

# A New Standard in Reactor Temperature Control with the Highly Dynamic HAAKE DynaMax™ System

Toni Kölbl Thermo Fisher Scientific Karlsruhe, Germany

## Abstract

The new Thermo Scientific HAAKE DynaMax™ system is designed to control the temperature in jacketed reactors more efficiently than other types of temperature control systems. Its “time to temperature” is the fastest in the industry. Temperature deviation control is accomplished with the help of Dynamic Heat Load Suppression (DHLS) technology. Most importantly, the HAAKE DynaMax system is designed not only to increase yield, but also to safeguard equipment and operator. An image of the HAAKE DynaMax system connected to a reactor vessel is shown in Figure 1

## Introduction

Jacketed reactor vessels and temperature control units have been used for years to respond to, and to maintain the temperatures of, exothermic and endothermic reactions. These partially or fully automated systems can be found in such markets as Chemical, Pharmaceutical, Biotechnology, and Food & Beverage. The typical uses for jacketed reactors are:

- Product development
- Process development
- Process optimization
- Safety investigations
- Scale up applications

Maintaining a precise temperature is desirable to ensure the process is kept in control for repeatability and reproducibility. Both low and high pressure options are available to control double-jacketed reactor vessels. Correct selection of a temperature control unit can be difficult, however, because there are many parameters that determine the heating/cooling requirements inside the reaction



Figure 1: HAAKE DynaMax System and Reactor Vessel

vessel. Here are some examples:

- Heat transfer efficiency of the jacketed vessel (glass, stainless steel, etc.)
- Flow rate of the heat transfer fluid through the jacketed vessel
- Flow state of the medium inside the reactor vessel (stirrer speed, flow resistance, etc.)
- Temperature difference between medium inside the reactor vessel and heat transfer fluid
- Viscosity and thermal capacity of the heat transfer fluid

## Ramping To and Maintaining Temperature

The HAAKE DynaMax system is designed to quickly ramp to, and then maintain, constant temperature. The heat transfer fluid circuit is shown in Figure 2. The system is characterized by three essential factors, as outlined subsequently.

### Heating

The HAAKE DynaMax system has separate circuits for heating and

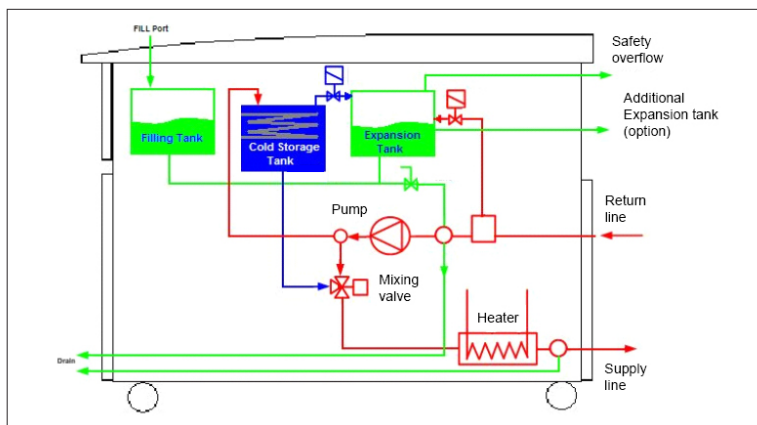


Figure 2: Heat Transfer Fluid Circuit within the HAAKE DynaMax System

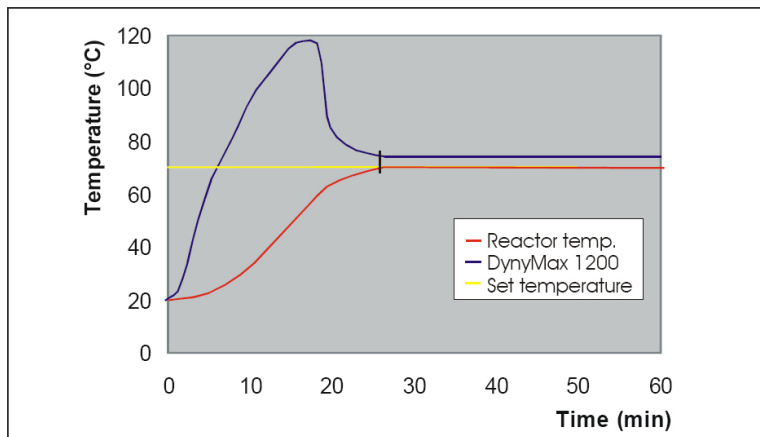


Figure 3: HAAKE DynaMax System Performance while Heating a 3-liter Reactor Vessel

