# Catalytic Conversion

# INTRODUCTION

Catalytic conversion can be done by changing the no. of carbon, changing the C/H ratio or by isomerization.

C no. is changed by catalytic cracking, hydrocracking and polymerization.

C/H ratio is changed by hydrogenation and dehydrogenation.

Isomerization neither changes the C no. nor C/H ratio but it changes the shape of the molecule and it's quality.

Catalytic processes removes impurities and convert certain hydrocarbons into the products by breaking it into simpler molecules.

# HYDROCRACKING

It is a process by which the hydrocarbon molecules of petroleum are broken into simpler molecules as of gasoline of kerosene by the addition of the hydrogen under high pressure and in presence of catalyst.

Amorphous silica alumina or zeolite catalysts are used.

# TYPES OF HYDROCRACKING

There are two types,depending upon the feedstock used.

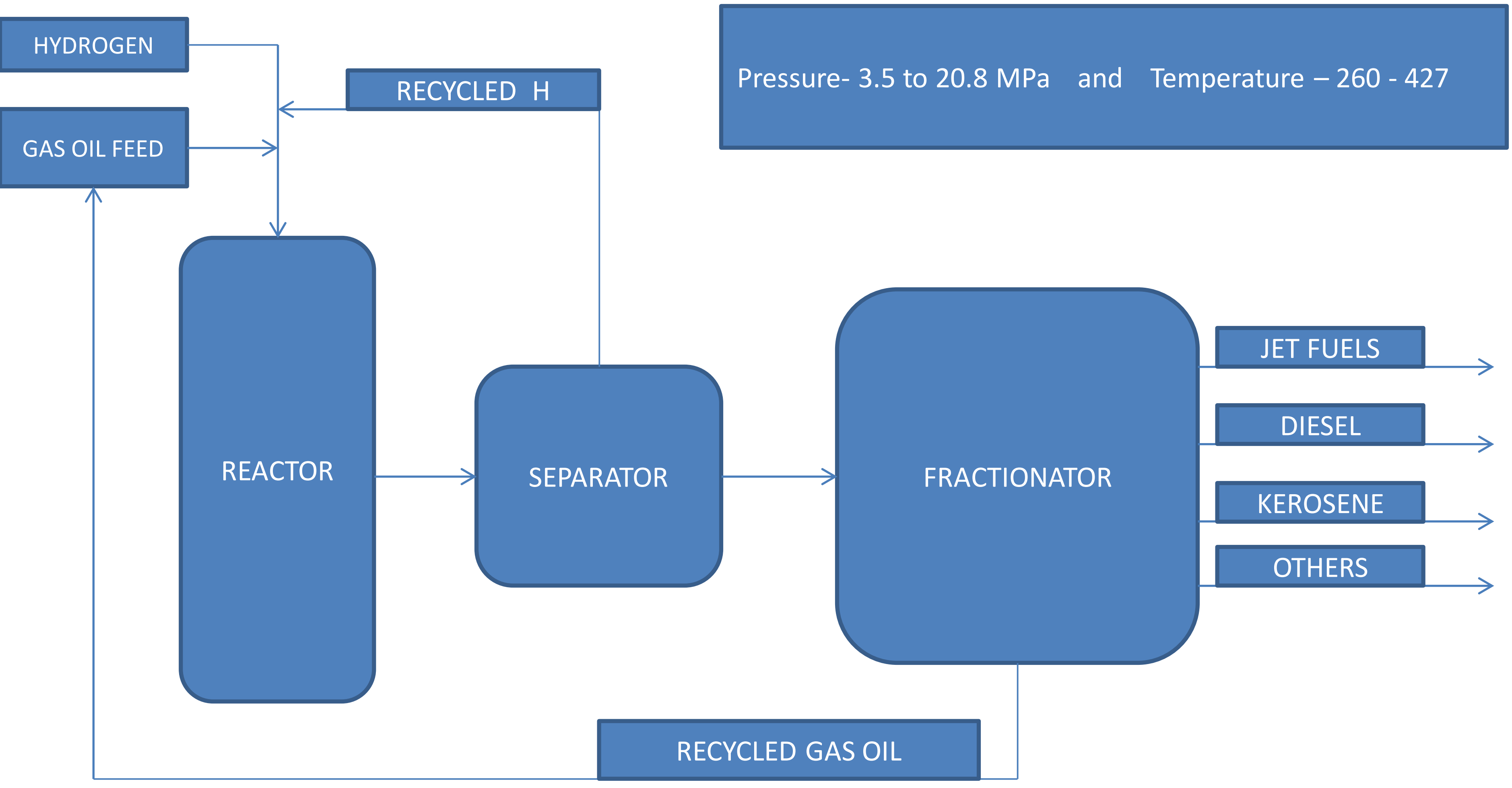
1 - Distillate hydrocracking

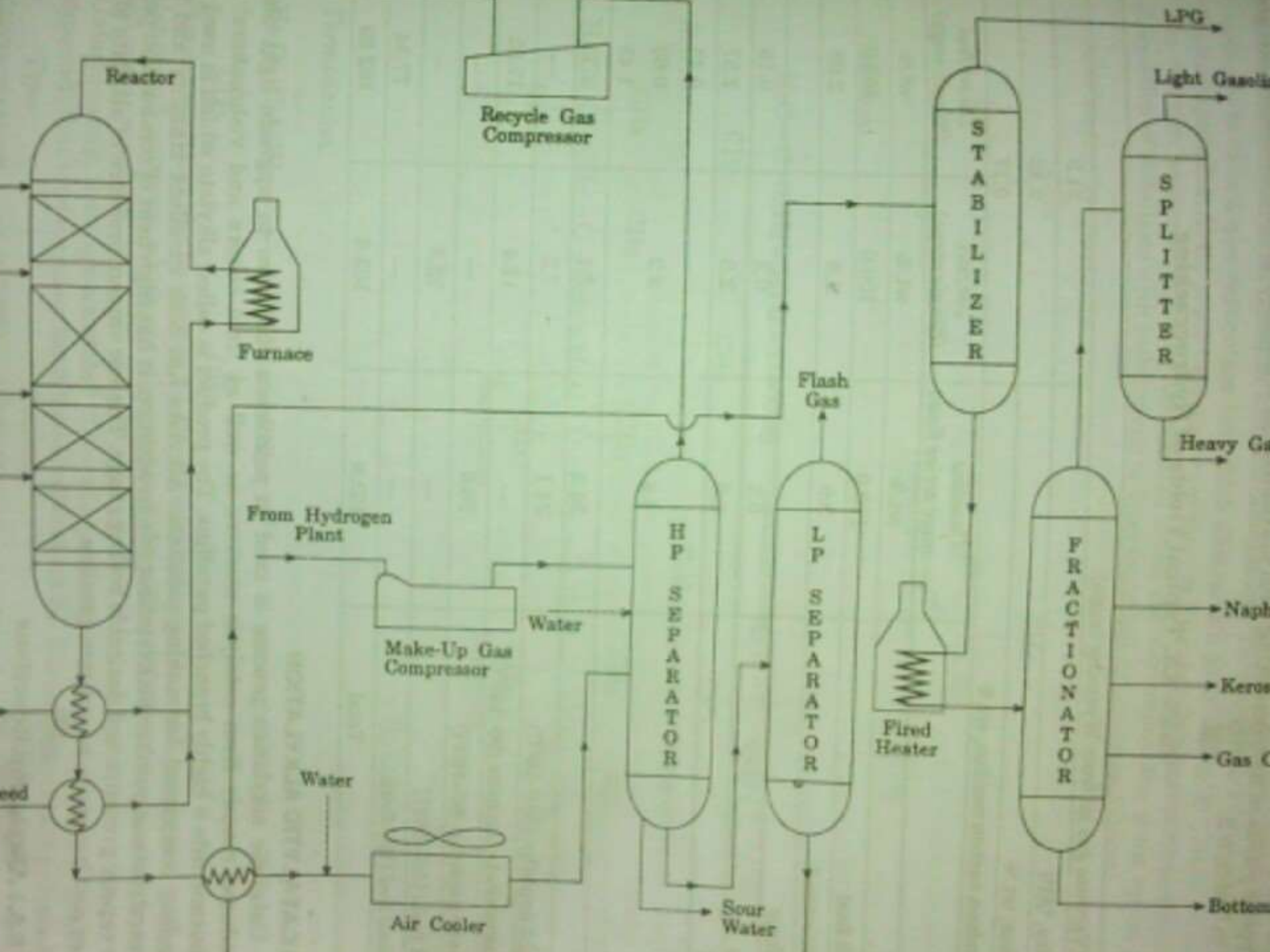
2- Residual hydrocracking

If the feedstock is heavy distillate obtained from straight-run refinery or cracking operation then it is called as distillate hydrocracking.

