Notes

Chapter - 6

LPG Bottling Plants

6.1 Introduction

Over 100 million LPG consumers in the domestic sector in India are serviced through a network of 9365 LPG distributors who are getting supply from 181 LPG bottling plants located across the country. In 2007-08, India consumed a total of about 1170 TMT of LPG which is around 10% of the consumption of total petroleum products in the country. Out of the total LPG consumption during the year 2007-08, almost 75% was used for cooking, 17% as auto LPG and the remaining 8% for industrial use. Of the total supply of 11.7 Million Tonnes of LPG during 2007-08, the indigenous production was 8868 TMT from crude oil and natural gas fractionation (3:1). Imports by PSUs and private entrepreneurs accounted for 2156 TMT and 673 TMT respectively.

LPG is transported from production installations i.e. Refineries, Fractionation plants and Import terminals to the bottling plants through pipelines, Bulk LPG Wagons or Bulk LPG Tank Trucks. This LPG, subsequently, is bottled in 19 Kg, 14.2 Kg and 5 Kg cylinders and is then delivered to commercial consumers and individual households. Bottling operation of LPG is very critical, as LPG is a highly inflammable product and the systems are required to be intrinsically safe. The systems also require very comprehensive fire safety arrangements.

A typical LPG bottling plant has the following major energy consuming equipment:-

1. LPG pumps
2. LPG compressors
3. Conveyors
4. Blowers
5. Cold repair facilities including painting
6. Air compressors and air drying units.
7. Transformer, MCC & DG sets
8. Fire fighting facilities
9. Loading and unloading facilities

Some of the LPG bottling plants use a comprehensive monitoring technique for keeping track of energy / fuel Consumption on per tonne basis. PCRA's energy audit studies in various LPG plants have found 20-25% energy saving potential in the LPG Plant operations. The following are major energy conservation opportunities in a LPG Plant:

6.2 Energy Conservation Opportunities in Air Compressors

Compressed air system is one of the most inefficient operation for conversion and storage of energy. Typically, efficiency from start to end-use is around 10%. In any compressed air system with a saving potential of upto 30%. This saving potential is mainly, towards efficient compressed air generation system, efficient compressed air transportation system, maintenance of optimum pressure levels and reducing misuse and leakages.

6.2.1 Compressor Air Pressure Level

In a bottling plant, compressed air is used as instrument air and service air. The pressure level of 5 Kg/cm ^{2} is sufficient for all the operations in a bottling plant.

The requirement of air pressure for various devices is as under:

Remote Operated Valve(ROV)	-	5.0 Kg/cm^2
Deluge valve	-	3.5 Kg/cm^2
Stopper/pushing/pulling of cylinders	-	5.0 Kg/cm^2
Instrumentation	-	2.0 kg/cm^2
Painting gun	-	4.0 kg/cm^2
Hydrostatic testing of cylinders	-	5.0 Kg/cm^2

Case Study 1 : Air Pressure Level Optimization

Brief

Air pressure level in the plant is fixed by setting the loading and unloading pressure through pressure switch provided in Air Compressor.

Energy Savings

Generally, the air pressure maintained in a LPG bottling plant is of the order of 6 to 6.5 Kg/cm^2 Reduction in pressure levels by 1.25 kg/cm^2 would mean saving of 12.5% in energy consumption and saving of another 15% in compressed air consumption. For a plant having 1 carousel system requiring 150 CFM (27kW motor load) compressed air and working 16 hours per day and 350 days per year, savings of 12.5%: 19170 kWh worth Rs. 90000/- per year is possible. Additional saving of Rs. 0.11 Million per year can be achieved through reduction in compressed air consumption.

This is a no cost proposition, requiring minimal technical skill in re-setting of pressure switches.

6.2.2 Performance test and measurement of output CFM of compressor:

Air compressors, specially reciprocating, suffer deterioration in performance over a period of time, resulting in lower volumetric efficiency. The drop in volumetric efficiency needs to be diagnosed and corrected at its earliest, so as to check the loss of energy.

Case Study 2 : Measurement of output CFM

Brief

Assessment of volumetric efficiency can be done in-house with least instrumentation support. Finding the volumetric efficiency dropping by more than 10%, should trigger for initiating major overhaul. Typical overhaul of a 150 CFM Air Compressor would cost Rs. 25000/- approx.

