1. 공정 설명

본란에서는 Dynamic simulation 의 역사에 대하여 ,현장에서 요사이 많이 쓰이고 있는 이유에 대하여 간단히 알아보고자 한다.

1.1 INTRODUCTION

Dynamic simulation 은 1980 년대 영국의 SPEED-UP 에서 그 유래을 찾을 수가 있으며,

그이후 ASPEN-PLUS 로 회사가 합병되면서 오늘날의 ASPEN-DYNAMIC SIMULATOR 에 이르고 있으며 ,HYSIS 및 ,CHEMCAD,C.C.C,TRICONEX,및 ELITTTOT 등이다.

일반 사용자에게 Lease 하거나 판매하는 Simulator 는 HYSIS,ASPEN-PLUS 및 CHEMCAD 이며 GAS 처리 및 화학 및 정유공장 공정 전반에 적용되며, 그 이외의 Simulator 는 Compressor maker 에서 사용하고 있으며,외부에 Lease 나 판매는 하지않고 Compressor 을 중심으로 Control system 및 안전시설 설계 하는데 적용하고 있다.

Dynamic simulation 은 가스처리시설,화학공장 및 정유공장등에서 경제적인 설계, 최적 조건, 및 안정한 운전을 하는데 많은 도움을 주고있다.

모든 공장 및 시설을 설계 할 때 우리는 STEADY STATE 의 조건을 가지고 설계을 하지만 결코 운전 및 Emergency state 에서는 정상상태의 조건을 가지고는, 기기 및 SYSTEM 이 견디어 낼 수가 없는 때도 있다.

원료,외부적인 환경의 변화 ,열교환기의 Fouling, Catalytic degration, 운전조건의 변화,갑작스런 Moving equipment 의 멈춤 및 지원시설의 공급 중단 등이 정상상태에서 운전되는 공장을 혼란으로 이르게 한다.

Process system 의 이러한 Transient behavior 을 앞에서 열거한 Dynamic simulator 을 가지고 검토를 한다는 것은 아주 편리하며 신빙성이 있는 일이다.

Process system 의 Design 및 Optimization 은 Steady state 와 dynamic behaviour 의 검토가 동시에 이루어져야 한다.

Steady state model 들은 정상상태에서의 열 및 물질 수지을 각각 다른 운전 scenarios 에서 얻을 수가 있다.

Design engineer 는 steady state simulator 을 가지고 최대 생산량의 조건에서 운전 비 및 투자비의 줄임으로서 공정의 최적화를 이룰 수 있으나 이러한 최적화 된 공정 system 이 보증 된 생산량과 순도 및 효율을 가지고, 안전하고 쉽게 운전이 되는지는 Dynamic simulator 을 가지고 confirm 을 할 수 있다.

각 unit operation 에 해당되는 기기의 상세한 사양 조건을 Dynamic simulator 에 의해 실제 운전 상태에서의 기능을 확인 할 수가 있다. 또한 control system 의 설계도 할 수가 있다. Process control system 의 선택 가능한 방법을 test 하여 가장 좋은 방법을 선택할수도 있다. System disturbances 에 대한 dynamic response 을 실험하거나, controller 의 tuning 을 최적화 할 수도 있다.

Steady state simulator 에 의해 규명 될 수 없는 부분에 대하여서는 Dynamic simulator 에 의해 feed back 되어 steady state model 을 개선을 할 수도 있다.

Steady state modeling 에 의해 규명될 수 없는 부분을 Dynamic simulator 에 의해 규명 될 수 있는 부분은 아래와 같다.

Process optimization.

Controller optimization.

Safety evaluation.

Transitions between operating conditions.

Startup and shutdown conditions.

1.2 OPERATING PHILOSOPHY FOR PROPANE SYSTEM

The new propane tanks and associated equipment such as boil off gas compressors, refrigeration compressors, chillers etc will be operated the same operating philosophy as that adopted for the existing facilities.

The following sections describe the process operating philosophy.

1.2.1 Product Propane Rundown System

Product Propane from NGL-1, NGL-2 and NGL-4 plants is dried and chilled to required temperature within respective plant and routed to refrigerated storage tanks.

The individual flows are connected to common header through which product flow can be routed to the selected storage tanks (T-9 to T-12).

Product Propane is sent under individual back pressure controllers in the respective plant and the pressure in the product rundown line to individual tanks (T-9 to T-12) is maintained at about 1.5 bara by separate back pressure controllers on each storage tank to prevent flashing in the line.

1.2.2 Propane Storage System

Product propane from either of the plants NGL-1, NGL-2 or NGL-4 can be routed to any of the storage tanks T-9/ T-10/ T-11/ T-12.

Normally one storage tank will be in receiving mode to take product from all the plants. Other storage tanks will be in holding mode or one of these may be in loading mode. Same tank will not be used for simultaneous product receipt as well as product loading.

Each of the storage tanks is equipped with one circulation pump and four loading pumps with provision to install an annular space pump. The annular space pump shall remove the liquid leakage through a damaged inner wall. It shall be kept in the warehouse.

1.2.2.1 Pressure Control for Tanks

The tank pressure shall be kept with the following control set pressure.

Relief valve to atmosphere	:	68 mmbarg
Relief valve to flare	:	62 mmbarg
Tank inlet valve trip close	:	60 mmbarg
Pressure letdown from BOG Header to flare	:	50 to 55 mmbarg
Normal operating pressure	:	34 (range 20-50) mmbarg
1st Hot propane supply starts to open	:	15 mmbarg
2nd Hot propane supply starts to open	:	10 mmbarg
Trip pumps and BOG compressors	:	7 mmbarg
Vacuum breaker start to open	:	-2 mmbarg
Vacuum breaker fully open	:	-5 mmbarg

1.2.2.2 Level Control and Volume Control for Tanks

Tank level gauge shall be supplied to read direct continuous tank level and tank volume that shall be compensated by average temperature.