If the feedstock is residue of the straight-run refinery it will be called as residual hydrocracking.

# OVERVIEW OF HYDROCRACKING PROCESS





Reactor
Recycle Gas Compressor
LPG
Light Gasoli
Furnace
Flash Gas
STABILIZER
SPLITTER
Heavy Ga
From Hydrogen Plant
HP SEPARATOR
LP SEPARATOR
FRACTIONATOR
Water
Make-Up Gas Compressor
Naph
Keros
Fired Heater
Gas O
Water
eed
Air Cooler
Sour Water
Bottom

# TYPICAL YIELD PATTERN

| Feed (Vacuum gas oil from Wyoming crude) | | | |
|---|---|---|---|
| Gravity, °API | | 21.2 | |
| Sulphur, wt.% | | 2.42 | |
| Conradson carbon residue, wt.% | | 0.17 | |
| | *Gasoline (Two stage series flow)* | *Jet fuel (Single stage)* | *Diesel fuel (Single stage)* |
| | wt.% | wt.% | wt.% |
| Fresh feed | 100.0 | 100.0 | 100.0 |
| $H_2$ consumed | 3.9 | 2.8 | 2.69 |
| *Products* | | | |
| $NH_3$ | 0.2 | 0.2 | 0.16 |
| $H_2S$ | 2.6 | 2.6 | 2.57 |
| $C_1$ | | | 0.43 |
| $C_2$ | 4.2 | 3.2 | 0.60 |
| $C_3$ | | | 1.43 |
| $C_4$ | 14.2 | 3.1 | 2.33 |
| Light naphtha (*IBP*–90°C) | 24.1 | 7.5 | — |
| Intermediate naphtha (90–130°C | — | 12.4 | 17.83 |
| Heavy naphtha (90–190°C | 58.6 | — | — |
| Jet fuel (150–280°C | — | 73.8 | — |
| Diesel fuel (low flash) | — | — | 77.34 |
| Total | 103.9 | 102.8 | 102.69 |

# APPLICATION OF HYDROCRACKING

Sulphur,nitrogen and oxygen are almost completely removed and olefins are saturated thereby giving a stable product.

Hydrocracking of vacuum gas oil and propane deasphalted oil to produce high quality lube oil.

It hydrocracks compound of  low viscosity index into high quality naptha and distillates.

Wide range od distillate products can be obtained in the hydrocracker namely either gasoline or jet fuel or diesel fuel.

| *Feedstock* | *Products* |
|---|---|
| Naphthas | Propane and butane (LPG) |
| Kerosines | Naphtha |
| Atmospheric gas oils | Naphtha, jet fuel and / or distillates |
| Natural gas condensates | Naphtha |
| Vacuum gas oils | Naphtha, jet fuel, distillates, lube oils |
| Deasphalted oils | Naphtha, jet fuel, distillates, lube oils |
| Reduced crude oils | Distillates and low-sulphur fuel oil |
| Vacuum residue | Naphtha, distillates, vacuum gas oil and low sulphur fuel oil |
| Light cycle oils (from FCC) | Naphtha |
| Heavy cycle oil (from FCC) | Naphtha and/or distillates |
| Coker distillates | Naphtha |
| Coker heavy gas oils | Naphtha and/or distillates |

# MAJOR ENGINEERING PROBLEMS

Hydrocracking unit is generally more costlier of the order of 1.6 times that of fluid catalytic cracking unit.

Operating cost is also high as compared to a catalytic cracker.

The metallurgy of unit needs special care,is costly and also more difficult from maitainance point of view.

# Catalytic Alkylation

## Introduction-

- This process is used in petroleum refineries to upgrade the light olefins and isobutane into highly branched paraffins.

- This product is called alkylate which is used for making gasolines .

- Main quality of alkylate is that it has high research octane number (RON) -96 , high heat of combustion per kg, low vapour pressure and desirable boiling range for suitable fuel using.

- Alkylation involves the reaction of isobutane with light olefin in presence of acid catalyst (concentrated sulphuric acid or anhydrous hydrofluoric acid).

