A Study Comparing Oil and Pressurized Water for Heating of Out of Autoclave Tools

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Agenda

- Intro
- Test Objectives and Equipment
- Oil Heating
- Pressurized Water Heating
- Conclusion

Intro

Oil has been used to heat Out of Autoclave tools for many years primarily as a carry over from knowledge gained in its use with other plant equipment and plant wide heating systems.

Pressurized water, having been used for some 40 years in the injection molding arena, has major advantages over oil systems but has only recently been introduced to the composite's sector.

As a manufacturer of both oil and water systems, SINGLE Temperiertechnik GmbH, has extensive knowledge of the benefits of both systems. Current customers include: GKN Aerospace, Bombardier Aerospace, Norduyn, Airbus supplier ACE, VW, Mercedes, Audi, Parkway Aerospace, and BMW.

This paper presents data gathered from equivalent testing of these two (2) systems with a nickel tool.

Test Objectives

Goals:

1. Use equipment with similar flow rates through the tool
2. Use equipment with similar heating/cooling capacities
3. Use similar line sizes to the test tool from both test units
4. Determine ramp rates, profiles, and energy consumption for both systems

Actual equipment used:

1. In order to use units from stock, an oil unit with 2x the heating capacity, 2.8x the cooling capacity, and 1.6x the maximum rated flow as compared to the water unit was used.
2. The oil unit's inside diameters for the heating/cooling inlets were 1.8x larger than the inside diameters for the water unit's heating/cooling inlets, thereby allowing for significant gains in flow rates through the tool.

Test Equipment (Water Unit)

single
first choice in temperature control

Item	Description
Used SINGLE H0.2	12 kW Heating / 41 kW Cooling
Hours	10 Hours on unit
Power Supply	480 V/60 Hz (3 phase)
Flow	60 liters/minute rated flow
Heating Lines out to tool	10 mm I.D
Line Length	1.5 m
Number of Lines	2
Cooling lines into TCU	10 mm I.D
Line Length	3.5 m
Number of Lines	2

Test Equipment
(Water Unit)

first choice
in temperature control

Dimensions: 695 mm x 310 mm x 765 mm

Test Equipment (Oil Unit)

single
first choice in temperature control

Item	Description
Used SINGLE D0.2	24 kW Heating / 116 kW Cooling
Hours	100 Hours on unit
Power Supply	480 V/60 Hz (3 phase)
Flow	100 liters/minute rated flow
Heating Lines out to tool	18 mm
Line Length	3.5 m
Number of Lines	2
Cooling lines into TCU	15 mm I.D
Line Length	3.5 m
Number of Lines	2

Test Equipment
(Oil Unit)

single
first choice
in temperature control

Dimensions: 1.060 mm x 350 mm x 1.220 mm

Test equipment

Item	Description
Tool	Weber externally plumbed Nickel, single sided test tool
Tool Weight	35.6 Kg
Measured flow through tool (water)	25 liters
Method	Differential pressure
Measured flow through tool (oil)	28 liters
Method	Differential pressure
Ambient air temperature for test	18.3°C
Temperature probe	Atkins Series 384 Digital
Amp Meter	Fluke 442
Chilled water supply temperature	26.6°C
Flow (water)	(60 l/minute)

☼❄ Oil

first choice in temperature control

ADVANTAGES

- Offers efficiency gains of convection heating
- Has higher density, specific heat, and thermal conductivity than air
- Can heat and cool the tool in the same channels
- High temperature range (350°C)