Tank level and volume can be observed in the control room and the following interlock and alarm shall be considered for safety operation.

HH : High high level shut down shall occur only minimum 2 out of 3 level instrument agree. Any one initiate an alarm.

H : High level make alarm

L : Low level make alarm

LL : Low low level shall trip the pumps (Loading and circulation pumps)

The tank bottom temperatures are maintained using electrical heaters to prevent ice formation in the earth. The tank bottom heating control is an ON/OFF type based on a set of temperature indications located in the tank bottom.

1.2.3 Propane Loading and Circulation System

Capacity of each loading pump is 750 m^3/h for tank T-9 and 1000 m^3/h for tanks T-10/T-11/T-12. Maximum loading rate from these tanks shall be limited to 3000 m^3/h on account of hydraulic limitations of existing loading arm.

However the provision of 4000m3/hr ship loading should be considered for future envisaged jetty for new propane storage tanks (T-10/T-11/T-12).

Tank contents are circulated using circulation pump or one of the loading pumps to prevent stratification of the storage tank contents and to keep the loading lines cool.

An important aspect that needs to be considered for the propane tanks is the
semi-long circulation mode. This mode is applicable for the propane tanks due to their diverse locations. When the long circulation mode is initiated from T-12 tank, the loading line from T-9 tank up to the jetty gate will remain in stagnating condition. This will lead to heat build up and subsequent boiling. To avoid this, the T-9 tank will be put on semi-long circulation mode. The same thing is also valid for the T-12 tank when loading or long circulation has been initiated from the tank T-9.

1.2.4 Propane Boil-Off Gas System

The boil off gases from storage tanks flow to the boil off gas compressors via the knock out drums provided with electric heating facilities to evaporate any entrained liquids. The compressed vapours

are recondensed in the chillers and returned to the tanks via the product rundown lines.

1.2.4.1 Propane Boil-Off Gas Compressors

New BOG compressors K-2511A/B/C will be provided for the propane BOG compression service.

The following table indicates the running and stand by philosophy and capacity utilisation of the compressor in different cases:

- Case-1 : Holding mode at 52 °C ambient temperature
- Case-2 : Holding mode at 40 °C ambient temperature
- Case-3 : Holding mode at 12 °C ambient temperature
- Case-4 : Loading mode for T-12 at 52 °C ambient temperature and 4000 m³/h product loading rate without ship vapour return to tanks.
- Case-5 : Loading mode for T-12 at 12 °C ambient temperature and 4000 m³/h product loading rate without ship vapour return to tanks.
- Case-6 : Loading mode for T-9 at 52 °C ambient temperature and 3000 m³/h product loading rate without ship vapour return to tanks.
- Case-7 : Loading mode for T-9 at 12 °C ambient temperature and 3000 m³/h product loading rate without ship vapour return to tanks.

CASE #	COMPRESSOR CAPACITY			REQUIRED CAPACITY (TPD)	AVAILABLE CAPACITY(*) (TPD)	CAPACITY UTILISATION(**) (%)
	K-2511A	K-2511B	K-2511C			
1	R	R	S	457	640	71
2	R	R	S	383	640	60
3	R	R	S	328	640	51
4	R	S	S	212	320	66
5	R	S	S	82	320	26
6	R	S	S	235	320	73
7	R	S	S	107	320	33

R = Running ; S = Stand-by

(*) Available capacity : Total capacity of duty compressor

(**) Capacity utilisation : Utilisation % of duty compressor

1.2.4.2 Propane Boil-Off Gas Condensers

The propane BOG Compressors (K-2511 A/B/C) will be located near the new propane tanks.

Propane BOG is compressed in the BOG Compressors (K-2511 A/B/C) and is delivered to the chilling train consisting of the Propane Tank Boil-off condenser operating at -49°C refrigerant level, the propane separator and the Propane Condensate pumps). One 100% standby chilling train has been provided so as to permit maintenance activities on the chiller train components without sacrificing the plant availability. The BOG condensate is pumped into the propane product rundown header going to tanks T-10/11/T-12.

1.2.5 Propane BOG Refrigeration System

A new refrigeration package will be provided to meet the chilling requirement of the new propane BOG chillers. The refrigeration package will consist of a fixed speed motor driven propane refrigeration compressor, an air cooled desuperheater, an air cooled condenser, accumulator, cooling water cooled sub-cooler, economiser stage, low stage suction drum and 2nd stage suction drum.

The conventional closed loop propane refrigeration package will be provided. A two stage configuration has been chosen so as to optimise the refrigeration package size. The condensation duty is at -49°C level. An economiser stage has been provided at -14°C level to reduce the total flashed gas quantity and to reduce the compressor power

The economizer shall be designed such a way that both refrigeration compressor shall be operated simultaneously.

- The compressed vapour is cooled and condensed by air cooled exchanger (desuperheater / condenser) at its vapour pressure corresponding to outlet temperature. The refrigerant is further sub-cooled in a water cooler to 44°C so as to improve the efficiency of the system. The cooling water consumption in the exchanger is nominal and is to be supplied from the existing cooling water system.
- The compressor will be provided with a suction throttling valve so as to improve as much as possible the turndown limit without recycling.
- The compressor will be restarted from the settle out pressure.
- One 100% capacity standby compressor will be provided. The standby compressor will be provided with its dedicated anti surge recycling system consisting of desuperheater, 2^{nd} stage suction drum and low stage suction drum. The standby compressor will be started independently and can be brought online so as to have a bump less transfer on the BOG condensing service.