- This reaction takes place in many steps not directly so the disadvantage behind it that there is many side reaction takes place also these unfortunate incident tend to reduce the octane number of alkylate to 96 .

- These side reactions are following – carbonium ion formation , addition , termination , polymerisation , hydrogen transfer , disproportionation and cracking.

# $H_2SO_4$ ALKYLATION PROCESS -

- $H_2SO_4$ alkylation units are based on three designs-
  1-Time tank process
  2-Effluent refrigeration process
  3-Cascade process or auto refrigeration process

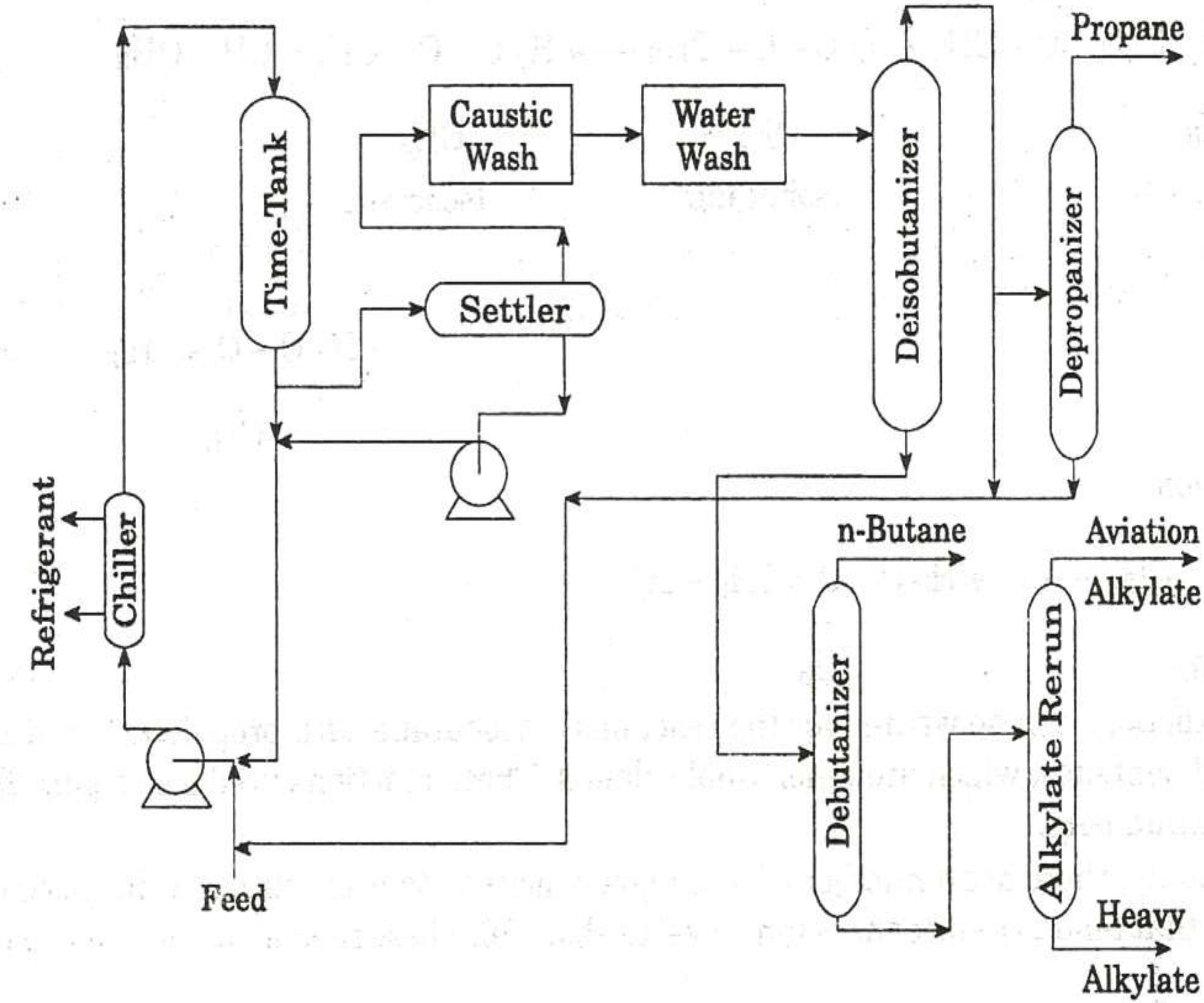
- **TIME TANK PROCESS –**

Process description-

1-System makes a close loop of time tank , heat exachanger , and a circulating pump .

