

# REPLACEMENT OF RECIPROCATING CHILLER WITH ENERGY EFFICIENT SCROLL CHILLER

(For Ankleshwar Chemical Cluster)

## Cluster Brief:

Gujarat is a major contributor in the production of basic chemicals as well as petro-chemicals with 54% and 59% share of the country's production, respectively. Also, chemicals /petro-chemicals and pharmaceutical sectors contribute to about 60% in the entire manufacturing output of Gujarat. About 50% of the total chemical production in Gujarat is contributed by industries in Ankleshwar. Ankleshwar and Panoli industrial areas have more than 1,200 industries, manufacturing diverse range of chemicals, pesticides, pharmaceuticals, bulk drugs, petroleum products, engineering, textiles, plastics, rubber, and packaging. Out of these 1,200 units, more than 600 are MSME units manufacturing various types of chemicals, like dyes, pigments, insecticides, specialty chemicals, petrochemicals, pharmaceuticals, and paints.



Varieties of basic chemicals are used as raw materials to manufacture major chemical products. These basic chemicals, used as raw materials, are classified according to a variety of features:

- ✓ Based on their chemical composition (organic and inorganic),
- ✓ Based on their origin (mineral, vegetative, and animal), and
- ✓ Based on their state of aggregation (solid, liquid, and gaseous).

Majority of the industries located in Ankleshwar and Panoli are wet processing units, which requires high amounts of thermal energy in the form of steam and thermic-fluid and electrical energy. The sector is unorganized in nature, mostly using old and inefficient technologies. There is a significant potential to make these units energy efficient and cost competitive, through accelerated adoption of energy efficient technologies in the cluster.

There are two types of chillers available in the cluster: Brine chiller and chilled water chiller. Based on the feedback from the units, Majority of the chillers are chilled water types. Therefore, we are proposing chilled water type scroll chillers in cluster. Supply and return temperature of the scroll chiller will be 5 degC and 12 degC respectively.

Out of 100 surveyed units, 14 units are having ice based chiller systems, 2 units are having cooling tower based chiller systems and 23 units are meeting their cooling load through electric chillers. Out of 23 units, 3 units are having screw chillers and remaining 20 units are having reciprocating chillers which can be replaced by energy efficient scroll chillers. The average specific power consumption of the existing chillers is in the range of 1.14 to 1.16 kW/TR.

For an ice-based unit, which consumes 12 TPD ice daily, the replacement of existing ice based system with scroll chillers, the payback period is more than 2.5 year. As mentioned above, ice bank units are also less than 20 (14 units) ; both criteria are not meeting for new technology.

Therefore considering the chilled water based and ice based units we recommending to replacing the ice bank based unit on a case to case basis if the payback period comes under 2 year only. Here we are proposing replacement of reciprocating chillers with scroll chillers only.

**Table 1: MSME chemical industry details in region**

Sl. No	Region	Type	Number of Operational Units	of Manufacturing MSME
1	Ankleshwar and Panoli	Chemical	670	67% manufacturing dyes and pigment , 27 % Parma and Parma intermediate, 6 % chloro –alkali

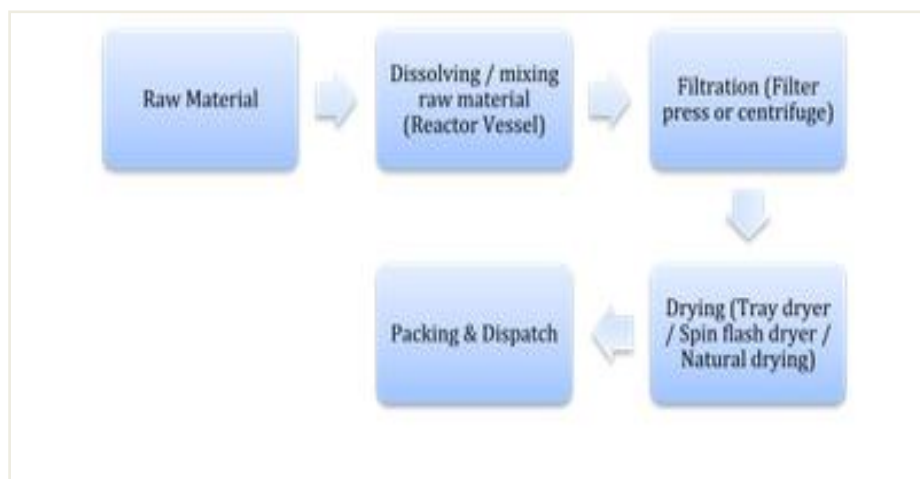
\*Source: Data from industry associations

### Existing practice:

Majority of industries are using reciprocating chiller systems for chemical processes, which are very old and inefficient. These old reciprocating chillers have high specific power consumption and require frequent maintenance. The running hours of these chillers are 16 to 20 hours a day. The



Production Process of the unit is given below:



**Figure 1: Process in chemical unit manufacturing**

## Some of the disadvantages of reciprocating chillers are:

### **PULSATING FLOW:**

Due to pulsation on the suction and discharge of the machines, pulsation suppression devices are required to dampen the pressure wave amplitudes, which are damaging to the compressor valves and connecting piping.

