

STRATCO® ALKYLATION INNOVATIONS FOR GRASSROOTS APPLICATIONS



ADVANCES IN ALKYLATION TECHNOLOGY

- Feed nozzle redesign
- Hydraulic head redesign
- 1" Tube bundle redesign
- 3/4" Tube bundle
- Contactor™ reactor tube inserts
- Contactor™ reactor XP2 technology
- Contactor™ reactor size options
- Acid settler redesign
- Instrumentation options
- New reactor development



A COMMITMENT TO INNOVATION

RESEARCH AND DEVELOPMENT

DuPont recognizes that continued improvement of the STRATCO® alkylation technology is critical to our customers' success. As such, DuPont has a dedicated team of scientists and engineers focused on alkylation R&D at the STRATCO® Alkylation Technology Center. The work of the center is directed to both meet present customer requirements and continue the R&D required to support our customers' needs for competitive technology well into the future. New alkylation technology is under investigation with the potential to significantly improve future alkylation systems. With the wide-ranging R&D resources of DuPont and our over 80 years of experience in alkylation technology, the STRATCO® Alkylation Technology Center is in a position to provide real value to all in the refining industry.

ADVANCES IN ALKYLATION TECHNOLOGY

DuPont is the world's leading licensor of STRATCO® alkylation technology using the most efficient, flexible and sustainable engineering design that consistently produces high quality alkylate for refinery customers.

Feed Nozzle Redesign: The olefin and isobutane recycle feed nozzles were redesigned for better dispersion and to pre-mix the two streams prior to coming into contact with the sulfuric acid within the reactor. This design change has shown an increase in alkylate product octane of 0.5-1.0 numbers and a reduced alkylate endpoint by 10–15°C.

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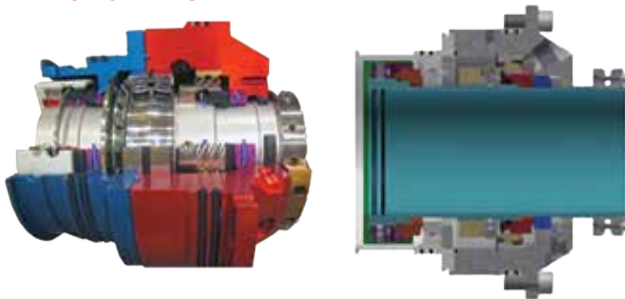
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ADVANCES IN ALKYLATION TECHNOLOGY *(continued)*

Hydraulic Head Innovation: The reactor hydraulic head was upgraded with a modified design as well as metallurgy, mechanical seal and drive shaft options. These developments have increased the mean time between failures from 1-4 years to 4-10 years depending on the option(s) included in the hydraulic head. The design improvements have also alleviated reactor/motor alignment issues that previously caused premature failure of the seal due to settling differences between the reactor and the motor.

HYDRAULIC HEADS



1" Tube Bundle Redesign: The arrangement and the tube support structure for the standard 1" bundle was redesigned to improve maintenance requirements and reduce the overall corrosion/erosion of the bundle.



3/4" Tube bundle: The 3/4" tube bundle increases the number of tubes from the 613 – 1" diameter tubes to 1,093 – 3/4" diameter tubes. This change increases the available surface area of the tube bundle from 935m² to 1,266m², a 35% increase in surface area. The increase in the number of tubes also creates additional turbulence and pressure drop within the reactor. This increase results in 40% more UA (heat transfer coefficient x area) for the tube bundle.

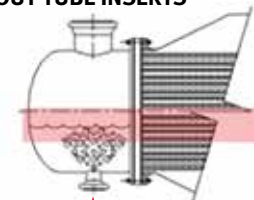


Contactor™ Reactor Tube Inserts: The standard STRATCO® alkylation design without tube inserts includes a control valve between the acid settler and reactor tube bundle to flash the hydrocarbon. The resulting two phase flow then enters the channel head and is distributed among the tubes. The inclusion of the tube inserts in the alkylation design eliminates the flashing service of the control valve and creates a liquid full channel head where each tube in the bundle receives liquid. The flashing then occurs within the insert itself and then continues within the individual tubes. The improved distribution of hydrocarbon refrigerant creates improved heat transfer and increases the overall heat transfer coefficient by 15-20%. An additional benefit is reduced corrosion within the tube bundle due to the improved uniform temperature profile and liquid refrigerant distribution within the tube bundle.

CONTACTOR™ REACTOR TUBE INSERTS

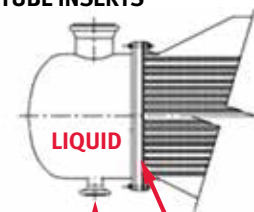


OPERATION WITHOUT TUBE INSERTS



TWO-PHASE EFFLUENT
REFRIGERATION INLET

OPERATION WITH TUBE INSERTS



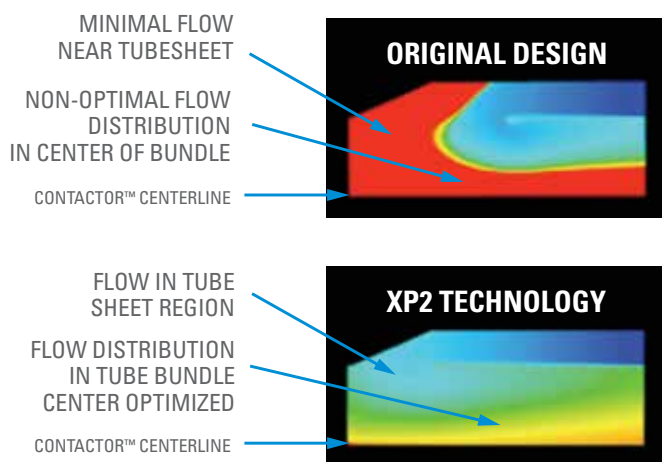
SINGLE-PHASE EFFLUENT
REFRIGERATION INLET