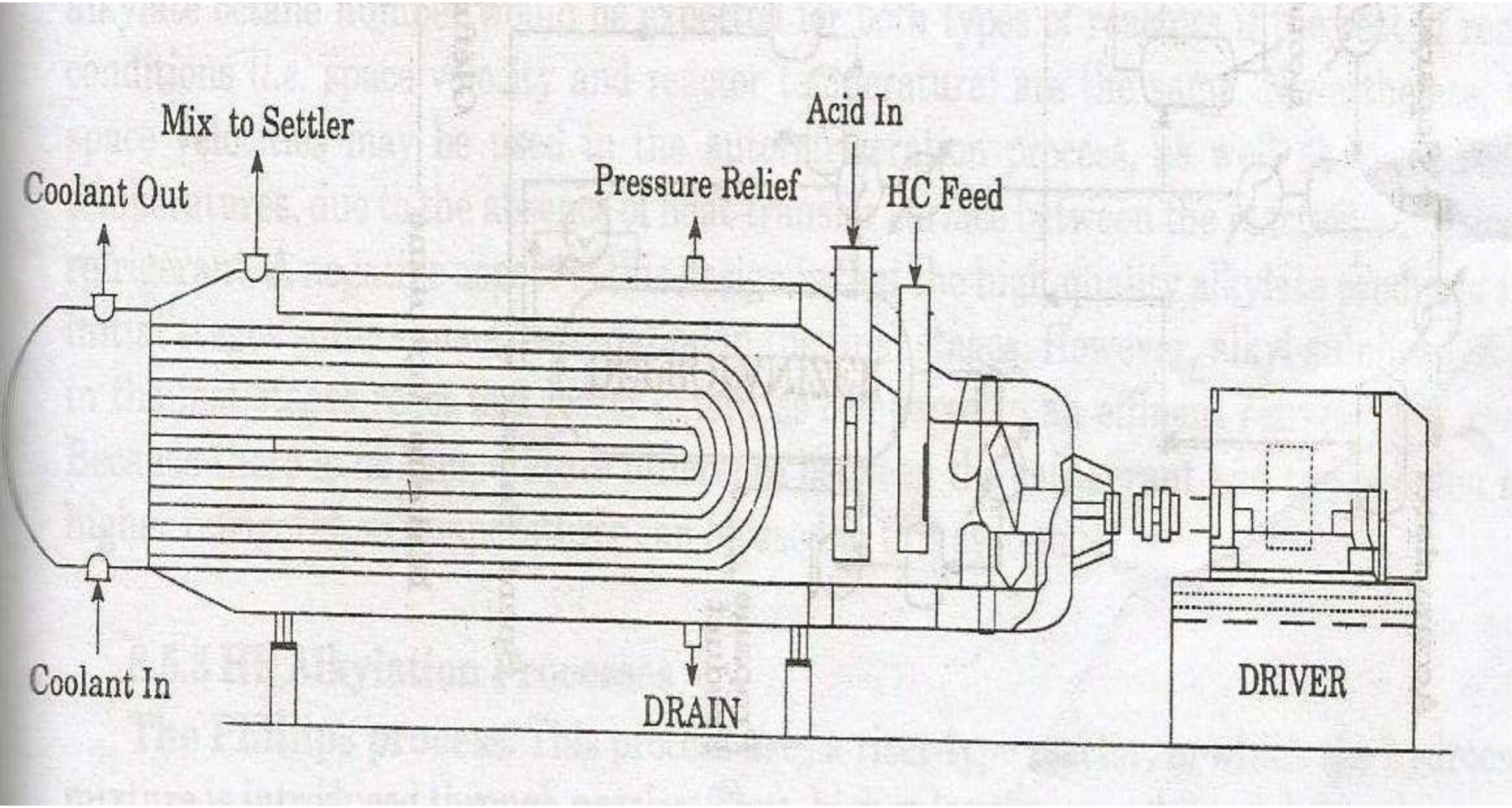
2-High temperatures are avoided for this process .

3-Heat exchanger is for removing the heat of reaction .
In The time reactor most of the alkylation reaction takes place .




