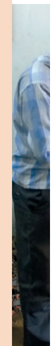
ENERGY PROFILE

COIMBATORE PUMP SET CLUSTER

The Energy and Resources Institute

SHAKTI SUSTAINABLE ENERGY FOUNDATION

Promoting Energy Efficiency in SMEs
SAMEEEKSHA



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Certificate of originality

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Coimbatore Pump Set Cluster

Overview of cluster

Coimbatore, located in the state of Tamil Nadu, is an important industrial cluster in India. The industrial activities in the cluster developed in the 1930s, with the setting-up of many textile and spinning units since the local weather was suitable for yarn processing. Initially, the metal casting industry flourished in Coimbatore to cater to the needs of the local textile machinery manufacturers. Subsequently, with the start of pump manufacturing in Coimbatore in 1930 and electric motors in 1937, it became an important cluster for manufacture of mono-blocks, domestic pumps, and subsequently submersible pumps. In 1970s, the wet-grinder was developed in Coimbatore for grinding of rice and lentils used in local recipes. The motor and drive-system of wet-grinders use casting components. Subsequently, major automobile manufacturing units came up in surrounding areas, such as Hyundai, Honda, Leyland, Allwyn Nissan, Pricol, L&T, LMW, and Mahindras.

There are an estimated 25,000 Micro, Small, and Medium Enterprises (MSME) units in Coimbatore cluster, of which majority are engineering and textile units. The cluster is spread within Coimbatore and neighbouring Small Industries Development Corporation (SIDCO) industrial estates as shown in Figure1. The engineering industry is diverse in nature. Some of the major engineering segments include foundry, pump sets, machine tools, auto components, sheet metal, cables and wires, printing and packaging, and food machinery.

Pumps are widely used in the agricultural, municipal, domestic, and industrial sectors. Coimbatore is one of the largest producers of submersible pumps for agricultural and domestic sectors as well as centrifugal pumps for domestic and industrial usage. There are about 600 pump manufacturing units and 400 ancillary units in Coimbatore; it accounts for nearly 40% of the pump sets manufactured in India.

The pump set manufacturing units are scattered both within and outside the city. Some of larger geographical concentration of pump set manufacturing units in the cluster includes Arasur, Annur, Avinashi Road, Ganapathy, Kanuvai, Manikkampalayam, Mettupalayam, Peelamedu, and SIDCO Industrial Estate. Smaller manufacturers produce pump sets from 0.5 to 20 hp capacity, while the bigger manufacturers produce up to 50 hp capacity. Leading pump manufacturers in the cluster include CRI pumps, Texmo industries, PVG industries, Flowserve, Aquasub engineering, Sharp industries, Deccan pumps, Ekki pumps, Mahendra pumps, and Suguna pumps.

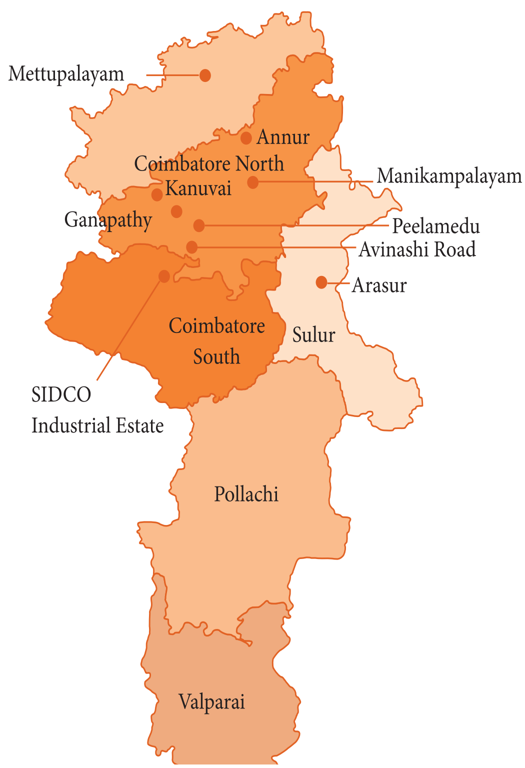


Figure 1: Major concentrations of pump set manufacturing units in Coimbatore

Product, market, and production capacities

The raw materials for pump set manufacturers are mainly castings and engineering components, including impeller, diffuser, and shaft. Castings are procured locally from foundry units and other raw materials are procured from allied component manufacturers.