Energy Savings

A 10% deterioration in volumetric efficiency in a 150 CFM system means, loss of 2.7 kW of power. For a 16 hour per day operation for 350 days in a year system, this works out to 15120 kWh.

On overhauling the compressor, the Annual saving in energy	*:*	*15120 kWh*
Annual saving	*:*	*Rs.71000.00*
Investment required	*:*	*Rs.25000.00*
Payback Period	*:*	*4 months*

6.2.3 Leakage of Compressed Air & Wastage:

Avoiding leakage is the largest opportunity of saving energy in a compressed air system. The leakage in compressed air system in a plant can be quantified by adopting the following process -

a) Raising the receiver pressure to the designed pressure and stopping the air usage with all intermediate valves open.
b) Keeping the complete line including pneumatic circuit pressurised
c) Recording loading and unloading duration of the compressor

% leakage can be calculated by

$$\% \text{ Leakage} = \frac{\text{Load Time}}{\text{Load Time} + \text{Unload Time}} \times 100$$

Case Study 3 : Arresting the leakage in a Compressed Air System

Brief

Leakage of anywhere between 40% to 90% has been observed in compressed air systems. Leakage can be arrested by conducting a leak test for identifying points of leakages and plugging the same. Leakage reduction is a continuous process and should be built into the system

Energy Savings

A reduction of 25% leakage in a typical 150 CFM system would mean saving of over 37 CFM. Equivalent power saving would be 6 kW having implication of 33600 kWh, worth Rs. 157000/- per year for a 16 hour per day operation for 350 days per year system.

It does not really cost much to arrest leakage, whereas the saving potential is very high.

6.3 Optimization of Power Supply System Billing and Demand Side Management

Various equipment forming the power supply system in a bottling plant are Transformers, Breakers, Switchgears, Changeover switches, PF controllers etc. Licensed area being a notified intrinsically safe area, all these circuit elements of the power supply system are installed outside the licensed area. Thus, the length of transmission cables is longer compared to any other application and hence demand side management becomes all the more important.

6.3.1 Transformers

Transformers are very efficient electrical equipment. However, losses are still an issue in the transformers in a typical power transmission network.

Normally, two number of transformers are installed in a bottling plant with one being stand-by and both are kept energised all the time so as to avoid any power failure due to break down in transformer. However, keeping two transformers energised (one being stand-by) is a wrong practice as the transformers are under charged condition for 24 hours everyday and losses are incurred even if no power is drawn from the transformer.

Typically, a 1500 kVA modern transformer having amorphous core has a no load loss of 555 Watts. De-energisation may risk the transformer of moisture ingress. However, moisture ingress can be avoided by following a sequential on/off regime.

De-energising the transformer is not always the solution. At times load re-distribution among transformers helps reduce load losses resulting in reduction of overall loss. Typically no load losses of the transformer is of the order of 50% of load losses. Thus, opportunity for saving Energy in a transformer system needs to be assessed for the system as a whole. Implementation of the proposition involves no investment and very little technical skill.

Keep the standby transformer De-energised and load the two transformers alternately every fortnight. This will save ½ KW worth power having yearly saving potential of 1/2X24X365 4381 kWh. This saving potential may be 7 times more if Silicon Core Transformer is used and over 3 times more, if Low Loss Silicon Core transformer is used.

6.3.2 Demand Side Management

Demand Side Management involves controlling various cost heads appearing in a typical electricity bill, with a view to optimise electricity bill. The factors appearing in electricity bill are Maximum Demand, Power Factor, Voltage Levels (HT/LT) etc. All these factors can be kept under strict control, resulting in substantial saving for units.

Keeping Maximum Demand under control helps units save on demand charges, at the same time helps the utility by way of spare capacity. It is always advisable to keep maximum demand under check. This issue becomes of paramount importance, where snap loads are there. Like in a bottling plant, fire water pumps testing, service water pumping etc are not continuous loads and hence these jobs can be done in off peak hours to save on maximum demand. It will also help in cases where Time Of Day (TOD) tariff system exists. Equipment like Maximum Demand Controller is used for keeping maximum demand under control through user defined sequential switching off and on.