*Time-tank process.*

# **Effluent refrigeration process-**



Process description-

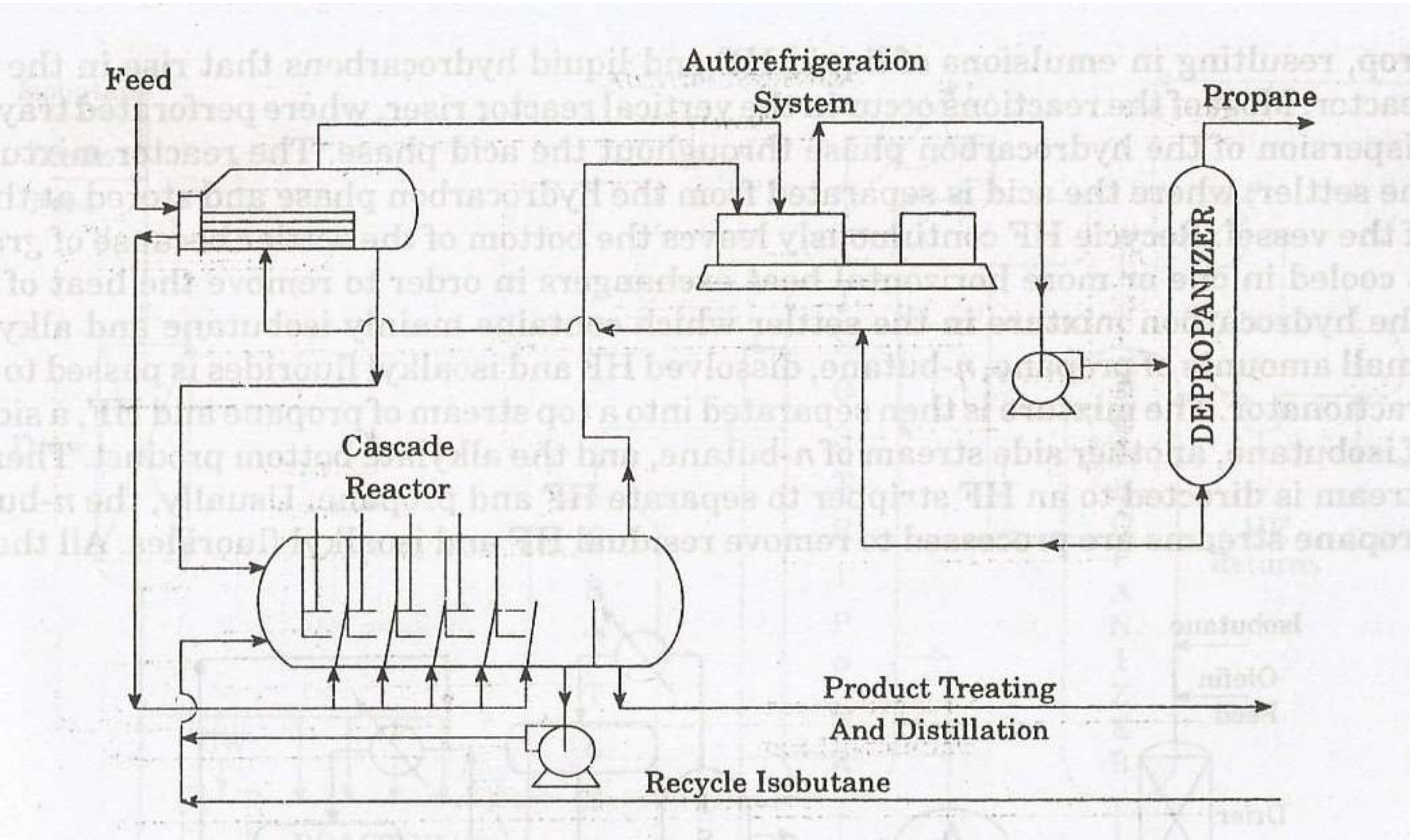
1. Reactor is a horizontal vessel provided with an impeller .
2. And a tube bundle or cooling coils .