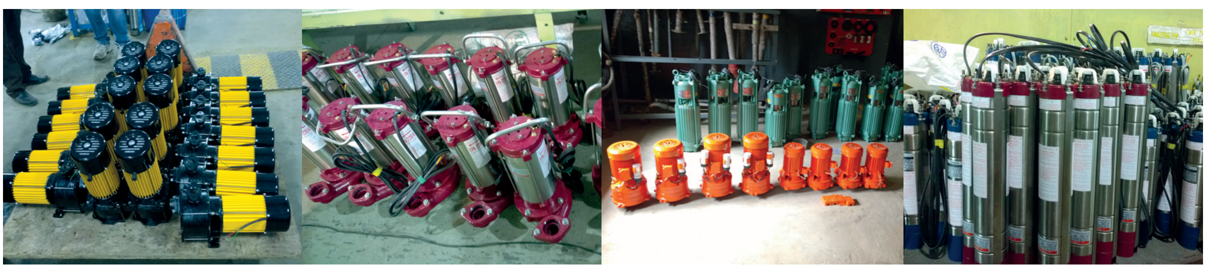
Coimbatore pump set manufacturers traditionally cater to the requirements of agriculture and domestic sectors. Few manufacturers also export to other countries covering industries such as oil refineries, steel mills, mines, etc. Major products under pump set component manufactured includes mono-block pumps, jet pumps, centrifugal pumps, reciprocating pumps, gear pumps, process pumps, and submersible pumps. Based on their average production levels, categorization of pump industries is given in Table 1.

Table 1: Categorization of units and estimated production

Category	Production capacity (Pump sets/day)	Number of units
A—Small and Micro	5–10	500
B—Medium	100–200	85
C—Large	1,500–2,000	15

The estimated production of pump sets from the cluster is 35,000 per day (about 10.5 million pump sets per annum). The pump set manufacturers employ close to 7,000 direct employees. The estimated annual turnover of the pump set units of the cluster is nearly ₹ 5,000 crore, of which only 1–2% corresponds to exports.

Two support industries for pump manufacturing include machine tool industry and component manufacturing industry. There are about 400 ancillary support units in the cluster. Pump industry needs components such as impeller, diffuser, and shaft, which are manufactured with machine tools, such as lathes and shaping machines. A simplified flow showing linkages in pump manufacturing is given in the Picture 1.



Picture 1: Major products of the cluster

The manufacturers in Coimbatore cluster produce pump sets of two different levels of quality: 'Premium' (or BIS equivalent) and 'Commercial' (or below BIS quality). According to industry estimates, majority of the pumps manufactured in the cluster are of commercial quality as their costs are about 30% lower than premium quality models.

Submersible pump sets account for the major share of the pumps (about 65%) produced in the cluster followed by pump sets used for domestic applications. These are multipurpose pump and are produced in high volume but have low profit margins. There are relatively few manufacturers in the cluster producing specialized pumps such as concrete volute pumps (for hydro power applications), drainage pumps, sewage pumps, split casing centrifugal pumps, and vertical turbine pumps; these are manufactured on a low volume but have higher profit margins. Most of the submersible pump sets manufactured in Coimbatore use gun metal or SS impeller as they possess better corrosion resistance properties. Plastic impellers are also used, especially for smaller clear water pump sets.

