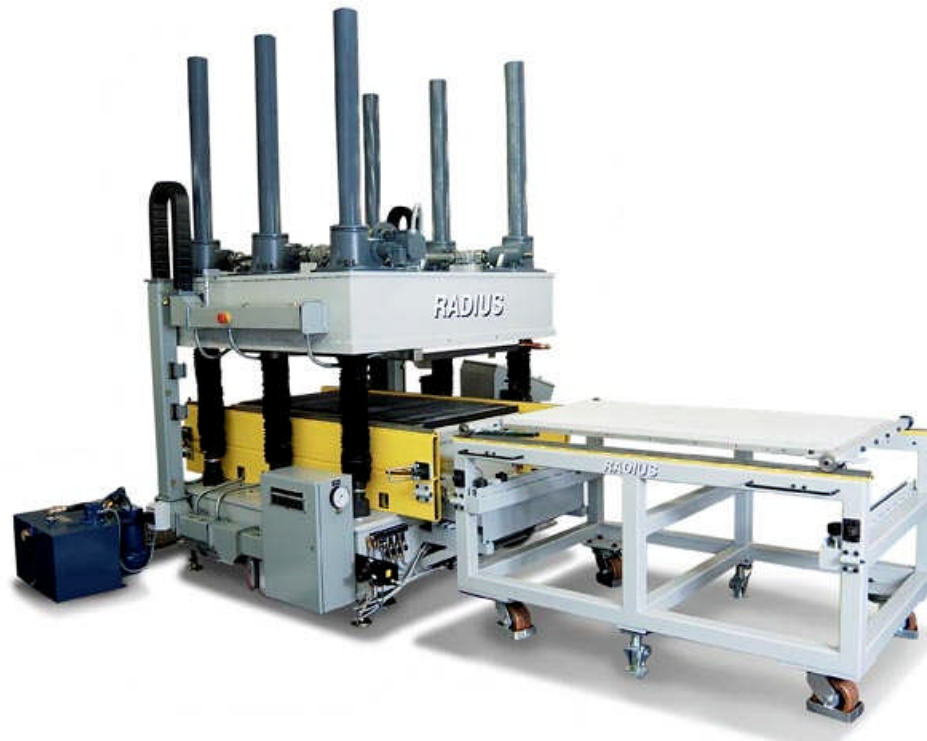


Radius Workstations Provide Superior Alternatives in RTM and SQRTM manufacturing

- ▶ Presses vs. Self-clamped tooling
- ▶ Pneumatic Presses vs. Hydraulic Presses
- ▶ Electric Platen Heating vs. Hot Oil Heating
- ▶ Integrated SCADA software vs. Generic solutions
- ▶ Why choose Radius Engineering?

Presses Are An Efficient Structural Solution When Compared to Self-Clamped Tooling

- ▶ Main purpose of an Press in closed mold composites manufacturing is to maintain the shape of the tool while under high internal injection pressure (150 psi).