3. Cooling coils have been made longer to provide the increase the over all heat transfer coefficients .

4. System provides a rapid circulation .

5. This system improves alkylate quality and lowers the refrigeration costs .

# Cascade process or auto refrigeration process



Process description-

1. Acid and isobutene are introduced in first stage of the reactor.

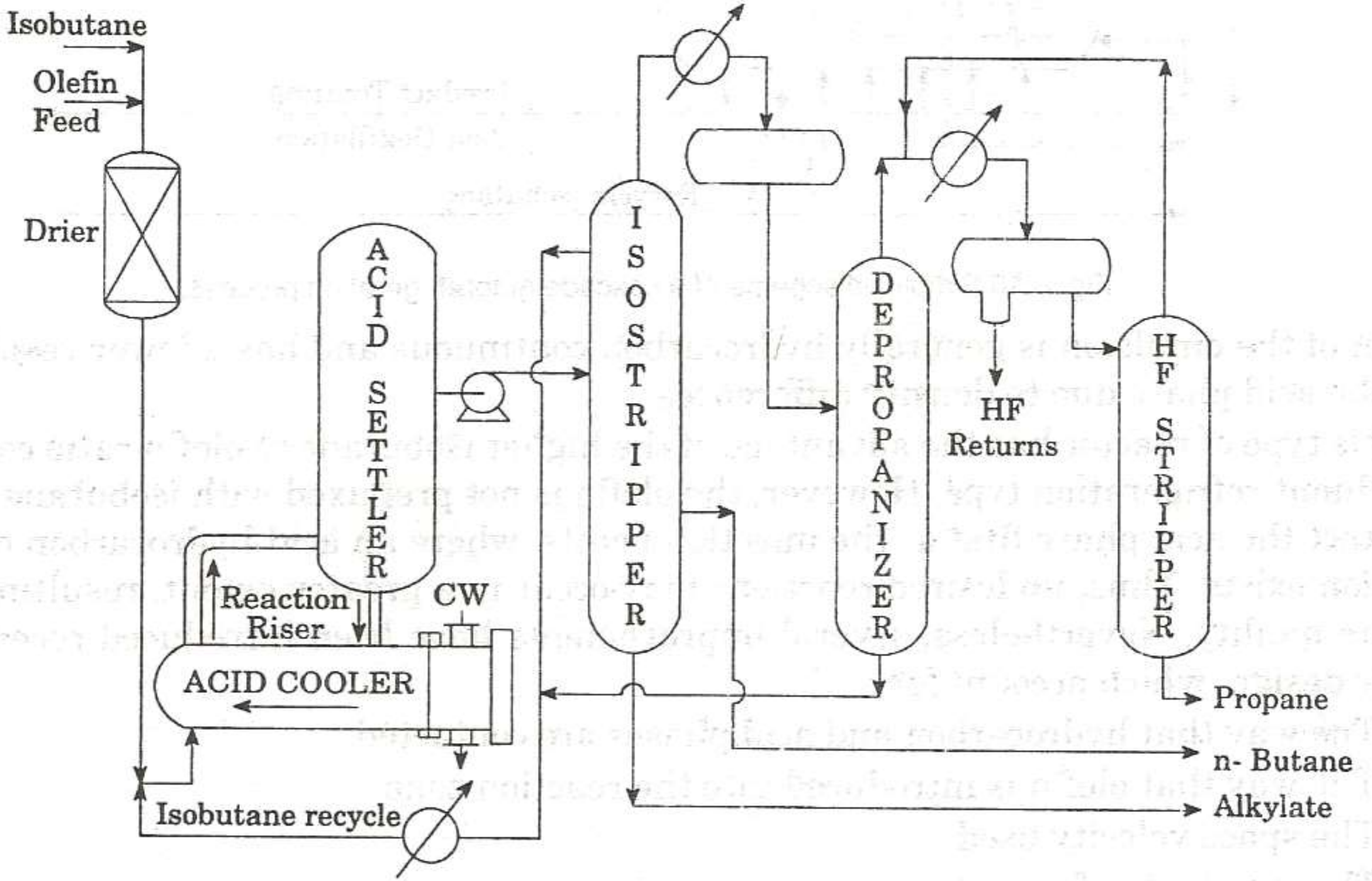
2. While Olefin feed is divided into all the stages .

3. This reactor has higher advantage than effluent refrigeration because the conversion (light olefins and iso butane into highly branched paraffins ) is higher.