TUBE INSERTS INSTALLED
IN EACH TUBE INLET

Contactor™ Reactor XP2 Technology: The XP2 technology is a combination of two improvements within the reactor which, working together, allows for improved performance as a result of XP2 installation. The first is the extension of the circulation tube to direct the internal flow further back within the reactor. The second piece is the addition of a flow distributor within the reactor annulus. These two patented changes improve mixing and flow distribution within the reactor and allow for a more efficient use of the entire tube bundle. Commercial data shows a 10% increase in the UA. The data also indicates that the installation of XP2 increases the product quality (octane number) and reduces acid consumption by 10-15%. The inclusion of the XP2 Technology within the Contactor™ reactors has allowed for increased throughput (capacity) per reactor while maintaining customer requested product quality. Therefore, there is a net reduction in number of reactors required when including the XP2 Technology on grassroots projects.

ORIGINAL DESIGN VS. XP2 TECHNOLOGY

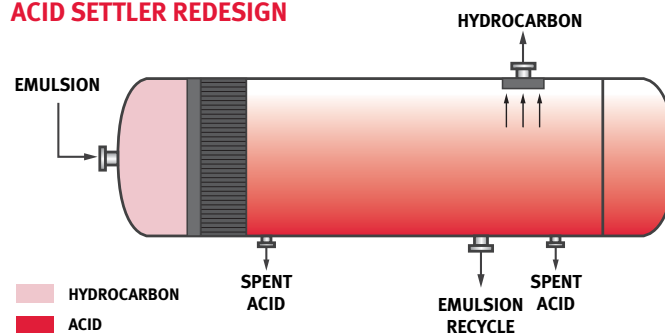
CFD MEAN AGE PLOT – TRACKS PARTICLE TRAVEL TIME THROUGH THE CONTACTOR™



Contactor™ Reactor Size Options: DuPont has two sizes of the Contactor™ reactor in commercial operation, the Model 42 and the Model 63, with the Model 63 being the standard offering. In addition to these two commercially available sizes, we also have a design for a larger Model 74 Contactor™ reactor. The Model 74 is also configured with our latest improvements and is available for commercialization. The approximate capacity increase of the Model 74 compared to the Model 63 reactor is 1.8 - 2.0 times.

Acid Settler Redesign: The current acid settler design uses two stages of coalescing media to aid in the separation of the sulfuric acid and hydrocarbon. Older designs have an H distributor and are sized based on gravity settling. The addition of the coalescing media has allowed for a smaller vessel size, improved separation and improved alkylate endpoint. The reduced size acid settler further improves the overall safety of the unit by reducing both the sulfuric acid and hydrocarbon inventories. The new design also reduces the amount of sulfuric acid and reaction intermediate carryover to the downstream equipment.

ACID SETTLER REDESIGN



Instrumentation Options: DuPont has worked with several vendors over the years to determine the most reliable method to monitor important parameters in the reaction system. The current design includes a reaction zone monitoring system (RZMS) which is comprised of a standardized sample station, a ratio glass, and an on-line measurement system which includes refractometers and Coriolis meters. Our acid settler level instrumentation has also improved to include magnetic gauges, thus decreasing the number of split glass level gauges.

New Reactor Development: DuPont has an active technology development program in which we look at improving the current STRATCO® Contactor™ reactor as well as developing next generation reactors. The next generation reactors are still in the development stage, thus details cannot be disclosed at this time.

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PROCESS PERFORMANCE SUMMARY

Below is a table indicating the process impact of the technology innovations which are available:

	1" TUBE BUNDLE (613 TUBES)			3/4" TUBE BUNDLE (1,093 TUBES)	
	BASE CASE	+ TUBE INSERTS	+ XP2	3/4" TUBE BUNDLE	+ XP2
CAPACITY PER REACTOR ¹	70 – 90	80 – 100	100 – 130	90-110	110 - 150
REDUCTION IN COMPRESSOR POWER REQUIREMENT ²	BASE	BASE – 4-5%	BASE – 3%	BASE – 8-9%	BASE – 10-12%
IMPROVEMENT IN R+M/2 ²	BASE	0	BASE + 0.0-0.5	0	BASE + 0.0-0.5
REDUCTION IN ACID CONSUMPTION ²	BASE	0	BASE – 10-15%	0	BASE – 10-15%
REDUCES CORROSION?	—	YES	YES	NO	YES

- NOTES: 1. kmta of alkylate product
2. compared to 1" tube bundle base case



WORLDWIDE SALES AND SUPPORT

For more information, please contact the following DuPont representative:

KEVIN BOCKWINKEL
Tel: +1-913-327-3536
kevin.b.bockwinkel@dupont.com

DuPont
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CLEAN TECHNOLOGIES
STRATCO ALKYLATION
TECHNOLOGY

6363 College Boulevard, Suite 300
Overland Park, KS 66211 USA

www.cleantechnologies.dupont.com