The Perils and Costs of Self-clamped Tooling are Numerous

Example Tool: 1m x 3m x .4m

Material Thickness (Tool wall) : 50 mm

Tool Mass: 10,000 kg

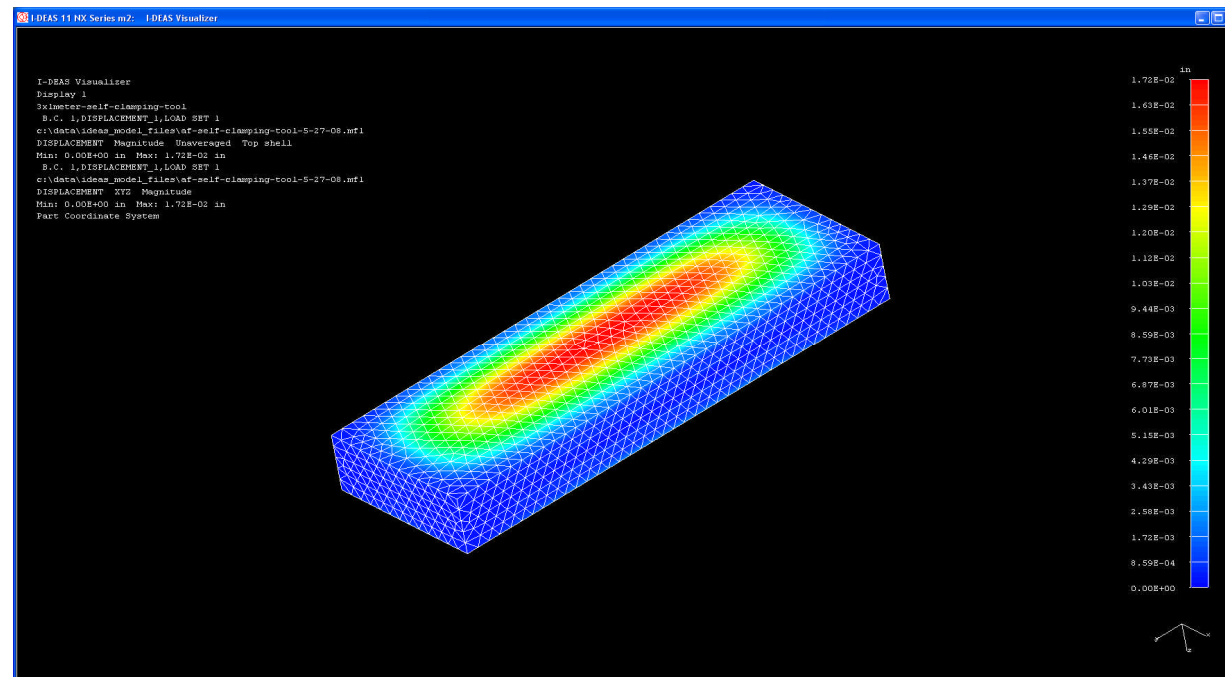
Internal Pressure : 150 psi, (10.3 bar)

90 M24 bolts required to keep tool closed; even so, bolt stretch = .13 mm

Maximum deflection of tool = 0.44 mm (far in excess of aerospace tolerances)

Excess resin injected = approx. 900cc: Fiber volume likely unacceptable

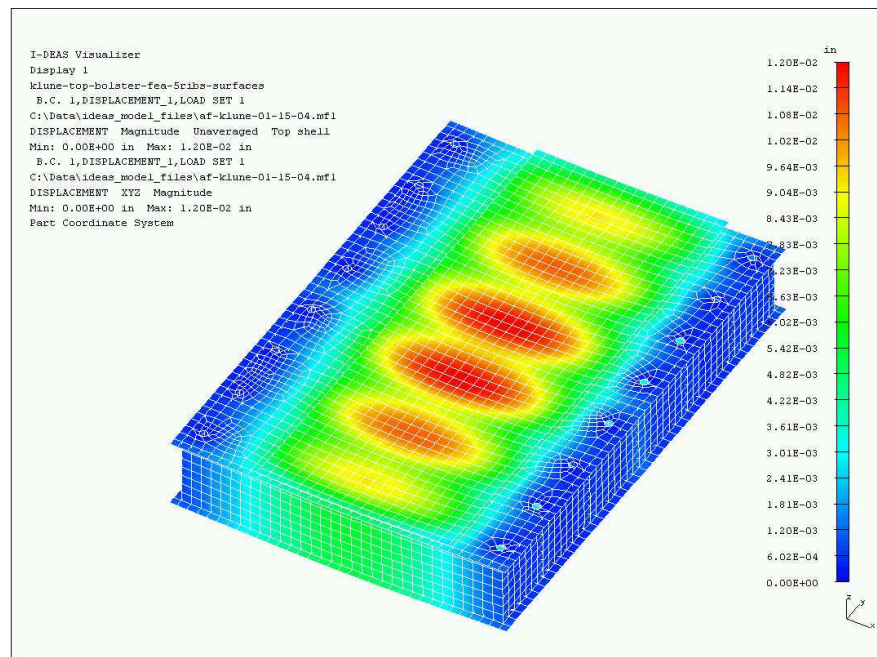
Costs for rigidity and heating are sunk in every tool