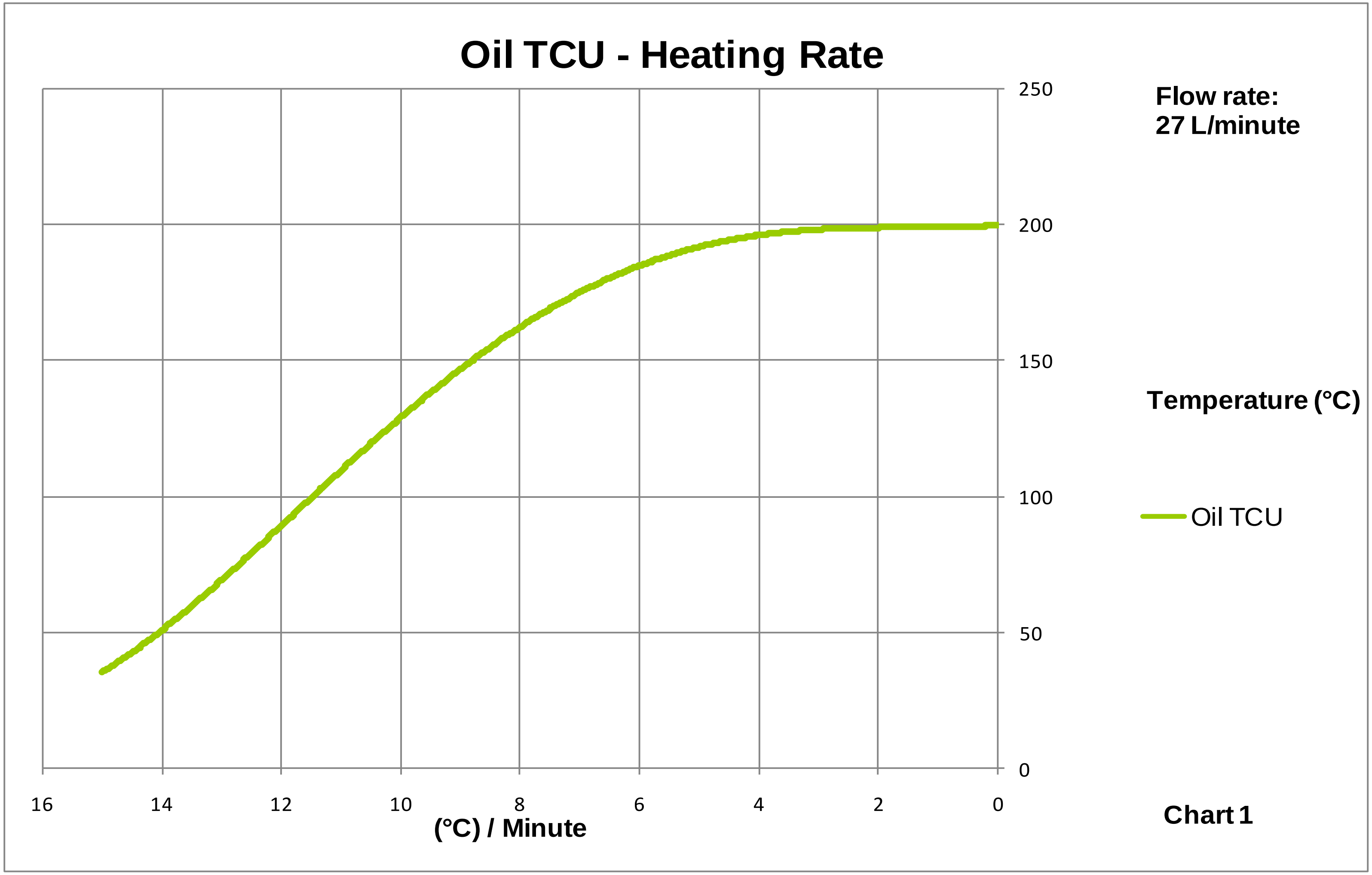
DISADVANTAGES

- More viscous than water, steam, or air
- Viscosity is very temperature dependent. Very slow to warm up in colder facilities
- Can be loud while operating due to modulation valves

Oil

- Can burn operators if a line breaks
- Have to run nitrogen over oil to minimize oxidation of oil
- Oil should be replaced every 3-5 years. $75/gal is typical
- Many Aerospace OE’s will not allow its use for composite part processing
- Not green for disposal. Many of the oils are Benzene based. A known carcinogen
- Messy during change over or the “inevitable leaking line”
- Stinky……..when running

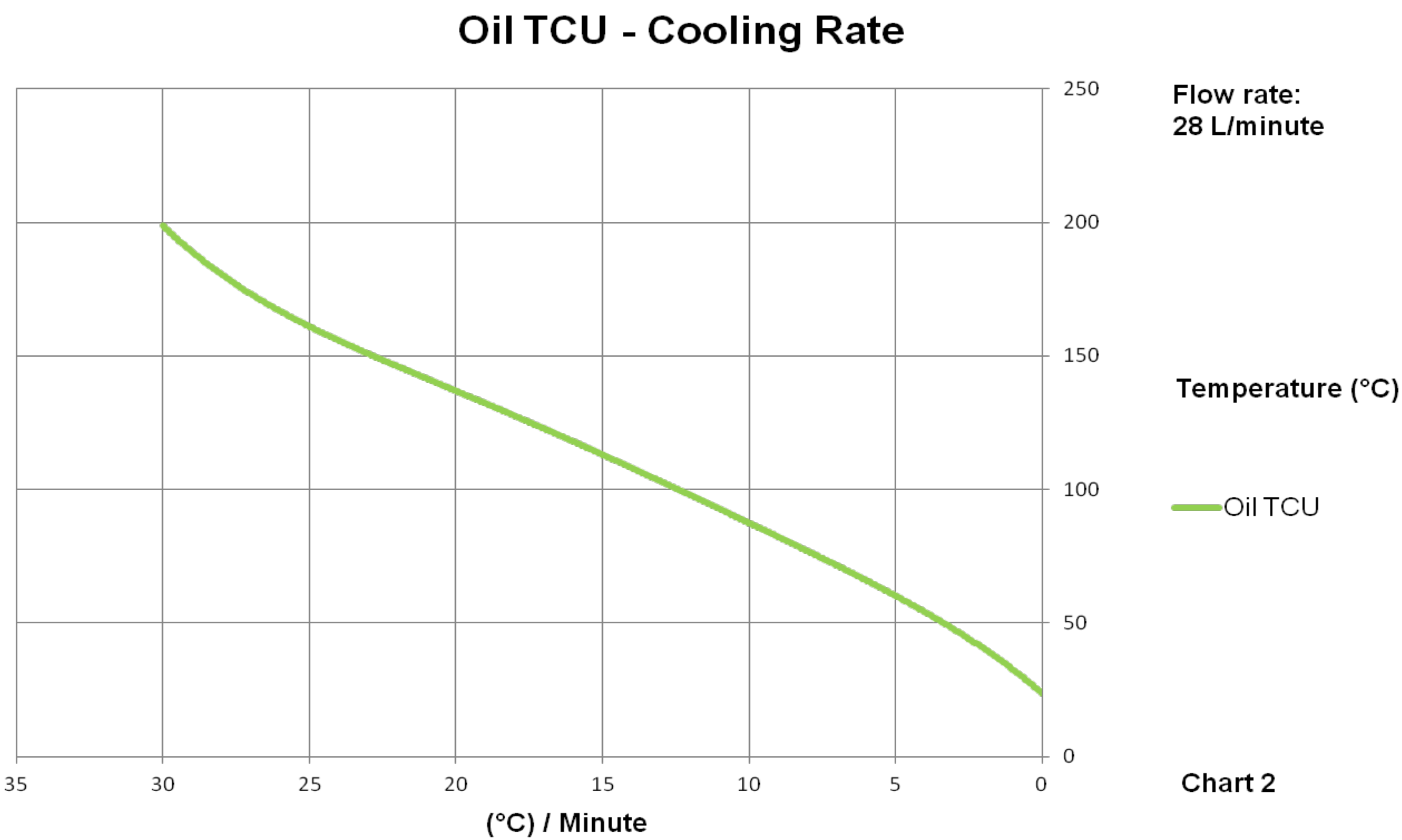
Oil



Oil TCU - Heating Rate
250
200
150
100
50
0
16
14
12
10
8
6
4
2
0
(°C) / Minute
Flow rate:
27 L/minute
Temperature (°C)
Oil TCU
Chart 1

Oil

first choice in temperature control



Oil

Flow rate:
27 L/minute

Temperature (°C)