Average of the of time integrated load for every half an hour period is registered in the electronic meter for the entire month. The maximum value registered is considered to be the maximum demand. Maximum demand can be controlled by monitoring number of energy consuming equipments, operated at any point of time and also by improving Power Factor. Industries have started use of relay based

intelligent Maximum Demand Controllers, which keep check on maximum demand by switching off and deferring non essential loads.

In two-part tariff system, Demand Charges are levied on the contract demand. The Demand Charges have been found to be higher up to 20% of net electricity bill in a Bottling Plant. The utility also levies penalty for exceeding contract demand. Thus keeping maximum demand under control, pays through saving in demand charges.

6.4 PF Control

Power Factor is a measure of the quantum of Inductive load present in an electrical system and also the extent of partial loading of these inductive loads. Utilities (Electricity Supply Companies) give incentive for maintaining higher Power Factor and the incentive may be upto 5% of the energy charges. Maintaining higher PF has the following advantages :

i Keeps current under check and hence the I^2R losses are reduced.
ii Saves transmission losses, in systems having longer cable lengths.
iii Power Utility companies pay incentive for maintaining higher PF.
iv Helps to keep maximum demand under check and hence lowers outgo towards demand charges.
v Helps in keeping voltage drop lower and hence better voltage availability and very less voltage imbalance to help save electricity.

Automatic Power Factor Controller (APFC) helps improve Power Factor and reach near unity.

Case Study 4 : Improving and maintaining the Power Factor

Brief

Improving and maintaining the power factor from 0.93 to near unity by providing additional capacitors having kVAh billing system.

Energy Savings

Annual energy consumption = 227340 kWh
Existing Average pf = 0.93
Annual consumption in KVAh = 227340 kWh / 0.93 = 244452 kVAh
On improving the power factor from 0.93 to 0.99 by installing required additional capacitors
The same annual energy consumption in KVAh = 227340 kWh /0.99 =229636 kVAh
Annual Saving of energy in KVAh = 229636 - 244452 = 14816 kVAh
Average unit rate is Rs 3.57 / kVAh
Annual Saving in Rs = Rs 52893.00
Cost of additional capacitors = Rs 10,000/-
Pay back period = 3 months

Case Study 5 : Improving and maintaining the power factor from 0.92 to near unity by providing additional capacitors for system having kWh billing system and having rebate of 0.5% for improvement in PF by 0.01, on its energy charges.

Energy Savings:

Annual energy consumption = 442040 kWh
Existing Average pf = 0.92
On improving the power factor from 0.92 to 0.99 by installing required additional capacitors the improvement is by 0.07.
The plant is eligible for a rebate of 3.5 % on its energy charges.

Annual energy charges @ Rs 4.09 / kWh	*= 442040 x 4.09 = Rs 1807944.00*
The rebate on energy charges	*= 3.5 % of Rs 1807944*
Annual Saving	*= Rs 63278.00*
Cost of additional capacitors	*= Rs 50,000/-*
Pay back period	*= 10 months*

The Demand control through scheduling of loads and also with the help of MDI controller is a proven solution working in industrial applications and is very reliable. Indian vendors are also available for the job. Reliable APFC and capacitors are very easily available and require little maintenance. The system may not work reliably and capacitors may fail, if harmonics are there in the system. APFC with harmonic filter gives comprehensive solution for systems having high harmonic distortions.

6.5 Voltage Optimization

Typically, in a transmission system, voltage at the load end, reduces with reduction in Power Factor or increase in current levels. Various loads, requiring electricity for its operation, are designed for a voltage of 415V. However, the voltage levels are generally higher and reach upto 460V during late night. This gives an opportunity to reduce voltage by upto 10%. A reduction in voltage by 10%, would give savings of upto 1.5% in motors because lowering voltage increases loading level of motors resulting in improvement in its efficiency. A 10% drop in voltage, also helps save upto 15% in energy consumption in lighting loads

There are two ways in which voltage control may be implemented -

6.5.1 Voltage control through Tap Changer

Use of Tap Changer - The provision for tap changing is an inbuilt feature of transformer / incomer system. Lowering the voltage through tap changing is the most convenient way of reducing voltage levels. It involves no cost and it is very convenient if the transformer has On Load Tap Changer (OLTC). Otherwise, every tap change involves switching off power and then effecting tap change.