### **LOW RELIABILITY:**

Due to reciprocating motion the parts are subjected to more wear and tear, this requires opening of machine periodically.

### **LOW COMPRESSION RATIO OR SMALL COOLING CAPACITY:**

Reciprocating chillers have less compression ratio compared to scroll chillers which leads to higher energy consumption.

## Proposed technology:

The existing reciprocating chiller is proposed to be replaced with chilled water based scroll chiller. The new chillers can be designed considering heat load of the existing system and temperature requirement in the reaction vessels. By considering these parameters into the design of the screw chiller system will reduce the investment for cooling demand; also improving the quality of the final product.

Additional advantages are listed below:

- Easy monitoring and control
- Cost effective
- High efficiency cooling system
- Better quality of cooling
- Reliable

The cooling capacity is generally higher for scroll compressors although the increase is very low at lower condenser temperature. Scroll compressor has cooling capacities between 1% and 12% greater than the reciprocating compressor at particular condenser temperatures. Refrigerant R-22 is using in



Figure: Air cooled scroll chiller

## Justification of technology selection:

The proposed technology of chillers not only helps to improve energy consumption and product quality but also can save down time. The improvement envisaged through the installation of the system has been summarized in the table below:

**Table 2: Performance parameters of energy efficient chiller**

Parameter	Existing scenario (Reciprocating system)	Post Implementation scenario (chilled water based Scroll chiller )
Specific energy consumption	The specific energy consumption of existing chiller is on the higher side	Installation of energy efficient chiller will reduce the specific power consumption by 25-30%
kW/TR	1.14-1.16	0.74-0.78
Maintenance	Routine maintenance required as there are too many parts and accessories	Less maintenance as there are lesser no of moving parts
Vibration	High	Smooth running and less vibration
Compression ratio	Low compression ratio, small cooling capacity with single unit	High compression ratio
VFD	Can be used	Can be used
Space required for system	More	Less , compact design
Efficiency	Less efficiency in partial loading	High efficiency in partial loading

### Estimated Energy & monitoring saving:

Capacity of electrical chiller will depend upon reactor capacity, which is having capacity range from 1kL to 20 kL at Ankleshwar Chemical Cluster. For calculating the energy and monetary benefits, a representative case of reactor of 5 kL capacity has been considered. The benefits envisaged through installation of electrical chiller have been summarized in the table below:

**Table 3: Cost benefit analysis for replacement of reciprocating chiller to energy efficient chiller**

Parameters	Units	Value
Rated capacity	TR	18
Existing SEC of Chiller-2	kW / TR	1.14
SEC of new EE chiller	kW / TR	0.74
Electricity savings	kW	7.2
Running hours / day	h / d	20
Running days / y	d / y	300
Electrical energy savings by replacing old in-efficient chillers with new EE chillers	kWh / y	43,200
Cost of electricity	Rs / kWh	7.3
Energy cost savings per year	Rs Lacs / y	3.2
Proposed investment for EE chiller	Rs Lacs	6.1
Simple Payback period	years	1.9

\*extracts of calculation provided.

The benefits can be summarized as:

- ✓ 25-30% reduction in specific power consumption
- ✓ 30-40% saving in maintenance cost

### Replication Potential:

Ankleshwar has a large number of chemical processing units forming clusters. The Ankleshwar Industries Association (AIA) is the biggest association operational in the cluster, with close to 600 registered chemical units. To establish the replication potential of the technology in the sector, the following were considered:

- ✓ Technology feasibility and adaptability through energy audits in 8 units.
- ✓ Survey of 100 units (under process)
- ✓ Meetings held with associations / stakeholders (including technology suppliers)

The outcome of the survey conducted across 100 chemical units in the cluster has been summarized below:

Table 4: Replication potential for scroll chiller

No. of units surveyed	Replication Potential (based on applicability of the technology in surveyed unit)	Replication potential in surveyed unit (%)	Replication potential in cluster (extrapolated based on 600 units)
100	20	20	90

\*A unit has on an average 1 to 2 Numbers of chillers. 20% of 600 units are 120 units but we considered 90 units for replication on conservative side.

The technology of energy efficient chilled water based scroll chillers has a significant demand in place of reciprocating chillers, with 18% of the units surveyed opting for the technology as 'first preference'. A total number of 20 interests were generated for the technology.