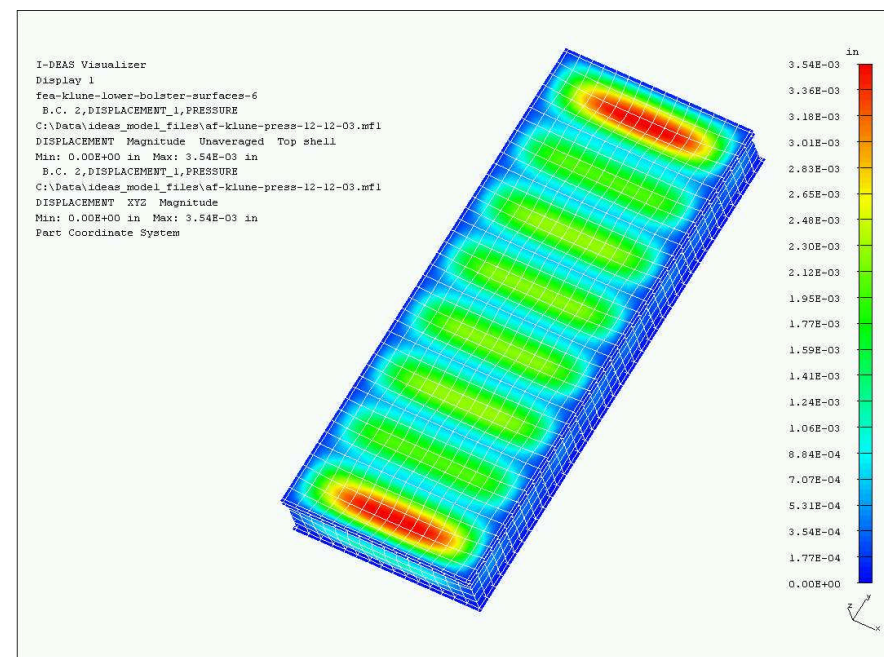
Radius' Welded Bolster RTM Pneumatic Press Maintains All Tolerances

- ▶ Bolsters designed with FEA analysis to maintain < .125mm tool deflection across the entire surface of the tool.

