DISCOVER WITH armfield

CE SERIES: BASIC PROCESS PRINCIPLES

CHEMICAL REACTORS TEACHING EQUIPMENT – CEXC

Now computer controlled as standard

NEW

3 new reactors available

CEXC service unit shown fitted with CEB-MkIII transparent batch reactor (laptop not supplied).

The Armfield CEXC family is a range of chemical reactors specifically developed for the teaching and demonstration of chemical reactor capabilities to Chemical Engineering students. Real chemical reactions take place within the reactors, and Armfield have developed a number of representative reactions which are easy and safe for students to use in the laboratory environment.

FEATURES

- ***Computer control and data logging as standard***
- ***Compact bench top equipment***
- ***Real time reaction monitoring instrumentation, eliminating the inconvenience and inaccuracy of multiple titrations.***
- ***Transparent reactors, so the student can see what is happening***
- ***Colour tracer experiments possible for some reactor types***
- ***Cost effective, up to five reactors share the same service unit.***
- ***Safe and student friendly***
- ***Five different reactor types available:***
  - ***> Continuous stirred tank reactor***
  - ***> Tubular reactor***
  - ***> Batch reactor***
  - ***> Plug flow reactor***
  - ***> Laminar flow reactor***

- *New and unique computer controlled equipment*
- *Three new reactor types*
- *Improved features*
- *Transparent batch reactor*
- *Open-ended for project work*

BM TRADA CERTIFICATION ISO 9001:2008 UKAS QUALITY MANAGEMENT 012

EXTENDED WARRANTY 2 years 2YR WARRANTY ON ALL ARMFIELD PRODUCTS

CEXC CHEMICAL REACTORS SERVICE UNIT

The CEXC provides the services required to run the various reactor types. It includes a hot water re-circulator used to control the temperature of the reactions, glass feed vessels for the reactants, two peristaltic pumps to pump the reagents to the reactors, computer software, sensors and instrumentation.

The CEXC is fully computer controlled, and supplied with software to allow the user to vary the feed pump speeds and flow rates, to vary the heater power in the hot water, to implement a PID control loop ensuring stable temperatures, switch on and off the hot water pump, and to control the speed of the stirrers used on some of the reactors.

Instrumentation for temperature and conductivity measurements is also supplied and these values are displayed on the computer screen. Two 'K' type thermocouples are included, one for the hot water and one for the reactor contents.

Note: An input for a third user supplied sensor is also provided for project work.

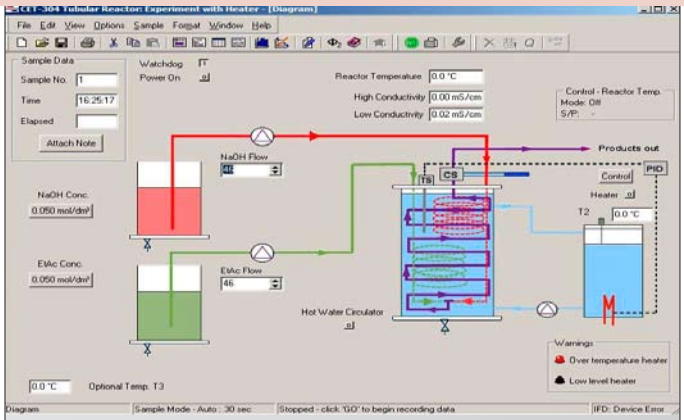
A dual range conductivity sensor allows for a wide range of operation. Armfield have developed an algorithm for the saponification reaction (ethyl acetate and sodium hydroxide) linking the degree of conversion of the reactants to the electrical conductivity, thus allowing the progress of the reaction to be monitored using the software.

The service unit includes a mounting position for the reactor being used. It is possible to change reactors quickly and easily without the use of tools. All fittings on the CEXC and the reactors are of the quick release type. The CEM, CET and CEB reactors are completely contained on the CEXC base unit. The CEY and CEZ also include floor standing columns for positioning next to the CEXC.

The CEXC provides a locating position for two standard 2.5 litre chemical storage bottles for the reagents within the plinth. This provides safety in use and the bottles can be quickly capped and removed as necessary for safe handling. Two 2.5 litre bottles are also provided with the equipment. Alternatively, for longer experiments, larger feed vessels could be located on the floor or on the bench by the equipment.