Average temperature delta between TCU and tool: 57°C

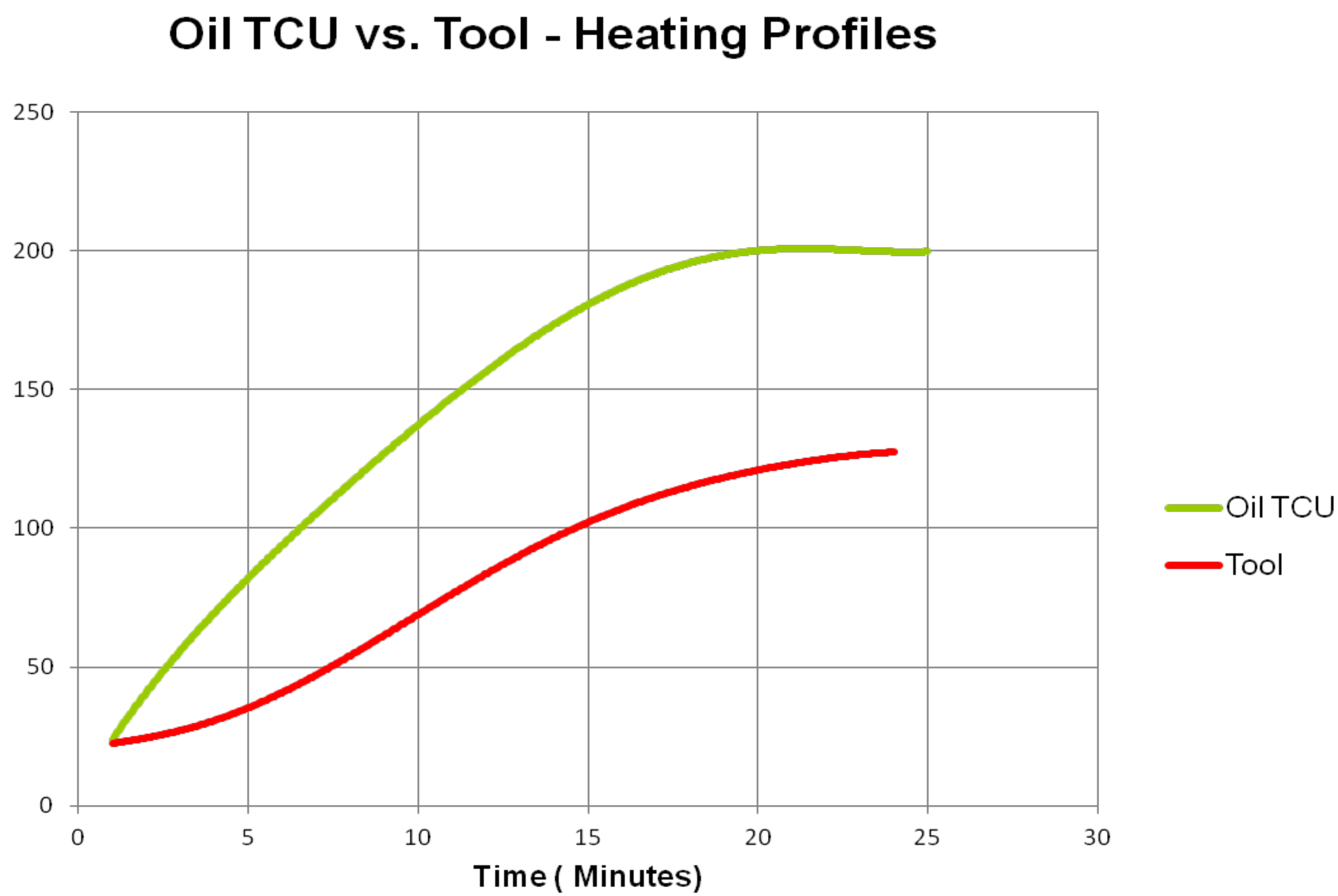


Chart 3

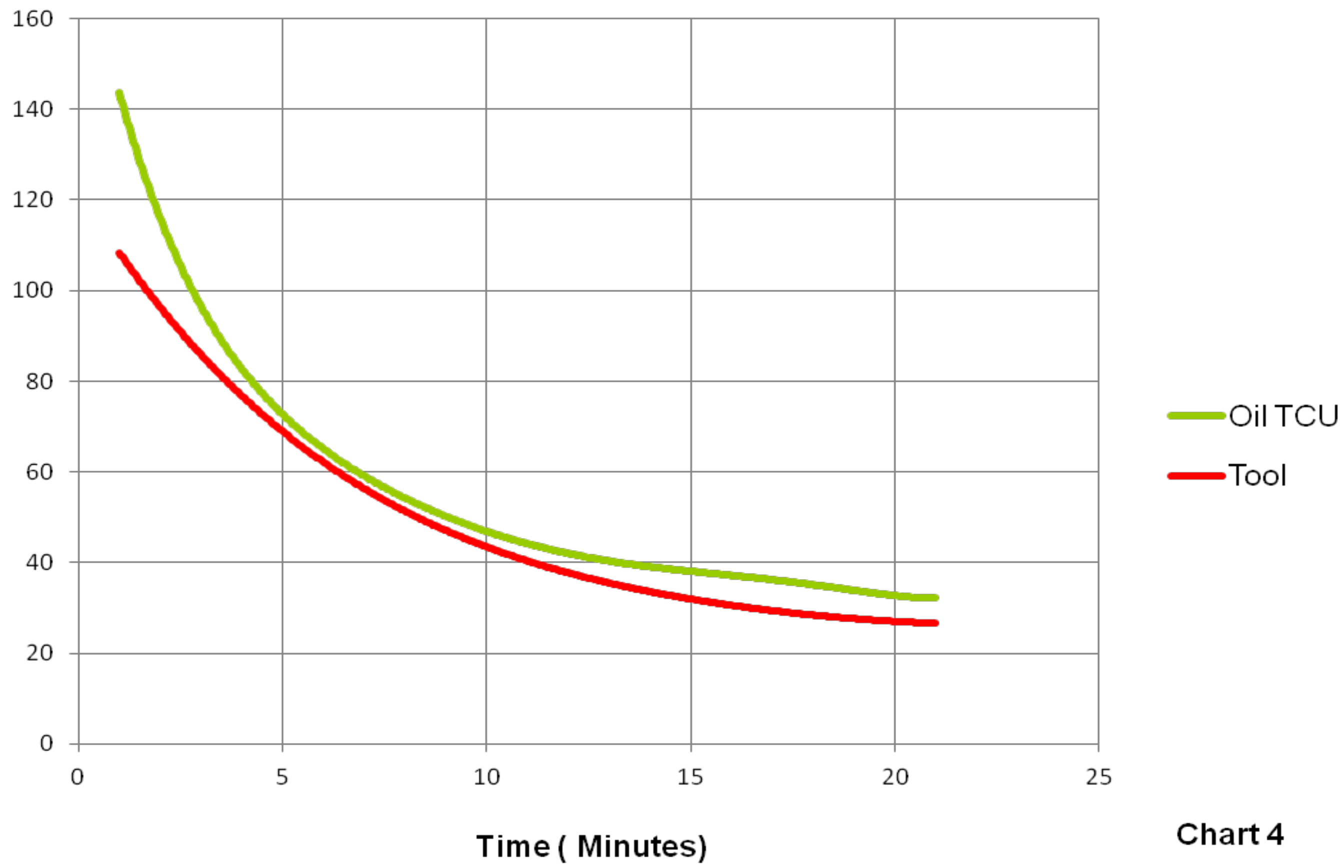
Oil

first choice
in temperature control

Oil TCU vs. Tool - Cooling Profiles

**Flow rate:
28 L/minute**

Temperature (°C)



Average temperature delta between TCU and tool: 12°C

Chart 4

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Pressurized Water

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first choice
in temperature control

ADVANTAGES

- Offers efficiency gains of convection heating
- Has higher density, specific heat, and thermal conductivity than oil or steam and has a lower viscosity
- Can heat and cool the tool in the same circuit
- High temperature range (225°C) SINGLE only
- Fast ramp rates on heat up and cool down