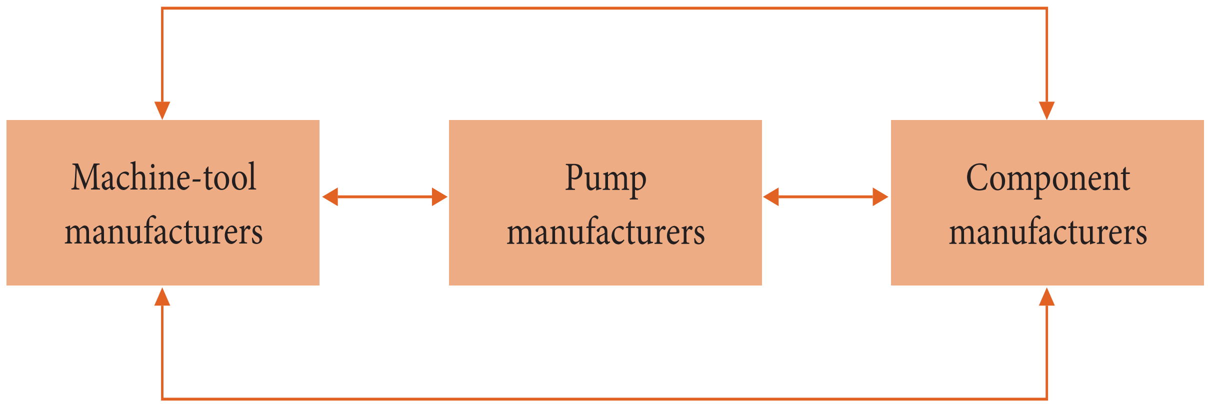


Figure 2: Linkages in pump manufacturing

Some of the Original Equipment Manufacturers (OEMs) include brands such as Crompton, KSB, Grundfos, etc. Almost all the manufacturers produce centrifugal pumps for high head and low discharge applications. However, production of industrial axial flow pumps for low head and high discharge is not common in Coimbatore. Other positive displacement pumps, particularly rotary types used for niche applications, peristaltic, progressing cavity, and rotary lobe pumps, are also not produced in the cluster. The high development cost of specialized pumps for industrial use and dominance of large pump manufacturers such as Mather & Platt, Kirloskar, Jyoti, Worthington, and KSB in this segment have been the major deterrence to their production in the cluster. The pump set manufacturers in Coimbatore cluster need to move beyond small-sized centrifugal pumps to higher value-added industrial pump sets.

Production process

The manufacturing of pump encompasses a wide range of processes including casting, shot blasting, machining, drilling, loading, winding, assembling, testing, painting, packing, and dispatching. A simplified process flow diagram of a typical pump set unit is given in Figure 2. The process steps are explained below.

Raw material inspection

The raw materials received from foundries and machine shops are inspected against specifications. After removing rejections or defective pieces, the castings are sent forward to other sections. In another section, the motor's rotor and stator components such as shaft, coil, and casing are inspected.

Machining

The castings are sent to machining section. Machining includes sizing, drilling, turning, boring, cutting, and milling. Category B and Category C units use Computerized Numerical Control (CNC) machines and Vertical Machining Centre (VMC) machines, for machining and have precise control over operations. Small and micro units use conventional machining and inspection is done manually using gauges.

Winding

The copper coils are tested for continuity, resistance, and high voltage before being sent for coiling. Coils could be insulated by a plastic insulation or by using coating coil with epoxy resin by dipping them in a bath. The coils are dried in an electrical oven. Once tested 'okay', the stator and rotor parts are wound with copper coil either manually or using automated machines. Some motors use squirrel-cage rotor, which are directly procured from ancillary units.

Assembly

The stator and rotor parts of motor are assembled carefully and housed within motor body. In next section, pump components, such as impeller, bearings, pump casing, and discharge nozzle are assembled. The motor and pump sections are assembled into a single product by mechanical coupling and housed in a single casing. Prior to assembly, some components, such as rotor shaft are heat treated for improving material properties. Heat treatment furnace is not available within all units, and most of the units sub-contract ancillary units for carrying out heat treatment.

Testing

Once assembled, the pump set is subjected to a performance test for measurement of following: flow rate, head, velocity head, power input, speed, pump efficiency and 'net pressure suction head' (NPSH). The purpose of the test is to verify whether the pump operates in range of its design specifications. It may be noted that not all pump set manufacturing units have sophisticated testing facility. The pump sets are tested at different voltages viz. 415 V (normal), 440 V (over voltage), and 385 V (low voltage). Single-phase pump sets are tested at 215 V and 230 V.

Painting and packing

The pump sets are painted in a paint shop. Most of the units use spray painting technique whereas a few units are using power coating technique. After drying, the pump sets are packed in cases for storage.

At each stage, industries use either in-house facility or sub-contractors. Large and medium manufacturers undertake manufacture of components as well as motors. Small and micro manufacturers mostly undertake jobs as sub-contractors. It is important to note that unlike other process industries (such as chemical, food, metal), pump manufacturing does not have a typical set-up, layout specification, capacity, product, product ranges, etc., and the various sub-contractors of the industry are equally important in the process of making pumps, the final stage of which constitutes assembling.