6.5.2 Voltage Control through AVR

Use of AVR - Automatic Voltage Regulators have emerged as a worthy solution. AVR technology is very proven and very easily available. The advantage of having an AVR is that one can have the desired voltage out put , say 3 phase, 415 V, 24 hours a day, irrespective of the incoming voltage. This is not possible in tap changers. It immunes the system of voltage fluctuation and high voltages, especially during late night hours. AVR is a very good proposition for exclusively lighting load as the voltage levels are higher during night time when they are ON and the percentage saving is more i.e 15% for 10% reduction in voltage.

Case Study 5 : Voltage optimisation for lighting through AVR

(i) Existing Average voltage level in daytime (10 hrs)= 230 V

Proposed voltage	*= 210 V*
Expected saving	*= 8.0%*
Total approx. lighting load	*= 25 kW*
Expected saving	*= 25 x 0.08*
	= 2 kW
Annual power saving	*= 2 kW x 10 hrs.x 300*
	= 6000 kWh

Annual monetary saving @ Rs 4.09 per kWh = Rs 24540

(ii) Existing avg. voltage level in off peak hrs	*= 240 V (14 hrs)*
Proposed voltage	*= 210 V*
Expected saving	*= around 9%*
Total lighting load in off peak hrs	*= 125 kW*
Expected saving	*= 125 kW x 0.09*
	= 11.25 kW
Annual power saving	*= 11.25 x 14 hrs. x 365 days*
	= 57487 kWh
Annual monetary savings	*= 57487 x 4.09*
@ Rs 4.09 per kWh	*= Rs 2,35,122*

Energy savings

Net Annual saving potential	*= Rs. 235122+Rs. 24540= Rs. 259662.00*
Net investment in providing AVR	*= Rs. 190000*
Payback Period	*= 9 months*

6.6 Energy Saving Opportunities in LPG Pumps

LPG pumps consume around 14-15% power of the total plant consumption. These pumps run continuously for 16 hours per day. Other pumps are service water pump, bore well pump, fire-fighting pumps, which are run as per requirement in the plant.

The filling rate at carousel varies depending upon the number of cylinders filled in the LPG bottling plant. This is controlled through return line (bypass) and is operated based on pressure in the header. The system operating with throttled valves or operated with bypass valves in partially open condition, leads to the wastage of significant energy. This wastage of energy can be eliminated / minimized by the following methods:

- By installing proper size pump
- By trimming the impeller of the pump
- By changing the speed of the pump through VSD

In the present system, the requirement of flow is not constant and it varies as per the filling rate and bullet pressure. Keeping this operational constraint in view, flow reduction through changing the speed of the pump by installing VSD with feedback from discharge pressure/ flow will be the best option to minimize the energy wastage.

Case Study 6 : Installation of Variable Speed Drive (VSD)

Brief

For a typical bottling plant having one carousel, 1 pump having 50 kW motor and 96m head / 150 m^3 per hour discharge is required to pump LPG from the storage tank to the carousel. Energy can be saved by closing the bypass valve on the return line and installing VSD on the motor of the pump to get the desired flow and Pressure at the carousel.

Energy Savings

- *Present power consumption by pump*	*- 40 kW*
- *Pump suction pr.*	*- 5-6 kg/cm^2*
- *Pump discharge pr.*	*- 10 - 12 kg/cm^2*
- *Expected power consumption by pump with VFD*	*- 30 kW*
- *Saving in power consumption*	*- 10 kW*
- *Annual operating*	*- 4200 hrs*
- *Annual Savings in kWh*	*- 42000 kWh*
- *Annual savings @ Rs 3.675 per kWh*	*- Rs 1,54,350*
- *Investment required for VSD & automation (for pressure transmitter, cable)*	*- Rs 5,00,000*
- *Payback period*	*- 39 months*

6.7 Energy Conservation in Lighting

Significant amount of energy is consumed in Lighting application in a bottling plant due to operation during the night and also security requirement in very large areas. The following saving opportunities exist in the lighting system in a LPG bottling plant -

Case Study 7 : Replacement of 96 T/Ls of 40 W (T12) (having electromagnetic chokes) operating in plant with 28W(T5) tubelights.

Brief

These are operated on an average for 12 hrs per day for 300 days in a year. the electromagnetic chokes in itself consume about 13W per tube light.

