distillation before the reaction can proceed. The reaction and product separation steps must be repeated until the concentration of product and reactant is too low to warrant further processing. In the conventional procedure, the chemical reaction (which produces waste heat) and distillation are performed in separate vessels, and an external heat source must be applied for the distillation stage.

DOE and Chemical Research and Licensing developed a new single-stage, catalytic reaction/distillation process for producing hydrocarbons such as MTBE (methyl tertiary butyl ether), isobutylene, ethyl benzene, and cumene. When compared with the conventional, multistage process, the new catalytic distillation process is more energy efficient and is also lower in capital cost. The new process saves energy because heat released by the equilibrium reaction is used directly for distillation, eliminating external heat exchange and its consequent energy losses.

At the end of 1988, six units were operating in the United States and one each in China, France, and Spain. Estimated current energy savings in the United States are 0.32 trillion Btus per year; estimated savings in 2010 are 99 trillion Btus per year.

Membrane Distillation

The petroleum processing industry uses thermal distillation to separate feedstock components of differing boiling points. As much as 30% of the industry's energy consumption is used to perform these separations. With DOE support, researchers at Allied-Signal Corporation developed a more energy efficient separation method that uses a membrane system to separate light hydrocarbons from a stream of heavy oils in the petroleum refining process. This process recovers solvents used in the deasphalting of heavy oils, reducing the amount of solvent to be stripped through evaporation by as much as 43%.

In the membrane distillation process, a gel layer, consisting of heavy molecules from crude oil feedstock, is allowed to build on the surface of the membrane, and its growth and stability are controlled by a proprietary method. This gel layer serves as a backing material and performs the actual separation process. The system is stable in a hydrocarbon environment up to 50°C. Potential savings by 2010 are estimated at 24.8 trillion Btus per year.

Beck Dyeing Modifications

Certain textile products are batch-dyed in a beck, a large stainless steel tub vented to the atmosphere. The conventional dyeing process involves loading the beck with undyed textile, filling it with water, adding the necessary chemicals and dyes, and bringing the water to a boil with steam injection. Once the boiling cycle is satisfactorily completed, the used dye-bath solution is discharged as waste, and the beck is refilled with water to rinse the textile. After the load is rinsed, the used water is discharged.

In cooperation with the Georgia Institute of Technology, Salem Carpets, and Adams-Mills, a DOE program tested three process modifications that reduce the use of energy, water, and materials in conventional dyeing. These modifications are known as bump-and-run, dye-bath reuse, and hot pull. The bump-and-run technique reduces the demand for steam during the dyeing process. Dye-bath reuse involves reconstituting and recycling the spent dye bath. The spent dye bath is analyzed to determine the amount of dye remaining, and additional dye is added to obtain the desired color. Small amounts of auxiliary chemicals are also added to replace those lost in the dyeing process. Hot pull is a handling procedure that eliminates the final rinse step, thus minimizing handling of the spent dye bath and saving the water used by the final rinse.

Process modifications in beck dyeing save energy in textile manufacturing.