- Can replace oil or steam systems while reducing plant floor space requirements by 50%
- Precise temperature control as compared to electric cartridge heating or steam (+/-1°C)
- With use of quick disconnects allows for modular plant equipment designs/layouts

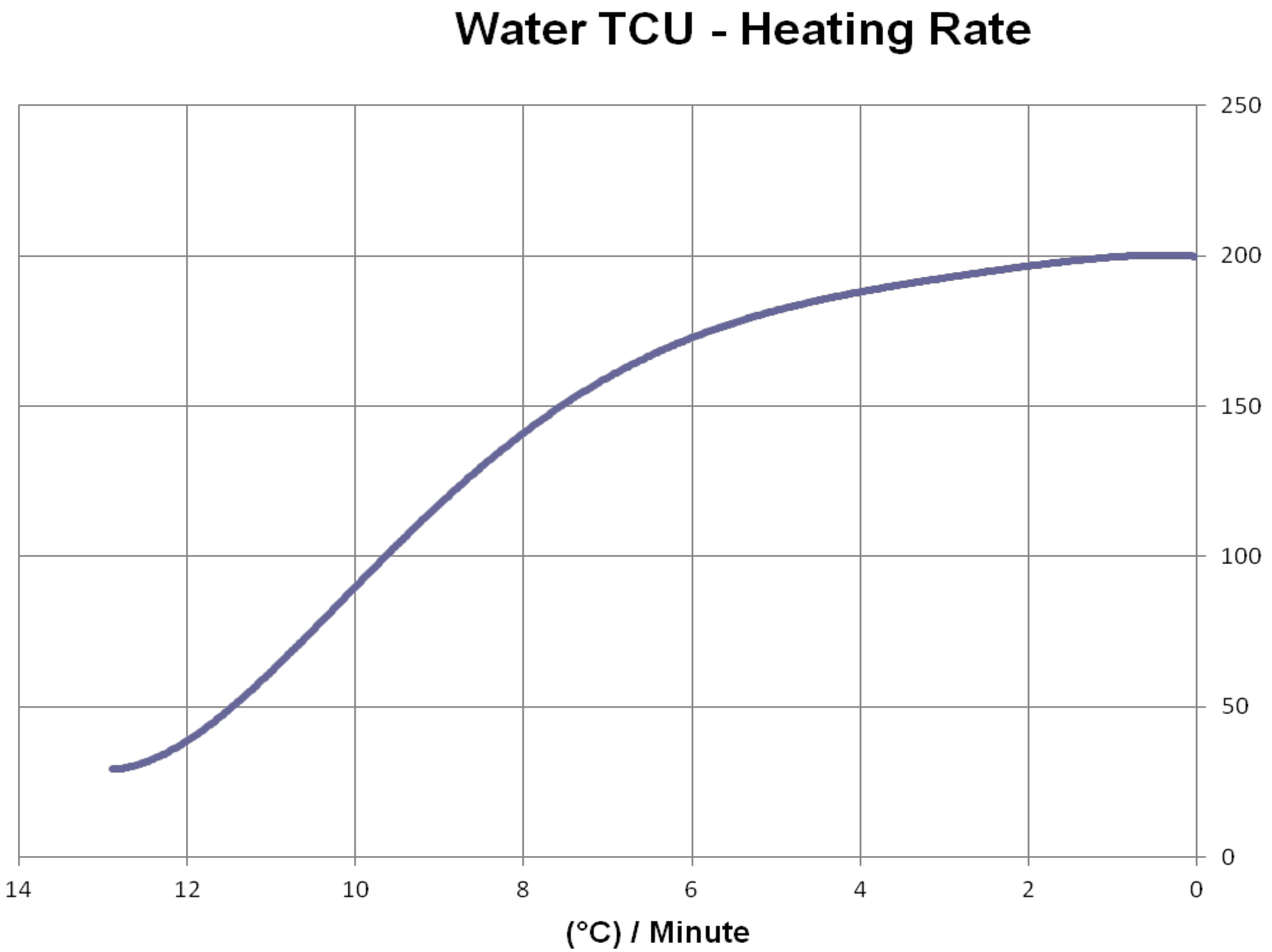
Pressurized Water

- Safe if a line breaks. Low temp water vapor due to decompression
- Low kW draw due to fluid cooling of heaters and efficient energy transfer to the medium
- Long heater life
- Enhanced process stability for thick part profiles due to the high specific heat of water (4.302 kJ/kg*K)

DISADVANTAGES

- Recommended de-mineralized water to achieve maximum performance and equipment life

Pressurized Water



Flow rate:
25 L/minute

Temperature (°C)