Upper Bolster

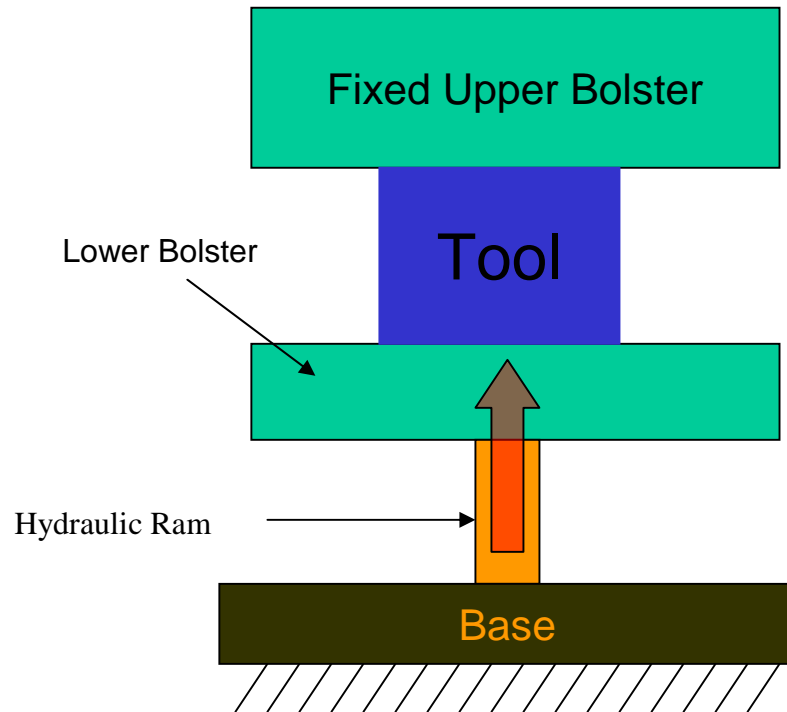


Lower Bolster



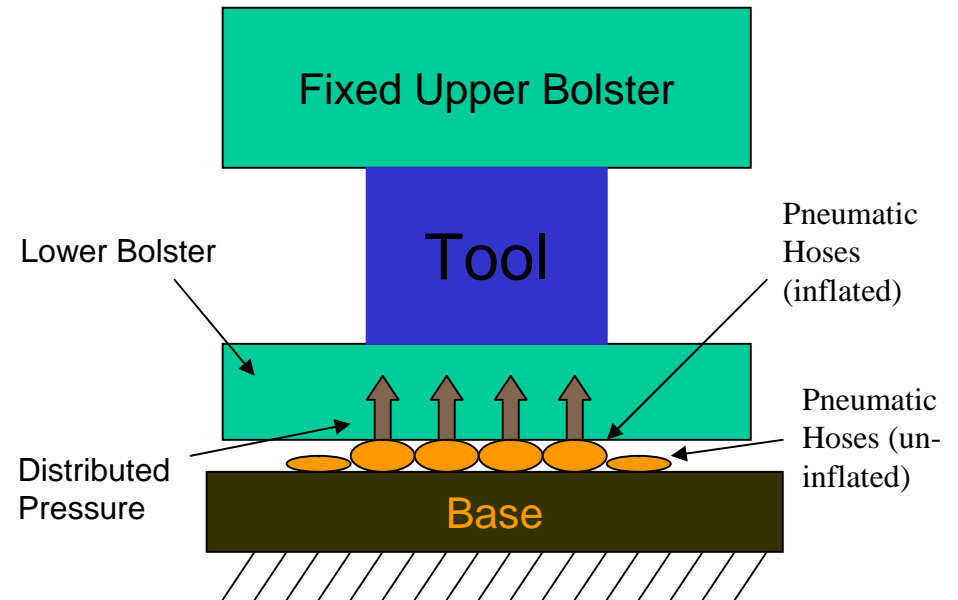
Pneumatic Presses Offer Significant Advantages Compared to Hydraulic Presses for Net-Shape Composites

Center Hydraulic Ram



- Hydraulic ram pushes only at center of tool.
- Pressure will be concentrated in tool center.

Radius Pneumatic Hose



- Pneumatic hoses apply pressure evenly across the entire tool.
- Pressure distribution is not concentrated.
- Number of inflated hose can be adjusted for a given tool width.

Hydraulic Presses Are Poorly Suited for RTM/SQRTM



- 300 Ton hydraulic press actuated through either single or multiple hydraulic cylinders.
- Requires hydraulic pressures up to 5,000 psi; hydraulic fluid is an unwelcome contaminant in the molding area
- Upper bolster moves as a single piece, i.e., cannot float to compensate for any misalignment, such as during initial tool closure, which can easily damage the tool
- Force applied at one or four cylinder locations – more massive structure has higher installed cost due to the need for special foundations
- Noise, operating cost, and lifecycle maintenance are relatively high

Radius Pneumatic Press are Specifically Designed for RTM/SQRTM Process



- Electrically adjustable upper bolster accommodates large tooling range with minimum moving parts or noise
- Pneumatic hose pressurization raises lower bolster, creating uniform clamping force on tool.
- Lower bolster “floats” on pneumatic hose bed, allowing adjustments in alignment due to tool variations during closure
- Clamping force evenly distributed.
- Number of pneumatic hoses inflated can be optimized for a given tool width.
- Clamping force generated by shop air, with minimum energy use
- No oil in system, eliminates possible composite part contamination.

Electric Platen Heating is Significantly More Economical Than Hot Oil Heating



Radius Engineering
cast Aluminum platen
with internal heating
and cooling – 20 kW



Gaumer 300 kW oil
heater w/ 15 hp pump
(2.5m x 1.5m x. 2.25m, 1500 kg,
600 l oil reservoir)

Example Tool Power Consumption Significantly Less with Electric Heat

- ▶ Tool size = 14m x 1.4m x .3m
- ▶ Material = Aluminum
- ▶ Heating Rate = 2.0°C/Min (3.6°F/Min)
- ▶ Required power to heat tool mass only = 530,000 watts (1,420,000 btu/hr)
- ▶ Power required using electric platen heat = 700,000 watts (1,870,000 btu/hr);
1,000 Amps @ 400 VAC / 3 phase
 - This includes the mass of the aluminum heating platens
- ▶ Power required using circulating oil heat = 885,000 watts (2,350,000 btu/hr);
1,280 Amps @ 400 VAC / 3 phase
 - The additional power is for heating the oil, steel oil heater structure, steel platens and the 20kW hot oil pump
 - This includes the mass of the steel oil heating platens
- ▶ Oil heating system consumes 28% more power!