The CEXC requires a computer to drive it. This computer is not supplied by Armfield. The computer must have a spare USB port and run a Windows operating system (32 bit).

SOFTWARE



Typical software screenshot (CET Tubular reactor experiment with heater)

Full educational software is provided with the CEXC for all the Armfield chemical reactors.

Separate programs are provided for each reactor, typical facilities are:

- ***> All the temperatures and flow rates are displayed on a diagrammatic representation of the equipment.***
- ***> The feed pump speeds are between 0 and 100%. The predicted flow rate for these speeds can be displayed and used for subsequent calculations. These values can be user calibrated for greater accuracy.***
- ***> The stirrer speeds can be controlled in a similar manner.***
- ***> The hot water temperature is set by entering a required temperature set point into a PID control function.***
- ***> Data from the sensors is logged into a spreadsheet format.***
- ***> Sophisticated graph plotting facilities are provided. Comparisons between data taken on different runs can be displayed.***
- ***> Processing of measured values to obtain calculated values.***
- ***> The data samples (measured and calculated) can be saved, or exported directly in Microsoft Excel format.***
- ***> Data from the sensors can be displayed independently from the data logging. This can be in bar graph format, or a recent history graphical display.***
- ***> Presentation screens are available, giving an overview of the software, the equipment, the procedure and the associated theory. This is backed up by a detailed 'Help' facility giving in-depth guidance and background information.***

User defined software

Included separately on the software CD are the 'drivers' required to allow other software applications to communicate with the CEXC via the USB interface. This allows users to write their own software instead of using the Armfield provided software. This software can be written in many different systems. Typically LabView, MatLab, 'C', 'C++', Visual Basic, Delphi, and any other software environment which allows calls to external drivers can be used.

CEM-MKII CONTINUOUS STIRRED TANK REACTOR (CSTR)

Service unit fitted with the CEM-MkII Continuous Stirred Tank Reactor (CSTR)

The continuous stirred tank reactor is probably the most common type of reactor found in industry. The Armfield CEM-MkII is a small scale demonstration version for educational use. It is extremely flexible in use and can be used for both continuous and batch reactions.

The volume of the reactor is adjustable between 0.4 and 1.5 litres using an adjustable standpipe, allowing different hold up volumes and residence times to be investigated. The temperature probe and conductivity probe (supplied with the CEXC) can be positioned in the reactor vessel.

A stainless steel coil is used for temperature control of the reactor from the hot water supply on the CEXC (or cold water from such as the Armfield CW17 Chilled Water Circulating Unit).

A variable speed mixer/agitator is included (controlled by the CEXC) together with baffles to improve the mixing.

CEM-MkII uses the saponification reaction and uses conductivity to measure the progress of the reaction. It also uses a step input change experiment to obtain the residence time distribution.

DEMONSTRATION CAPABILITIES - CEM-MKII

- *> Effect of residence time on conversion*
- *> Determination of reaction rate constant*
- *> Residence time distribution*
- *> Evaluation of empirical rate expressions from experimental data*
- *> Effect of temperature on reaction rate*
- *> Effect of mixing on reaction rate*
- *> Effect of flow rate on conversion*

When in use the CEM-MkII is wholly contained on the CEXC. When removed from the CEXC, storage dimensions are 350mm high, 250mm wide, 300mm deep.

CEM-MkII reactor

CET-MkII Tubular reactor fitted to CEXC service unit

CEB-MkIII Transparent batch reactor fitted to CEXC service unit

NEW

CET-MKII TUBULAR REACTOR

The Armfield Tubular Reactor is in the form of a tube wrapped in a spiral around an acrylic former which is enclosed in a transparent tank. Water at a controlled temperature (from the CEXC) is circulated within the tank, this maintains the reactants at constant temperatures.

The reagents are separately piped to the reactor through quick release fittings mounted on the lid and are pre-heated in stainless steel coils in the water tank, before being mixed and fed into the reactor coil.

Mounting positions are provided for the CEXC water temperature sensor (in the water tank) and the conductivity probe (at the reactor output).

CET-MkII uses the saponification reaction and uses conductivity to measure the progress of the reaction.