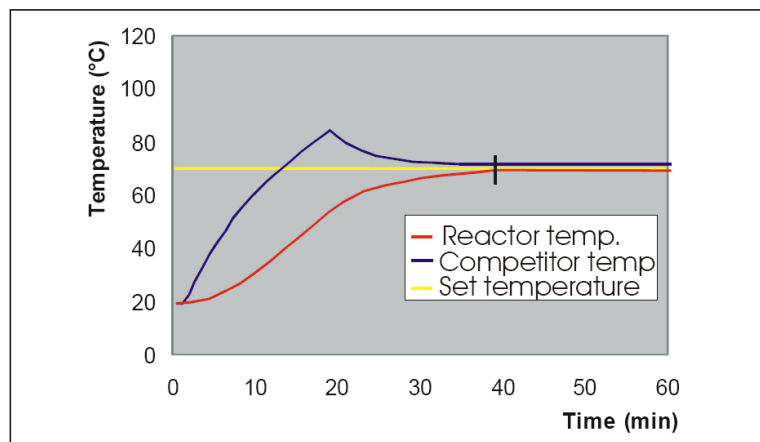


Figure 4: Competitor Unit's Performance while Heating a 3-liter Reactor Vessel

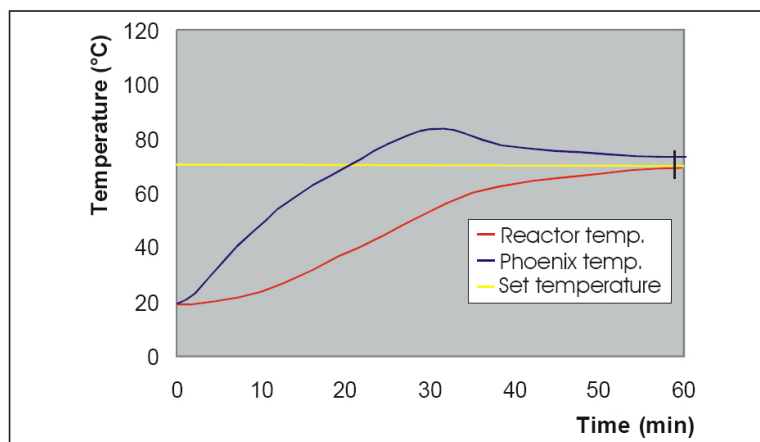


Figure 5: Standard Circulator's Performance while Heating a 3-liter Reactor Vessel

cooling that are isolated during the heating process. The design minimizes the volume of heat transfer fluid during ramp up in temperature. This means that less heat is used to raise the temperature of the heat transfer fluid and that more heat reaches the application. During the heat-up phase, the volume of heat transfer fluid is minimized to less than two liters. A larger volume of fluid is cooled separately in the cold storage tank for temperature deviation control and to respond to rapid temperature changes.

The performances of the HAAKE DynaMax system, a competitor unit and a standard circulator while heating a three liter reaction vessel are compared in Figure 3, Figure 4 and Figure 5.

#### Deviation Control

In conventional temperature control systems, the heating and cooling process happens in the same circuit with the total volume of heat transfer fluid. The cooling system runs and the heater pulses as needed for precise temperature control. In contrast, the HAAKE DynaMax system uses a mixing process between the heating and cooling circuits that allows for a rapid, dynamic control of the application temperature. Conventional systems must heat or cool their entire volume of heat transfer fluid before the application can achieve the desired temperature. The HAAKE DynaMax system mixes hot and cold fluid together to rapidly correct temperature deviations caused by exothermic and endothermic reactions. This feature not only allows it to achieve the application temperature faster, but also to minimize the temperature overshoot or undershoot, thereby enabling the application temperature to be reached more quickly.

### Dynamic Heat Load Suppression (DHLS)

Both endothermic and exothermic chemical reactions should be brought under thermal control quickly to ensure that proper reactions occur. These reactions can result in rapid changes in the desired application temperature. Because only the HAAKE DynaMax system has separate heating and cooling circuits, a large amount of cooling capacity is created in the cold storage tank while the application heats up. This large volume of cold fluid can be introduced to the fluid circuit via the mixing valve to rapidly regain control of the application temperature. This process is called dynamic heat load suppression as the mass of cold fluid acts to suppress the heat generated by exothermic reactions.