Chart 5

Pressurized Water

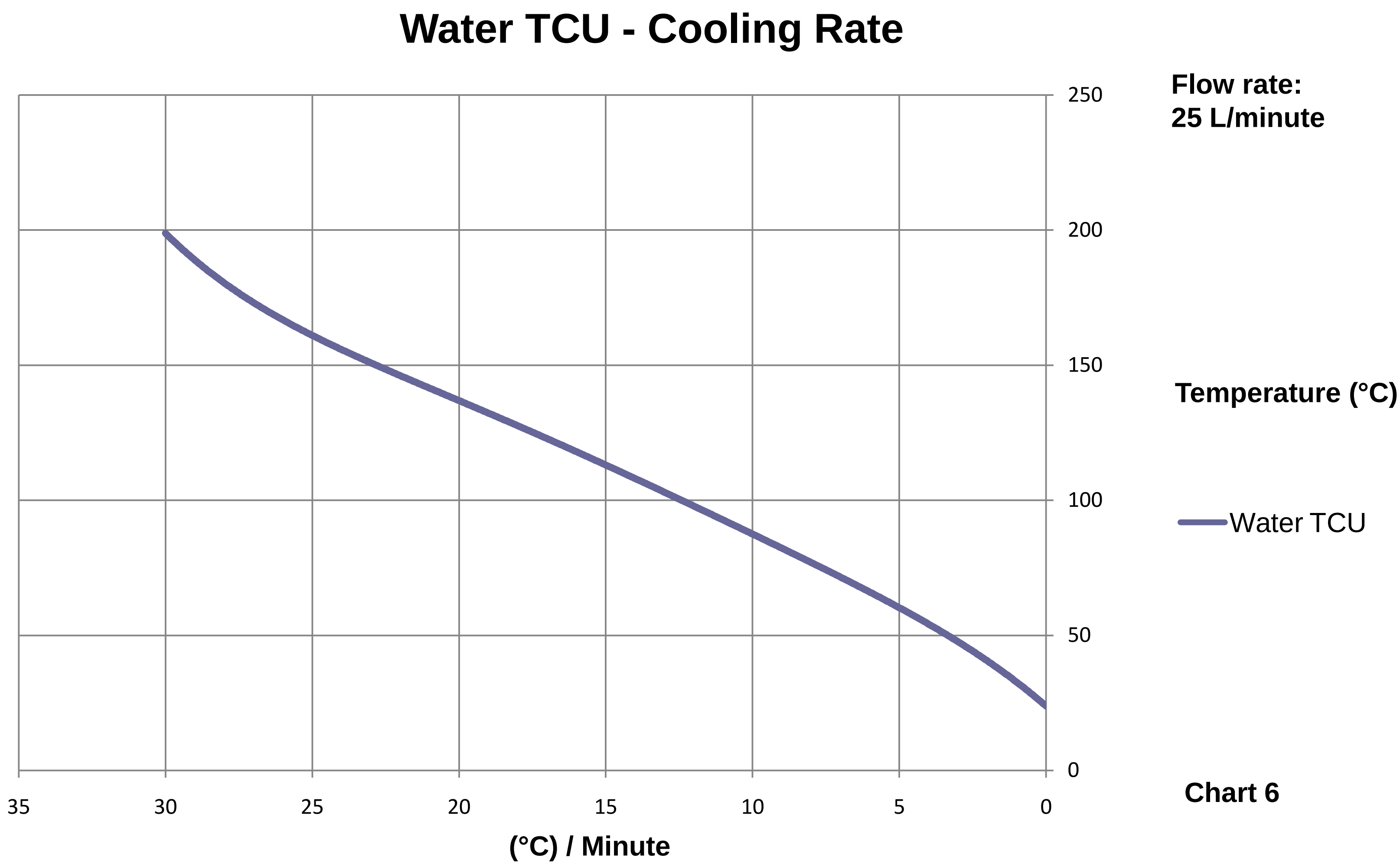


Chart 6

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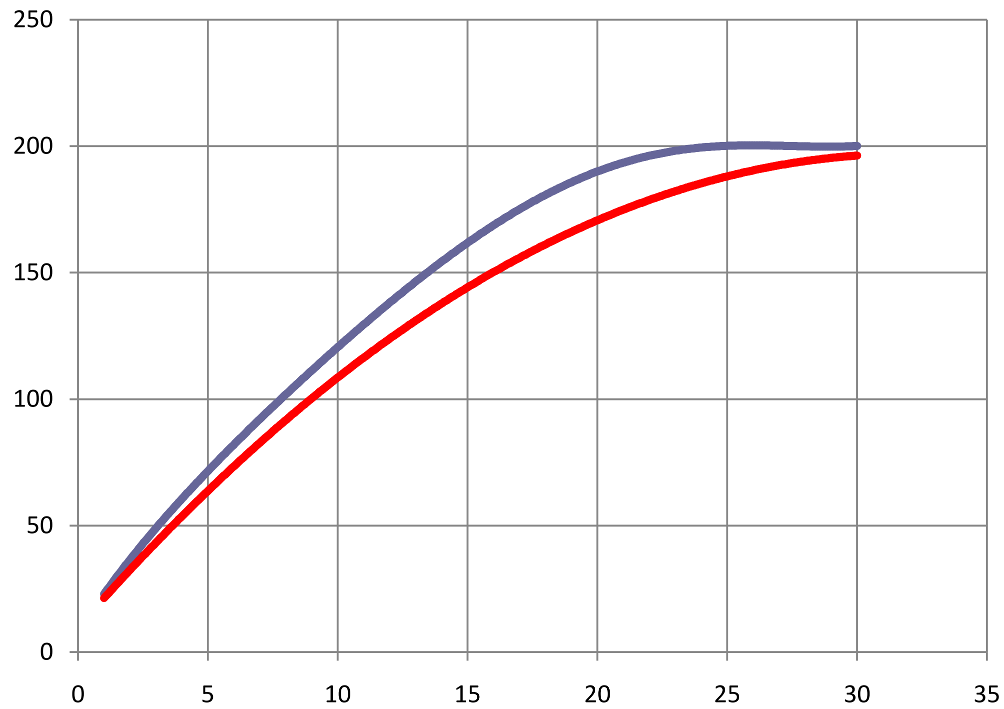
Pressurized Water

Water TCU vs. Tool - Heating Profiles

Flow rate:
25 L/minute

Temperature (°C)