DEMONSTRATION CAPABILITIES - CET-MKII

> *Determination of reaction rate constant*
> *Investigation of the effect of throughput on conversion*
> *Demonstration of the temperature dependence of the reaction and the rate constant*
> *Determination of the residence time distribution*
> *Study of the effect of flowrate on conversion*

When in use the CET-MkII is wholly contained on the CEXC. When removed from the CEXC, storage dimensions are 500mm high, 250mm wide, 300mm deep.

CEB-MKIII TRANSPARENT BATCH REACTOR

The CEB Transparent Batch Reactor is a double skinned glass vessel with a one litre internal working volume, fitted with a variable speed agitator.

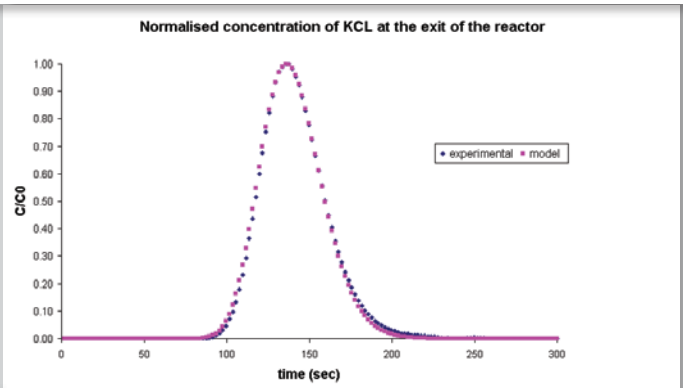
Hot water from the CEXC or cold water from the CW17 can be circulated through the jacket for temperature control purposes, maintaining the reactor contents at constant temperature.

Glands in the clear acrylic lid allow the CEXC conductivity and temperature probes to be fitted to facilitate monitoring of the reactions in progress such as the important saponification reaction. Isothermal and adiabatic operation reactions may be demonstrated. (Note, the Isothermal reaction requires the Armfield CW17 accessory if experiments at low temperature are to be studied or if the ambient temperature is high).

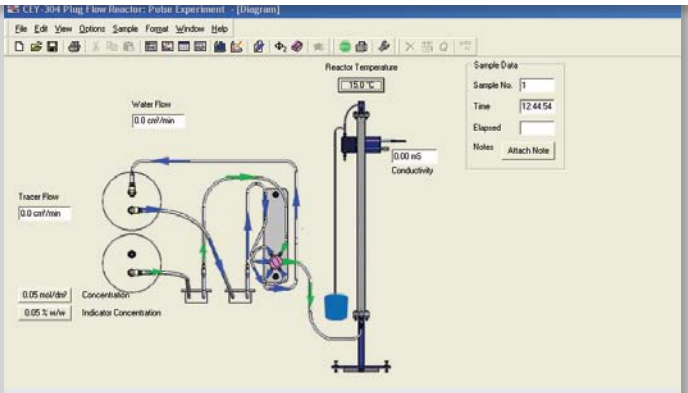
For adiabatic operation, the use of dyes allows the chemical reaction rates to be monitored visually by the change in colour at different degrees of conversion.

DEMONSTRATION CAPABILITIES - CEB-MKIII

> *Determination of the reaction rate constant*
> *Investigation of the effect of reactant concentration on the reaction rate*
> *Investigation of the effect of temperature on conversion*
> *Visual monitoring of the chemical reactions*
> *Study of the temperature variation of an exothermic reaction on an adiabatic operation.*



Reactor response to a pulse change perturbation



Typical CEY software screenshot

NEW

CEY PLUG FLOW REACTOR

CEY Reactor

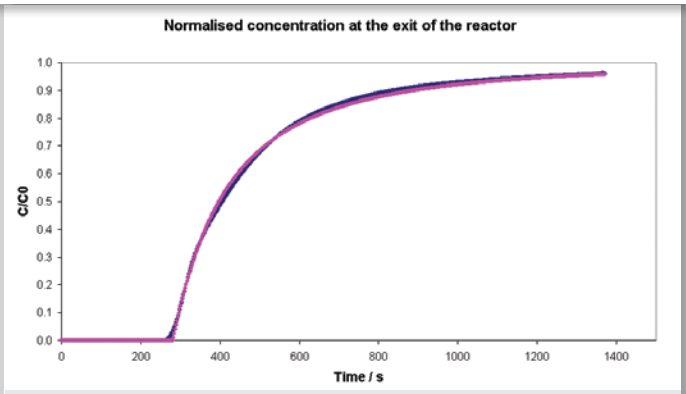
The CEY Plug Flow reactor demonstrates step and pulse changes for Plug flow characterisation and steady state conversion for a second order reaction. It is a tubular packed column reactor made of clear acrylic and mounted on a steel frame. A static premixer at the bottom of the column provides pre-mixing of the reagents entering the reactor and improves the flow distribution.