Electric Heating Advantages are Numerous

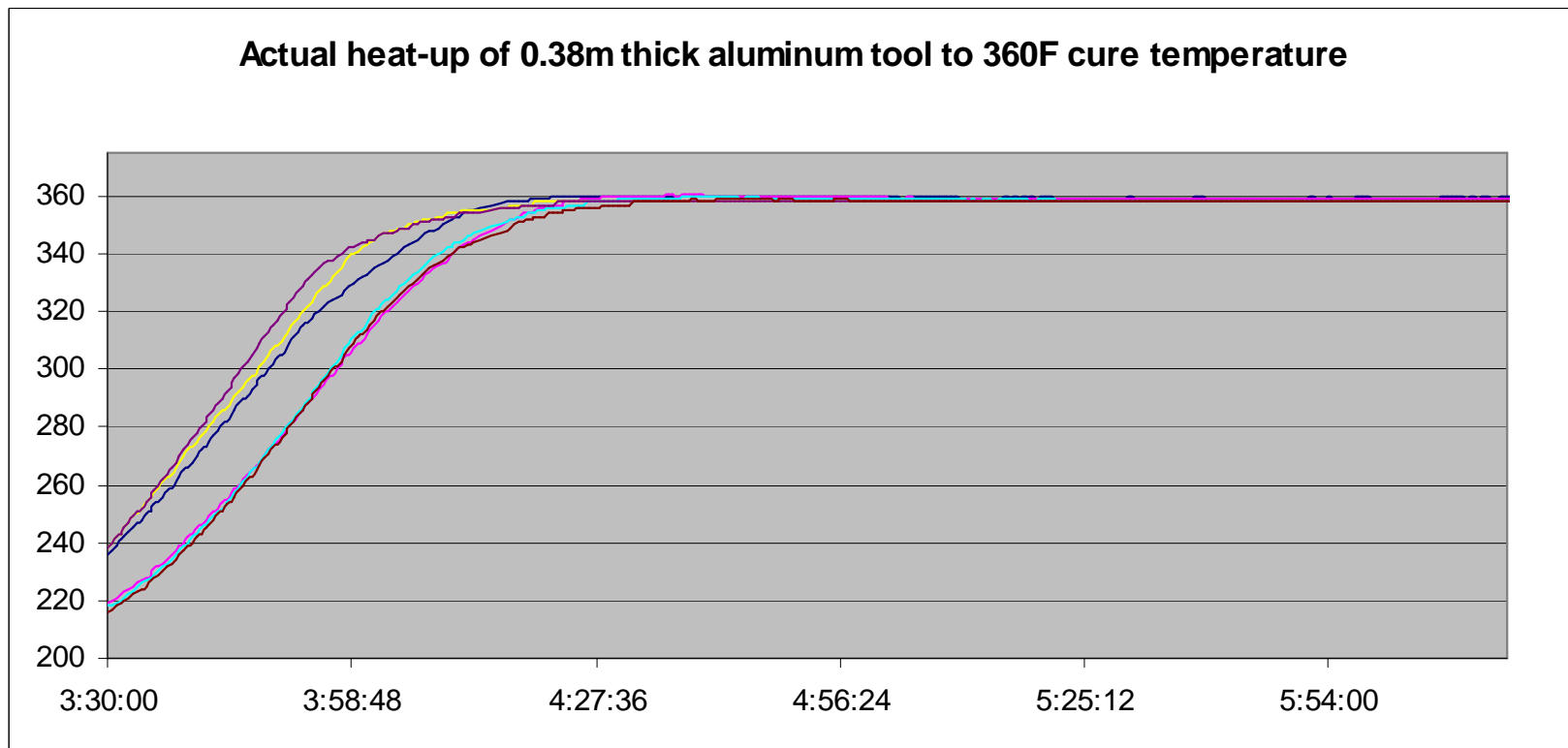
Electric heating platen

- ▶ Maximum efficiency – no energy wasted in thermal transfer
- ▶ Extremely safe operating environment
- ▶ Each platen is individually controlled for maximum heat-up and uniformity (for example: a 14 meter press has 40 individually controlled heating zones)
- ▶ Easily replaceable with a minimum of spare parts
- ▶ Requires no preventative maintenance
- ▶ Each platen can be manufactured with integral