Average temperature delta between TCU and tool: 12°C



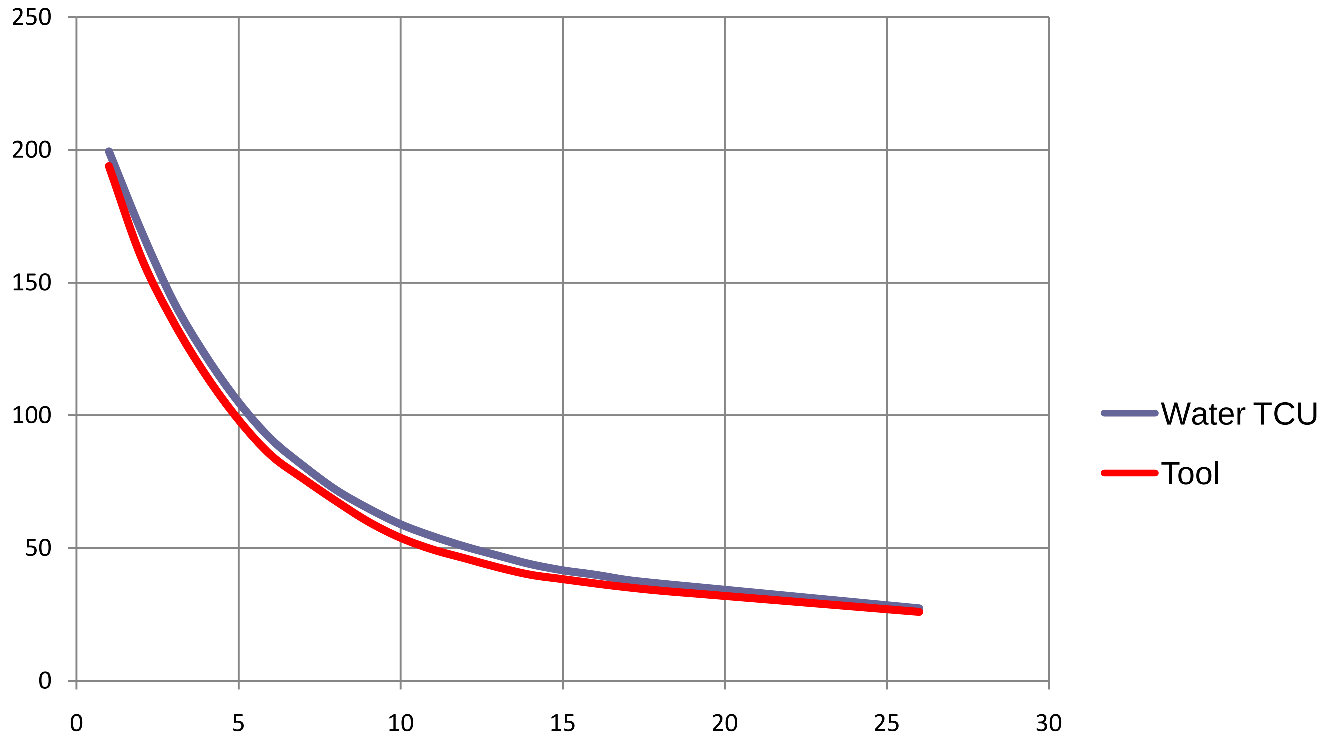
Time (Minutes)

Chart 7

Pressurized Water

Water TCU vs. Tool - Cooling Profiles

Flow rate:
25 L/minute



Temperature (°C)

Average temperature delta between TCU and tool: 4°C

Time (Minutes)

Chart 8

Conclusion

- Even with 2x the heating capacity (24kW vs. 12kW), 2.8x the cooling capacity (116 kW vs. 41kW), and 1.6x higher rated flow (100 Liters/min. vs. 60 Liters/min.), the oil unit was unable to significantly reduce heating and cooling times of the temperature control unit as compared to the water unit. (see following slides)

- The oil unit consumed 69% more electricity.

- The oil unit was unable to raise the tool to the set point temperature (200°C)