A clear acrylic sensor block is mounted on the frame and houses the CEXC conductivity and temperature sensors. The reagents are fed to the reactor by the CEXC feed pumps, using PTFE tubing. A 6 port injection valve fitted to the CEXC Reactor service unit is used to provide the step or pulse input changes of the reagents.

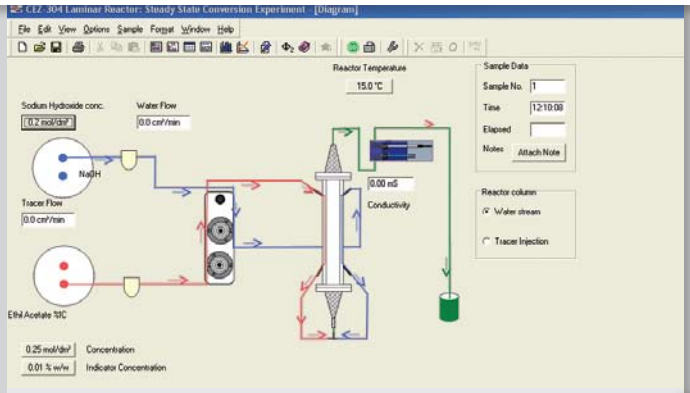
Tracer experiments and conversion experiments may be demonstrated and followed visually. Conductivity data logging allows the student to apply the flow pattern characterisation theory and compare it with the experimental results.

DEMONSTRATION CAPABILITIES - CEY

- *> Determination of the residence time distribution of the reactor*
- *> Study of the reactor response to different perturbations: step and pulse change*
- *> Effect of flow rate and feed concentration on the determination of flow pattern*
- *> Demonstration of the flow pattern in the reactor and comparison with the theoretical model*
- *> Determination of the steady state conversion of a second order reaction*
- *> Effect of flow rate and feed concentration on the steady state conversion*
- *> Visual demonstration of the reactor response with tracer techniques*
- *> Visual monitoring of the steady state conversion for a chemical reaction*



Reactor response to a step change perturbation



Typical CEZ software screenshot

NEW

CEZ LAMINAR FLOW REACTOR

The Armfield Laminar Flow reactor is a tubular reactor made of clear acrylic and mounted on a steel frame, with two diffusers packed with glass beads located at the ends . A static premixer at the bottom of the column provides pre-mixing of the reagents entering the reactor and improves the flow distribution.

It includes two reagent vessels fitted with heat exchangers, mounted in the CEXC plinth. The heat exchangers are used to cool down the reagents before performing the experiment.
A cold water jacket keeps the reactor contents at constant temperature in order to maintain the laminar characteristic. A thermostatically controlled supply of chilled water is required for this, such as the Armfield CW17.

A clear acrylic sensor block is mounted on the frame for the CEXC conductivity and temperature sensors. The reagents are fed to the reactor by the CEXC peristaltic pumps, using PTFE tubing. Pulsation dampers are used to ensure a smooth flow.

Tracer experiments and conversion experiments may be demonstrated and followed visually. Conductivity data logging allows the student to apply the flow pattern characterisation theory and compare it with the experimental results.