Hot Oil Heating

- ▶ In Example Tool, 640,000 btu used just to heat the oil and heating system (28% more power required!)
- ▶ Requires pumping and storage of 200°C oil at high pressure.
- ▶ Malfunction of the oil circulating pump or hydraulic pump disables the press.
- ▶ Hot oil releases fumes
- ▶ Single zone temperature control only
- ▶ Large stock of spare parts
- ▶ Requires preventive maintenance and inspection with qualified personnel
- ▶ Requires periodic oil changes
- ▶ Additional floor space and plumbing is required
- ▶ Oil leaks are inevitable
- ▶ Additional heat exchanger is required for cooling
- ▶ Local code may require additional fire suppression system

Actual large tool run using 7,500 kg tool demonstrates temperature uniformity using cast aluminum heating platens



Radius Integrated SCADA Software Provides Centralized, Secure Process Control for Press and Injection Systems

Radius PressWare™ SCADA software Features Include:

- ▶ Dedicated Control and Data Acquisition software designed to allow the operator to control both the injection and cure cycles.
- ▶ Standard, easy to read .csv data files contain all of the customers required data for each production run.
- ▶ File headers easily customizable by the end user
- ▶ One PC can communicate with up to 8 pieces of Radius equipment
- ▶ Software written in Visual Basic for easy modification
- ▶ Design based on years of experience using Composite manufacturing equipment

Radius Engineering PressWare™ SCADA software

The collage displays five different screens from the Radius PressWare SCADA software:

- Radius PressWare 2006G Setup:** A configuration window for the current injector, showing user information (Operator, Date: 05/28/2008, Time: 01:21:29 pm) and options for data logging and equipment status.
- Radius PressWare 2006G: Press Control Screen:** A central control panel with tabs for SYSTEM/CURE SETUP, INJECTOR CONTROL PANEL, OPERATOR NOTES, REAL-TIME DATA DISPLAYS, HISTORICAL DATA DISPLAYS, and EQUIPMENT STATUS. It features a CYCLE PROGRAM STATUS table, RTM PRESS STATUS (HEATING PLATENS, TOOL TEMPERATURE, CLAMPING PRESSURE), and cycle control buttons (START, PAUSE, NEXT, ADVANCE, ABORT).
- New Cure Setup Screen 5 of 5:** A screen for creating a new cure data file, with fields for TOOL SELECTED (Cap and Rib Tool), RTM PRESS RECIPE, and INJECTION SYSTEM PROFILE. It includes a 'Delete Temporary Data File' checkbox and 'Reset Elapsed Time to 00:00:00' option.
- Radius PressWare 2006G: Systems Status:** A status window showing CURRENT INJECTION SYSTEM ALARMS (Injector RS-232 DATA LINK, INJECTION SYSTEM POWER, PISTON REFERENCE) and CURRENT RTM PRESS SYSTEM ALARMS (PRESS RS-232 DATA LINK, PRESS SYSTEM POWER). It includes 'ALARM ACKNOWLEDGE' and 'ALARM SILENCE' buttons.
- Press Recipe Editing Screen 3 of 4:** A screen for editing recipes, featuring a table with columns for STEP, WAIT, TYPE, HOLD, RATE, TEMP, SIZE, PSI, TOOL SP, and TOOL D. The table contains 10 rows of data. Below the table are buttons for 'ADD', 'EDIT', 'DELETE', 'BACK', 'NEXT', 'CANCEL', and 'FINISH'.

Why Choose Radius Engineering?

- ▶ Industry leader in integrated manufacturing equipment for the composites industry
- ▶ OEM equipment designer and manufacturer can customize solutions for the end user
- ▶ State of the art analysis tools and control systems assure a quality process
- ▶ Complete Turn-Key solutions for your RTM / SQRTM press and injection systems
- ▶ World-wide installed equipment base and experience with local regulatory statutes (UL, CSA, CE, VDE, etc.)

Current Workstation Group Activities

- ▶ FY 2008
 - 2 Fixed daylight RTM Presses
 - 4 Electrically actuated RTM Presses
 - 3 Composite Noodle Forming Machines

- ▶ Current Project under design: Modular and Expandable 8m x 1.75m RTM / SQRTM Workcell