The performance of the HAAKE DynaMax system, a competitor unit and a standard circulator in temperature control during an exothermic reaction is shown in Figure 6.

#### Speed Combined with Safety

To properly size cooling systems, reliable data about the present energy potential of a chemical reaction as well as the heat transfer properties of the jacketed reactor and/or heat storage capacity need to be available to ensure proper thermal management of the chemical reaction. Even with proper sizing the potential always exists that an exothermic reaction might exceed operational controls. If the released heat from the exothermic reaction cannot be dissipated quickly enough, then a defined temperature is exceeded.

The HAAKE DynaMax system will sound an alarm and will automatically trigger a switch to safe mode, i.e. it will ensure that the heat transfer fluid returns to preset temperature limits. Further engineering safety measures can be initiated simultaneously via a dry contact. The system also contains other application safety alarms and system limits to ensure that the reaction remains under control and the environment is safe.

In general, baths and circulators are designed as hydraulically open systems. The heat transfer fluid in the bath is not sealed from the atmosphere, thus allowing the heat transfer fluid to expand without limits under varying temperature conditions. Hot heat transfer fluid in contact with atmospheric oxygen creates vapor that causes the fluid to break down, thus decreasing the lifespan of the fluid and potentially damaging the equipment. Not so with the HAAKE DynaMax system. It incorporates all of the advantages of a closed and open system. It is a hydraulically sealed recirculating system with an atmospherically open expansion vessel for closed loop reactors. The detailed filling process and the design of the temperature control circuit prevent the contact of hot heat transfer fluid with atmospheric oxygen from occurring. Therefore vapors do not occur at all. The system is clean. In addition, the life expectancy of the heat transfer fluid is substantially prolonged.

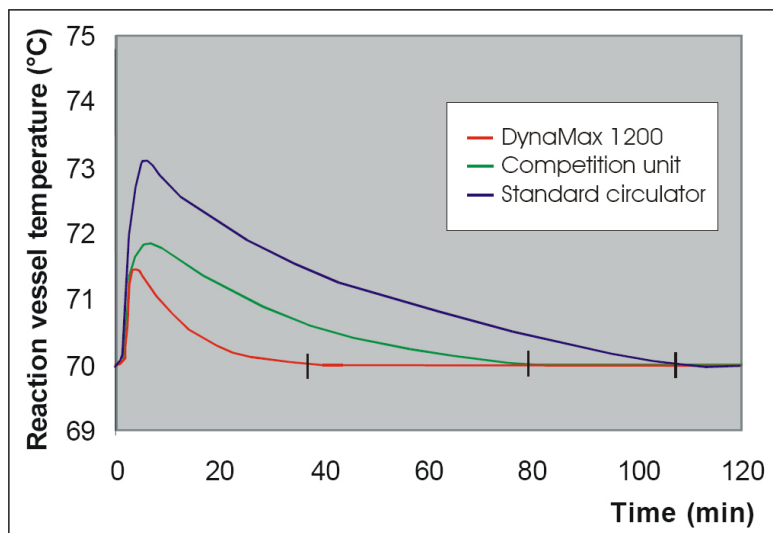


Figure 6: DHLS in an Exothermic Reaction

#### Conclusion

The HAAKE DynaMax system represents a new definition in reactor temperature control. The system's ability to reach set heating and cooling temperatures quickly is complemented by its dynamic ability to control the temperature during exothermic

Benelux  
Tel. +31 (0) 76 5 79 55 55  
info.tc.nl@thermofisher.com

China  
Tel. +86 (21) 68 65 45 88  
info.tc.china@thermofisher.com

France  
Tel. +33 (0) 1 60 92 48 00  
info.tc.fr@thermofisher.com

Germany  
Dieselstr. 4,  
76227 Karlsruhe  
Tel. +49(0)721 40 94-444  
info.tc.de@thermofisher.com

India  
Tel. +91 (22) 27 78 11 01  
info.tc.in@thermofisher.com

United Kingdom  
Tel. +44 (0) 1785 81 36 48  
info.tc.uk@thermofisher.com

USA  
Tel. 603 436 9444  
info.tc.us@thermofisher.com

[www.thermo.com/tc](http://www.thermo.com/tc)

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