DEMONSTRATION CAPABILITIES - CEZ

- *Determination of the residence time distribution of the reactor*
- *Study of the reactor response to inlet perturbations: step change*
- *Effect of flow rate and feed concentration on the determination of flow pattern*
- *Effect of the temperature on the laminar flow characterisation*
- *Demonstration of the flow pattern in the reactor and comparison with the theoretical model*
- *Determination of the steady state conversion of a second order reaction*
- *Effect of flow rate and feed concentration on the steady state conversion*
- *Visual demonstration of the reactor response with tracer techniques and laminar flow*
- *Visual monitoring of the steady state*

CEZ Reactor

ORDERING SPECIFICATIONS

CEXC - CHEMICAL REACTORS TEACHING EQUIPMENT

- *A self contained bench top service unit designed to provide services for up to five different chemical reactors:*
  - *o Continuous Stirred Tank Reactor*
  - *o Tubular Reactor*
  - *o Transparent Batch Reactor*
  - *o Plug Flow Reactor*
  - *o Laminar Flow Reactor*
- *Fully computer controlled and supplied with educational software specific to each reactor type. Simple interfacing to the (user supplied) computer by a USB interface*
- *Two peristaltic feed pumps with individually variable flow rates, 0 - 140 ml/min*
- *Provides PID temperature controlled hot water in order to maintain reactor temperature*
- *Complete with two thermocouples, an input for a third (user) thermocouple and a dual range conductivity sensor*
- *A comprehensive instruction manual is included which details installation and operating procedures*

CEM-MKII - CONTINUOUS STIRRED TANK REACTOR (CSTR)

- *A small scale continuous stirred tank reactor for use with the Chemical Reactors Service Unit*
- *Adjustable volume of 0.4 - 1.5 litres*
- *The vessel is equipped with a variable speed square blade turbine agitator*
- *The vessel is constructed from borosilicate glass and PVC, with stainless steel heat transfer coil and removable reactor baffle*
- *Fitting points for temperature and conductivity sensors (supplied with Chemical Reactors Service Unit)*
- *Demonstration Capabilities*
  - *o Effect of residence time on conversion*
  - *o Determination of reaction rate constant*
  - *o Residence time distribution*
  - *o Evaluation of empirical rate expressions from experimental data*
  - *o Effect of temperature on reaction rate*
  - *o Effect of mixing on reaction rate*
  - *o Effect of flow rates on conversion*

CET-MKII - TUBULAR REACTOR

- *A small scale tubular reactor for use with the Chemical Reactors Service Unit capable of demonstrating large scale behaviour*
- *The 20m long reactor coil is mounted in a clear acrylic vessel through which heating or cooling medium is circulated. Volume of reactor coil is 0.4 litre*
- *Two heat exchanger coils bring the reactants up to the reaction temperature separately before they are mixed to start the reaction.*
- *Fitting points for temperature and conductivity sensors (supplied with Chemical Reactors Service Unit)*
- *Demonstration Capabilities*
  - *o Determination of reaction rate constant*
  - *o Investigation of the effect of throughput and flow rates on conversion*
  - *o Demonstration of the temperature dependence of the reaction and the rate constant*
  - *o Determination of the residence time distribution*

CEB-MKIII - TRANSPARENT BATCH REACTOR

- *A small scale batch reactor for use with the Chemical Reactors Service Unit designed to demonstrate both adiabatic and isothermal operation (The Chilled Water Circulation Unit accessory is recommended for isothermal operation).*
- *1 litre working volume*
- *The vessel includes a jacket through which hot water from the Chemical Reactors Service Unit or chilled water from Chilled Water Circulation Unit is passed. A variable speed agitator aids heat transfer through the vessel.*
- *The vessel is made of glass to give full visibility of the contents and allow the use of colour tracers to illustrate the reaction process.*
- *Fitting points for temperature and conductivity sensors (supplied with Chemical Reactors Service Unit)*
- *Demonstration capabilities:*
  - *o Effect of temperature on reaction kinetics*
  - *o Effect of concentration on conversion*
  - *o Determination of the rate equation and activation energy through mass and energy balances*
  - *o Study of temperature variation for exothermic reaction*
  - *o Use of colour tracers to illustrate reaction progress*