Energy Savings

Total energy consumption by 96 nos. 40-Watt tube lights with Electromagnetic chokes for 12 hrs as mentioned above	*= 96x (40 +13)x 300x 12* *= 18316 kWh/year*
Total energy consumption by 96 nos.28 W(T5) tube lights	*= 96x28x300x12* *= 9677 kWh/year*
So, total energy saving	*= 8639 kWh/year*
Monetary saving potential at Rs 4.09/ kWh	*= Rs 35333/year*
Total investment@ Rs 500 per tube light	*= Rs 48000*
Pay back period	*= 7 months*

Case Study 8 : Replacing HPMV Lamp fittings with metal Halide fittings

Brief

About 186 nos of 125 W HPMV lamp fittings in various sheds can be replaced by 70 W Metal halide fittings in a phased manner whenever any of the items of luminary goes out of order.

Energy Savings

Total energy consumption by 186nos, 125W HPMV fittings, when operated for 12 hours for 300 days.	*= 186 x 125 x12x300* *= 83700 kWh/year*
Total energy consumption by 186 nos. 70W Metal Halide fittings	*= 186x 70 x 12 x 300* *= 46872 kWh/year*
Total kWh saving per annum	*= 36828 kWh*
Monetary saving potential at Rs 4.09/ kWh	*= Rs 150636/year*
Total investment@ Rs 1000 per light	*= Rs 186000.00*
Pay back period	*= 15 months*

6.8 Energy Conservation Opportunity in LPG Compressor

Contribution of LPG Compressor in the energy consumption pattern of a LPG Bottling Plant is significant. LPG compressor is essentially a reciprocating compressor like air compressor and the saving potential in air compressor more or less holds good for LPG compressors as well, except leakage. Thus, volumetric efficiency assessment and corrective action thereof, happens to be a major energy saving opportunity in LPG compressors.

Operating practices contribute a lot to energy consumption. The higher the specific pressure ratio, the higher is the energy consumption. Thus, the endeavour should be to keep the specific pressure ratio as low as possible.

In actual practice, discharge pressure of LPG compressor is made higher for increasing bottling output or for hastening the process of LPG loading/ decantation. However, all these practices have implication on Energy consumption.

6.9 Other Energy Conservation opportunities

1) Use energy efficient lamps and replace incandescent bulbs with Compact Fluorescent Lamp (CFL).
2) Use task lighting, as keeping the light source as close as possible to the work place; as the light intensity decreases exponentially as the distance from the light source to the task increases.
3) Provide reflectors on the tube lights to enhance lumens/m^2 (LUX), always keep reflector clean.
4) Make effective use of daylight wherever possible.
5) Clean luminaries to increase illumination, normally 10 to 20 % light output reduces over a period of six months if not cleaned.
6) Improve colour & reflectivity of walls, ceilings to reduce lighting energy needs.
7) Whenever replacing a burnt out lamp, attempt should be made to replace it with a more efficient lamp and the ordinary T/L fitting with an electronic ballast fitting.

Electronic ballast consumes only 2 Watts in comparison to the electromagnetic ballast which consumes around 13 Watts of electrical energy.

8) Use time clocks or daylight sensor control for outdoor lighting.
9) Train personnel to switch off the light whenever not required, posters as reminders can be placed on the doors for this purpose.
10) Wherever LUX level is specified, it must be counter checked by LUX meter.
11) During breaks, the lights of a specific workplace should be switched off, for which individual switches hanging at the worktable shall be helpful.
12) Interlocking of chain conveyor with cylinder washing pump.
13) Avoiding idle running of pump conveyor system.

References

1. PCRA Energy Audit Report, HPCL LPG Bottling Plant, Asauda Bahadurgarh (Haryana), December, 2006
2. PPAC Ready Reckoner, Information as on 1.4.2008, Petroleum Planning & Analysis Cell, MOP&NG, GOI New Delhi
3. Teri Energy Data Directory & yearbook 2007, TERI Press, New Delhi
4. World Energy Outlook, 2007, IEA Publication, Paris, France
5. Basic Statistics on Indian Petroleum & Natural Gas, 2006-07, Ministry of Petroleum & Natural Gas, (Economic Division), GOI