Conclusion

first choice in temperature control

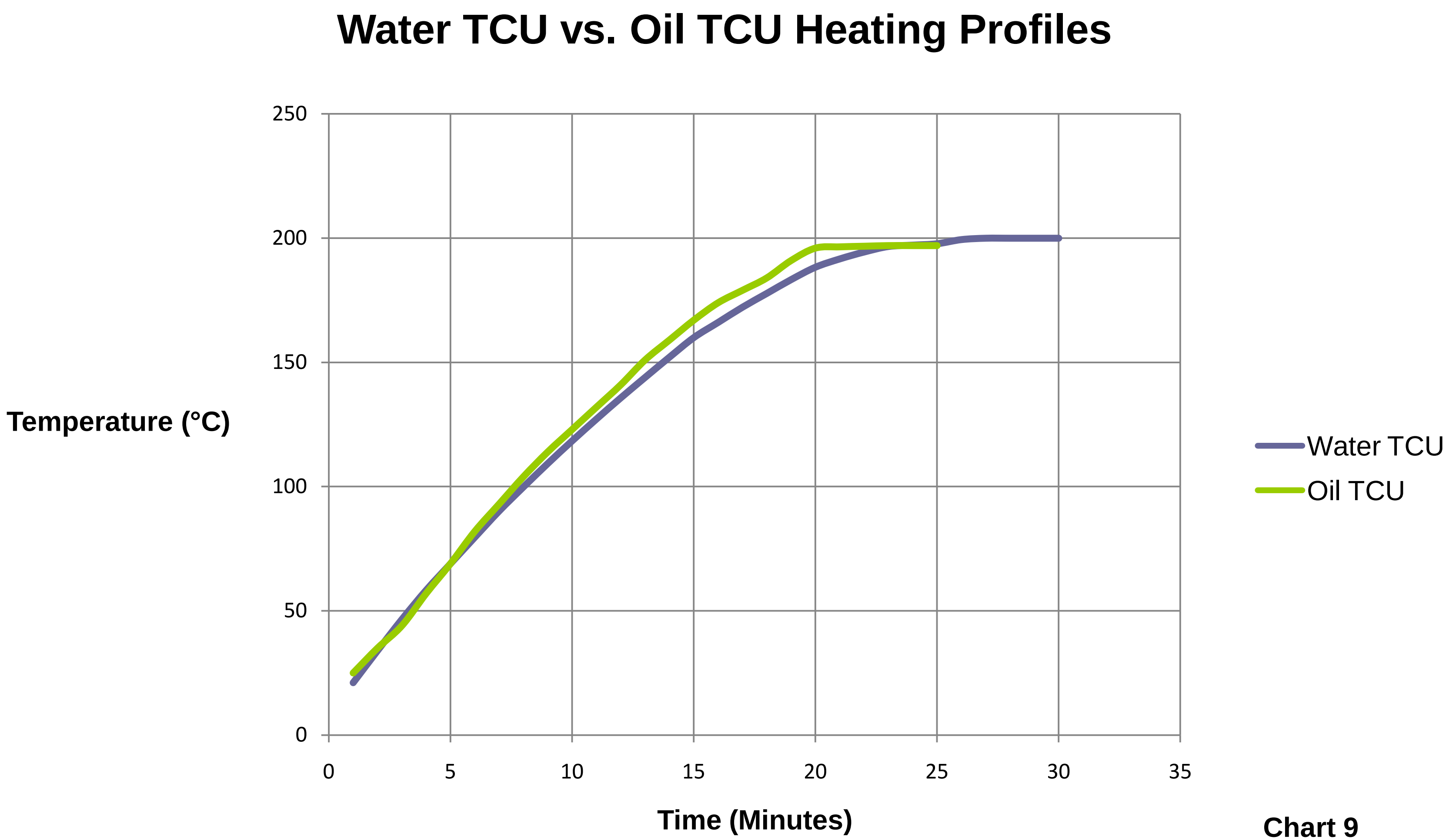


Chart 9

Conclusion

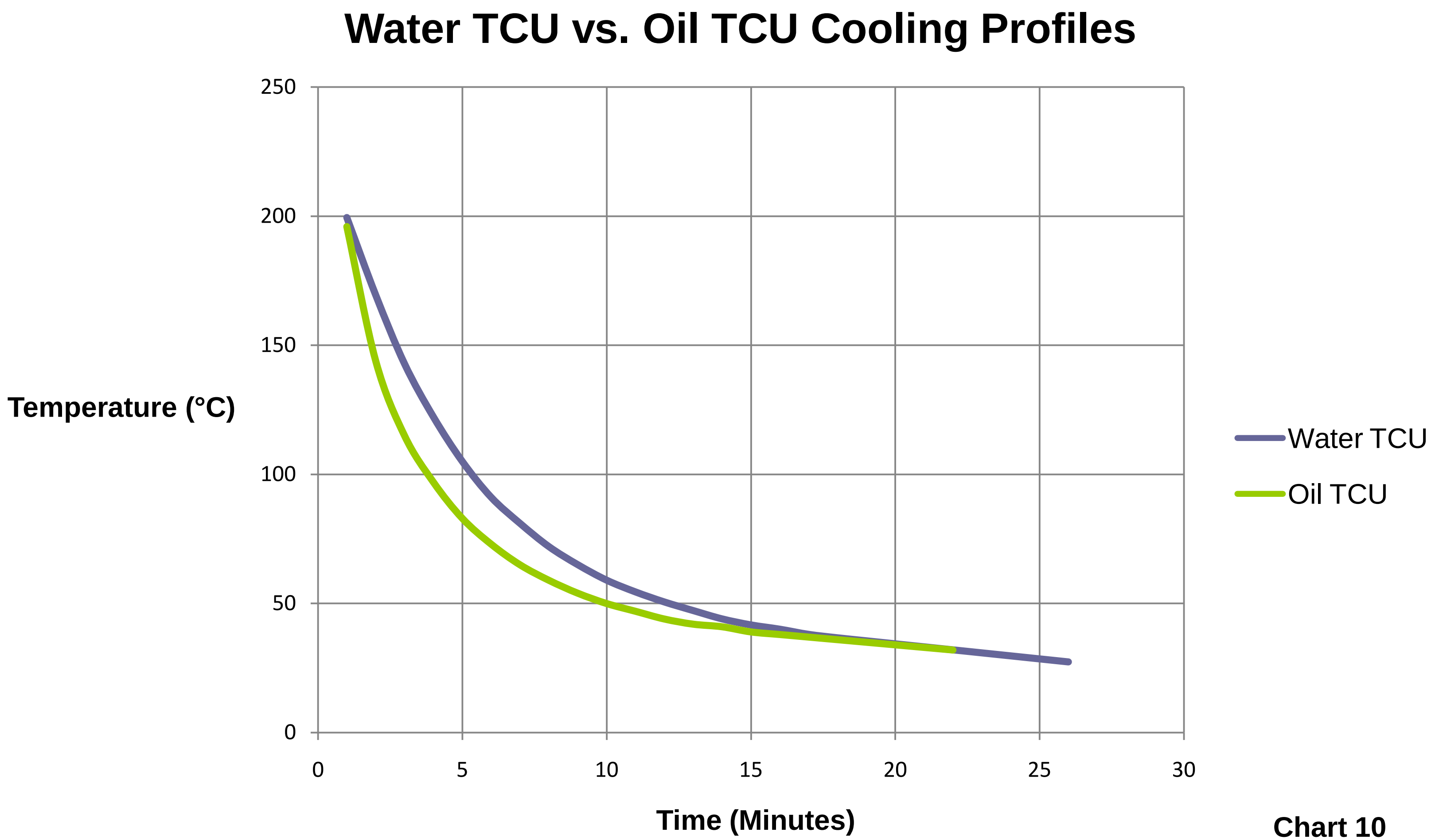


Chart 10

Conclusion

Tool (Water TCU) vs. Tool (Oil TCU) Heating Profiles

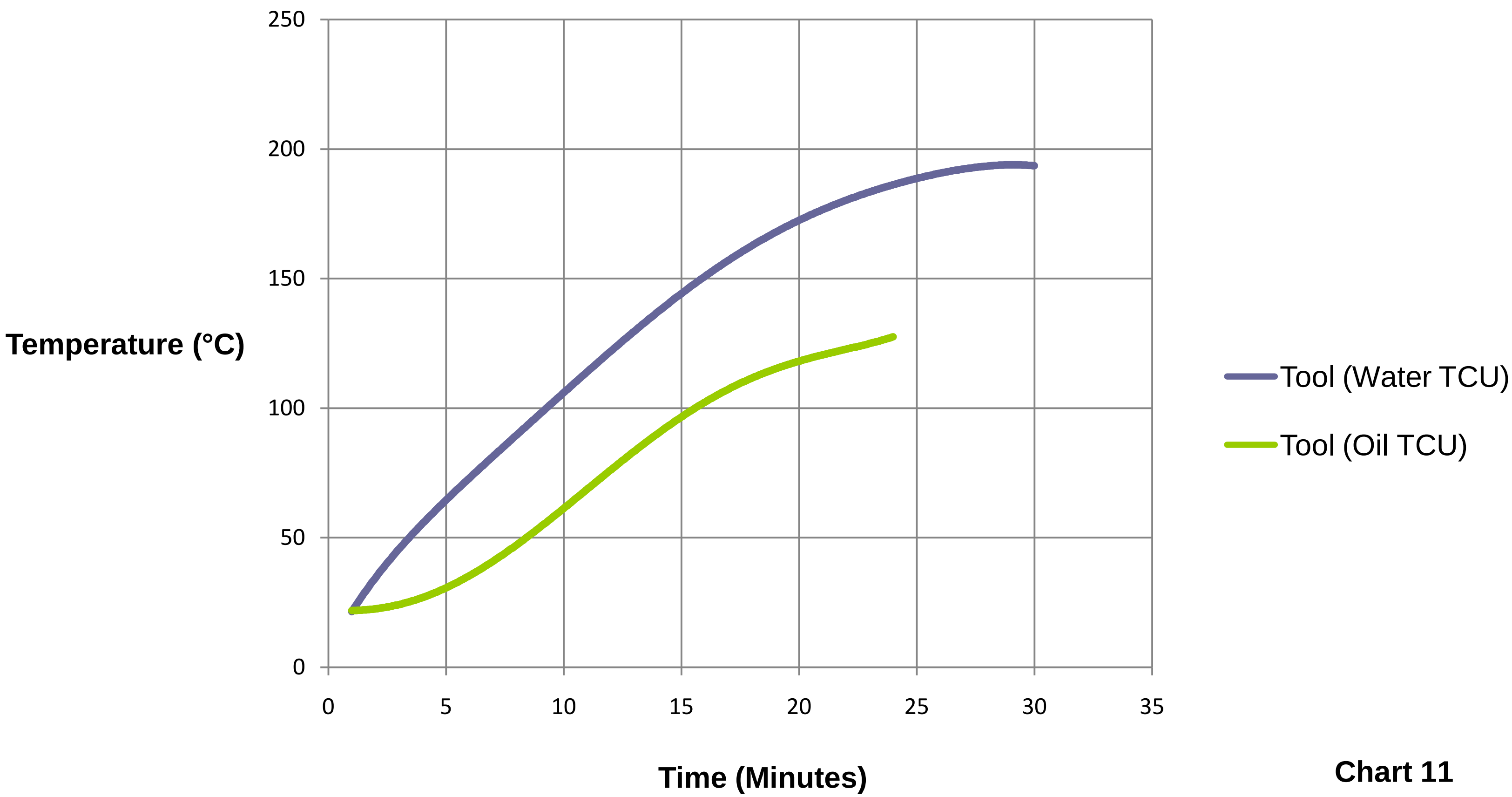


Chart 11

Conclusion

Energy Consumption Water TCU vs. Oil TCU