CEY - PLUG FLOW REACTOR

- *A small scale plug flow reactor for use with the Chemical Reactors Service Unit, designed to demonstrate both flow pattern characterisation and steady state conversion in a packed tubular reactor with axial dispersion*
- *The reactor column is 1107mm long, with a 1 litre working volume. It is packed with 3 mm diameter glass beads*
- *A feed assembly is supplied with the reactor which consists of a 6- port injection valve mounted on a base plate and a feed vessel assembly with heat exchangers for cooling for use with the Chemical Reactors Service Unit and Chilled Water Circulation Unit*
- *The reactor assembly is mounted on a painted frame and includes a sensor block for the conductivity and temperature sensors from the Chemical Reactors Service Unit*
- *Can perform flow visualization where the progress of the reaction can be monitored visually using colour*
- *Can also perform true reactions where the progress of the reaction is recorded using the Service Unit conductivity sensor and compared with the theory*
- *Demonstration capabilities include:*
  - *o Flow pattern characterisation in a packed Plug Flow reactor with axial dispersion*
  - *o Steady state conversion for a chemical reaction in a packed reactor*
  - *o Understanding the principles of tracer techniques in flow pattern characterisation*
  - *o Visual monitoring of the tracer and conversion experiments using colour*

CEZ - LAMINAR FLOW REACTOR

- *A small scale plug flow reactor for use with the Chemical Reactors Service Unit, designed to demonstrate both flow pattern characterisation and steady state conversion in a packed tubular reactor with axial dispersion*
- *The reactor column is 1107mm long, with a 1 litre working volume. It is packed with 3 mm diameter glass beads*
- *A feed assembly is supplied with the reactor which consists of a 6- port injection valve mounted on a base plate and a feed vessel assembly with heat exchangers for cooling for use with the Chemical Reactors Service Unit and Chilled Water Circulation Unit*
- *The reactor assembly is mounted on a painted frame and includes a sensor block for the conductivity and temperature sensors from the Chemical Reactors Service Unit*
- *Can perform flow visualization where the progress of the reaction can be monitored visually using colour*
- *Can also perform true reactions where the progress of the reaction is recorded using the Service Unit conductivity sensor and compared with the theory*
- *Demonstration capabilities include:*
  - *o Flow pattern characterisation in a packed Plug Flow reactor with axial dispersion*
  - *o Steady state conversion for a chemical reaction in a packed reactor*
  - *o Understanding the principles of tracer techniques in flow pattern characterisation*
  - *o Visual monitoring of the tracer and conversion experiments using colour*

SERVICES REQUIRED

CEXC-A	*230V, 50Hz, 10A*
CEXC-G	*230V, 60Hz, 10A*
CW-17-A	*230V, 50Hz, 13A*
CW-17-G	*230V, 60Hz, 13A*

ESSENTIAL ACCESSORIES

CEXC	*CEM-MkII*	*CET-MkII*	*CEB-MkIII*	*CEY*	*CEZ*
At least one reactor accessory	*CEXC*	*CEXC*	*CEXC*	*CEXC*	*CEXC*
Windows PC			*CW17 (for isothermal operation)*		*CW17*

SHIPPING SPECIFICATION

	CEXC	*CEM-MkII*	*CET-MkII*	*CEB-MkIII*	*CEY*	*CEZ*
Volume (m^3)	*0.4*	*0.1*	*0.1*	*0.1*	*0.5*	*0.5*
Gross weight (kg)	*40*	*10*	*10*	*15*	*22*	*22*

OPTIONAL ACCESSORY - CW-17 CHILLED WATER CIRCULATING UNIT

CW17 is a thermostatically controlled chilled water circulating unit which can be used for providing water at below ambient temperature. It is essential for use with the CEZ reactor and for the CEBMkIII isothermal demonstration and can be used with the other reactors. The temperature of the water is controlled by an adjustable thermostat mounted on the CW17. Alternatively, it can be used as an ice bank chiller to supply water slightly above freezing point.

OTHER ARMFIELD CE REACTOR PRODUCTS

CEP MkII - Stirred Tank Reactors In Series
http://www.discoverarmfield.co.uk/data/cep

FOR FURTHER INFORMATION ON THE ADVANCED FEATURES OF THE SOPHISTICATED ARMFIELD SOFTWARE VISIT:
www.discoverarmfield.co.uk/data/armsoft

Head Office:
Armfield Limited
Bridge House, West Street,
Ringwood, Hampshire.
BH24 1DY England
Telephone: +44 1425 478781
Fax: +44 1425 470916
E-mail: sales@armfield.co.uk

U.S. Office:
Armfield Inc.
436 West Commodore Blvd (#2)
Jackson, NJ 08527
Telephone: (732) 928 3332
Fax: (732) 928 3542
E-mail: info@armfieldinc.com

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