4. This reactor gives the higher alkylate quality.

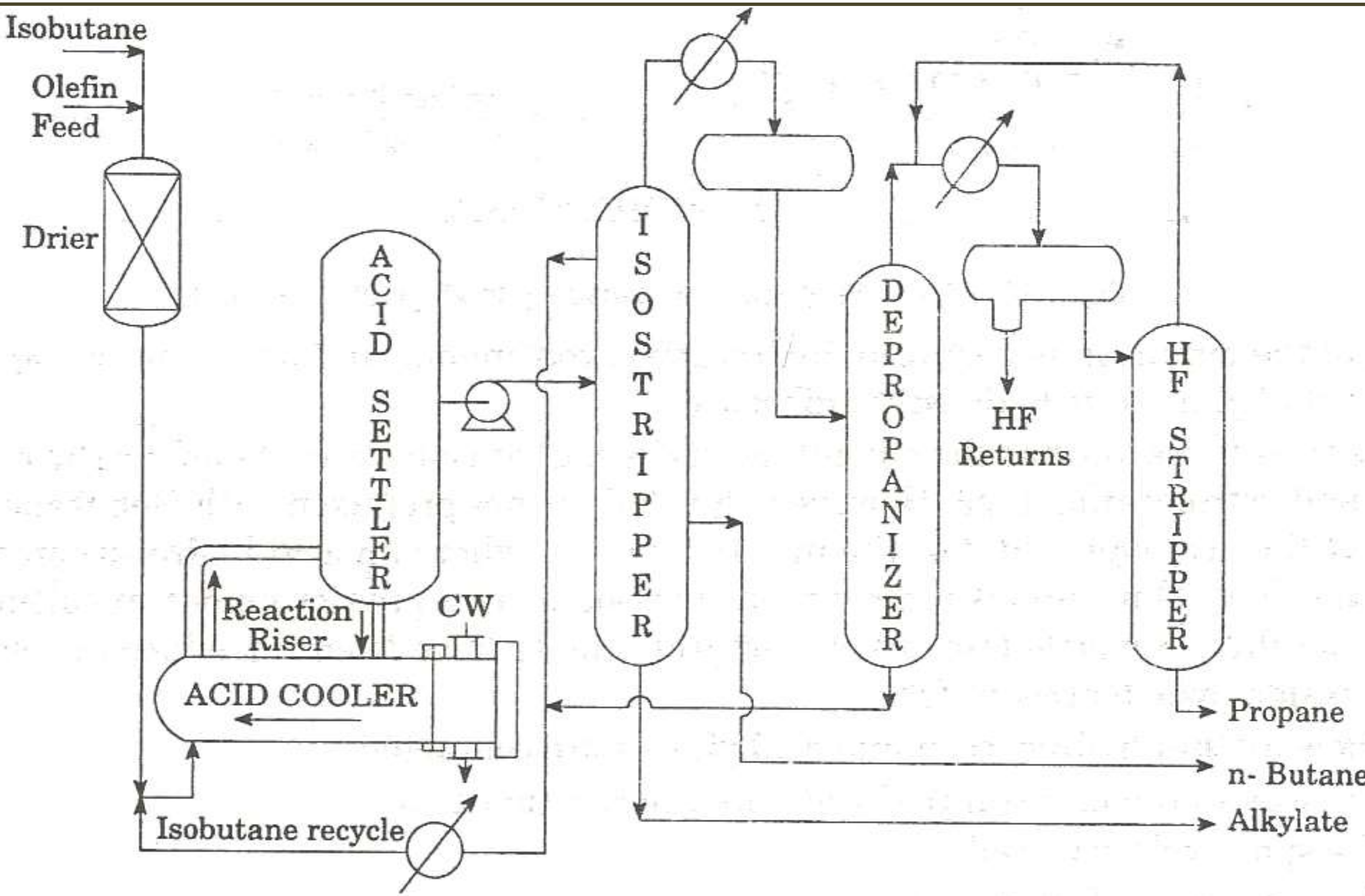
## HF Alkylation Processes

**The Phillips process.** This process uses a riser-type reactor




HF alkylation-The Phillips Process.

# UOP PROCESS -




HF alkylation-The Phillips Process.

# PROCESS VARIBLES -

THE PRIMARY PROCESS VARIABLES AFFECTING THE ECONOMICS OF $\mathbf{H_2SO_4}$ alkylation are-

- REACTOR TEMPRATURE
- ISOBUTANE RECYCLE RATE
- REACTOR SPACE VELOCITY
- SPENT ACID STRENTH

# Thanks