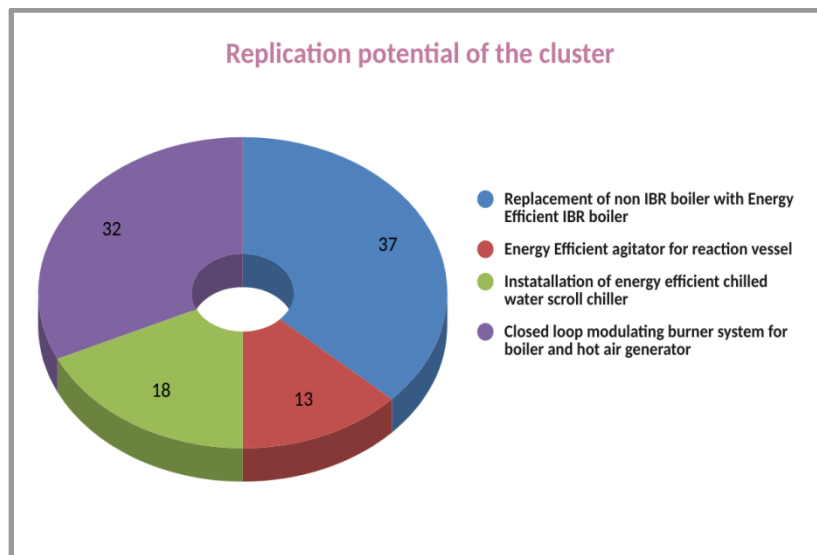


Figure 2: Summary of survey results

Source: Survey of 100 MSME units under UNIDO-EESL Project

Considering the survey results and based on further discussion with associations, units, stakeholders and outcome of the energy audits, it is estimated that the technology has a replication potential of 90 units. Based on replication in 90 units, the overall project benefits will be as follows:

**Table 5: Impact of replication of technology**

Parameter	UoM	Value
Annual electrical energy saving (one unit)	kWh/y	43,200
Annual electricity saving (considering 90 units)	kWh/y	38,88,000
Annual energy saving (considering 90 units)	MJ/y	13,99,664
Annual CO2 emission saving (one unit)	tCO2/y	35
Annual CO2 emission saving (considering replication in 90 units)	tCO2/y	3188
Estimated investment in technology (one unit)	Rs Lakh	6.5
Estimated investment in technology considering 90 units (assuming price down due to demand aggregation)	Rs Lakh	549
Total Investment	Mn USD	0.77
Total energy savings (in 10 years)	TJ	140
Annual CO2 emission saving (in 10 years)	tCO2	31882

### Barrier for implementation:

Although the technology has been successfully proven; there has been limited replication of the technology in the cluster. The barriers identified for limited penetration of the technology in the cluster are as follows:

- ✓ **Cost:** Cost difference of new chillers and second hand chillers is high and second hand chillers are easily available in the scrap market. Unit holders are not interested to give bank guarantee of 80% cost of project
- ✓ **AMC of chillers:** Unit holders are quite worried about AMC of chillers as they are having current practice of local AMC units.
- ✓ **Variation in temperature:** Temperature variation is very high in chemical units which may affect performance of chiller
- ✓ **Knowledge barrier:** Based on discussion with units, it has been found that knowledge dissemination related to the technology has been limited.
- ✓ **Lack of after-sales service:** The technology penetration has been limited due to the lack of after sales service. The delay in such services forces the units to bypass the automation system. The annual maintenance contract and warranty, which has been inbuilt in the present model, is expected to take care of the issue.

- ✓ **Risk related to implementation:** The units lacks confidence related to performance of the technology. The risk of performance has been covered under the project.
- ✓ **Lack of monitoring instruments:** Not clear about their existing level of operations and efficiency, due to lack of instrumentation & non availability of energy consumption data
- ✓ **Narrow focus on energy:** The units have much interest in production figures and committed for target production

#### Availability of technology supplier:

The technology of “Replacement of reciprocating chiller to energy efficient scroll chiller” has been well established. A large number of reputed technology supplier cum integrators are involved in supply and service of the technology. Most of these technology suppliers have local offices / representatives at Surat and nearby. In addition to the established names, a large number of smaller system integrators are also involved in the supply of this technology. Some of the established technology suppliers are:

**Table 6: Vendors details**

S. No	Vendor's name	Daikin	Super cool refrigeration Pvt. Ltd.	Voltas	Blue Star
1	Experience/ Year of establishment	1924	2006	1954	1943
2	Presence in India	Mumbai based company. We are well equipped with all necessary machinery and handling equipments .	Dealing in all over India	Dealing in all over India	Dealing in all over India
3	Presence in Ankleshwar cluster	Yes, and head office in Mumbai	Yes, Office in Surat	Yes, Office in Ankleshwar	Yes, Office in Ahmedabad
4	Contact details	Phone No. 9879015984	8048429590		

#### Technology Summary:

The benefits of the technology of energy efficient scroll chiller system in Ankleshwar Chemical Cluster are summarized below:

**Table 7: Technology summary: EE Scroll chiller**

Sl. No.	Category	Sub-Category	Value
1	Energy Efficiency	% improvement from baseline	30-35% saving in specific energy consumption can be achieved
2	Financial Feasibility	Payback period	The simple pay-back period for the technology is around 1.9 year
3	Replicability	No. of MSMEs to accept	The technology has a replicability potential in 20% of the units

Sl. No.	Category	Sub-Category	Value
4	Availability	Local Availability	The technology is locally available at Ankleshwar
		Technology provider	There are 3-4 technology provider
5	Ease of Implementation		Medium: Requires production downtime of 2-3 days