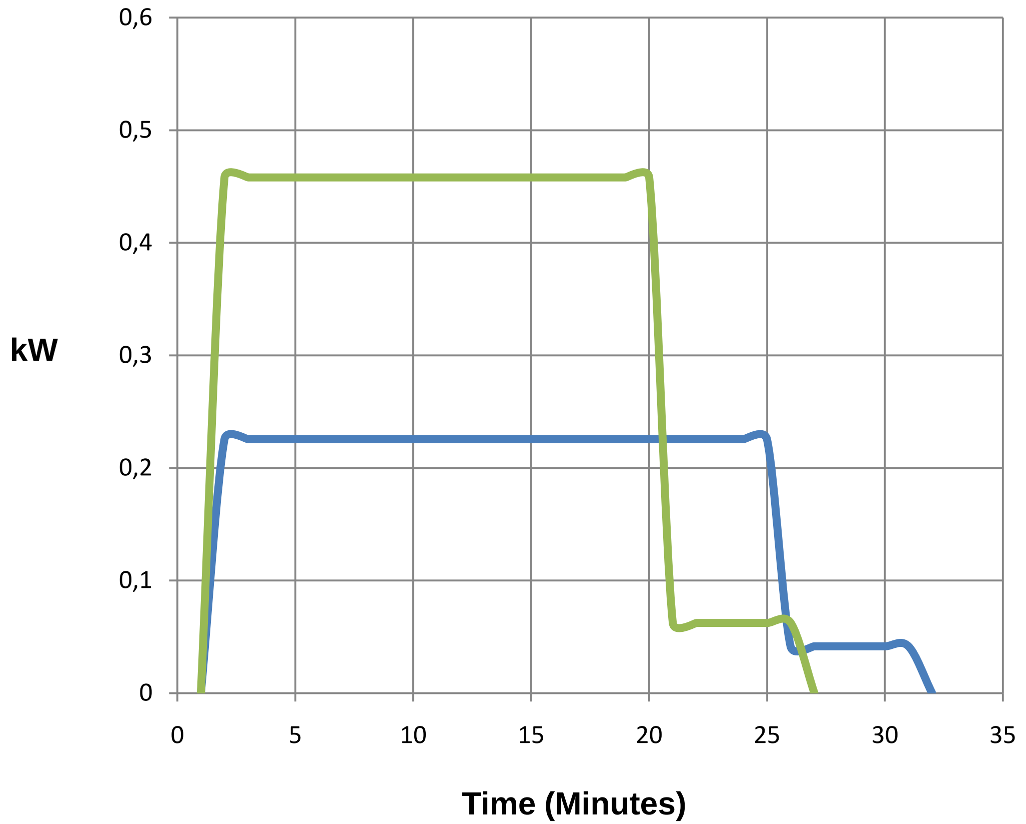


Chart 12

Conclusion

single
first choice
in temperature control

In summary, Pressurized Water units appear to:

1. Heat and cool at least 2x faster than oil units
2. Consume 69% less electricity
3. Maintain tool temperatures closer to set points
4. And take up 50% less floor space (see slides 6-8)