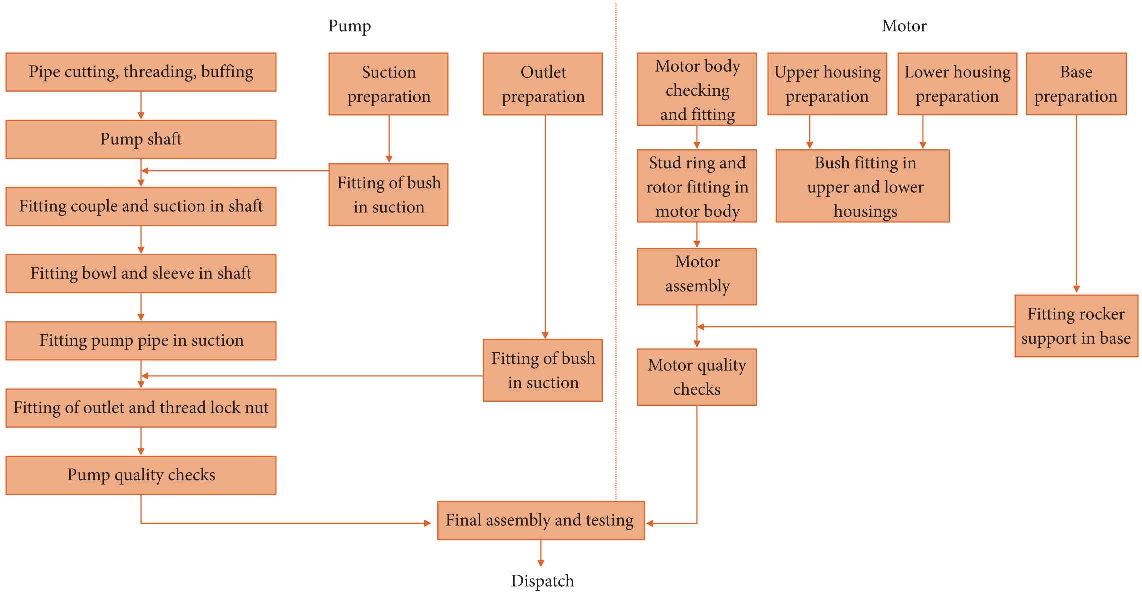


Figure 3: Manufacturing process of submersible pump

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Technologies employed

Following are some of the major pump set processes/equipment:

Machining

The small and micro units use conventional manual machining units. Conventional machining includes machine tools such as lathes, drill presses and milling machines that are used with a shearing tool to cut materials to desired shape and dimensions. The large and medium units use CNC machines. The CNC machines can reduce time, enhance productivity, reduce tooling and hence decrease overall costs. CNC machines are more expensive compared to manually operated machines, although costs are slowly coming down. CNC machines come in different orientation—horizontal and vertical—and the units choose the type based on applications.

Conventional machining

Hydraulic press

Hydraulic force is used in a number of applications in pump-manufacturing process. Motor driven hydraulic machines are available for different pressures and power ratings. The machines used in small and micro units for making smaller pump sets are in the range of 20–60 tonne pressure. The large and medium pump set manufacturers use relatively bigger machines ranging from 60 to 300 tonnes pressure driven by motor of rating 15–50 hp.

Hydraulic press

Assembly

Majority of units follow manual assembly process. Selected units have invested in low-cost automation to improve assembly accuracy and precision. The time taken for assembly reduces considerably with automation thereby improving production efficiency.


Reciprocating air compressor

Air compressor

Compressed air is used in pneumatic grinders, casting cleaning, and packing and for other miscellaneous uses in a pump manufacturing unit. The connected load of an air compressor size may range from a few kW (single air compressor) for a small and micro scale unit to 30 kW for a medium or large scale pump manufacturer. The pressure requirement for majority of applications is below 5.5 kg/cm^2 (bar).

Energy scenario in the cluster

Electricity is the major source of energy for the pump manufacturers for operating all machinery. Grid electricity is supplied by Tamil Nadu Generation and Distribution Corporation (TANGEDCO). Diesel is used in diesel generator (DG) sets only in case of emergency during unscheduled power outage and is procured from local market. It is estimated that the industries face up to 40 hours of power cut per month. Few large and medium industries procure electricity partly or completely from wind power producers in the state. The details of major energy sources and tariffs are shown in Table 2.

Table 2: Prices of major energy sources

Source	Remarks	Price
Electricity	High Tension connection (HT)	₹ 8.00 per kWh (inclusive of energy, demand charges, other penalty/ rebate and electricity duty)
	Low Tension connection (LT)	₹ 9.00 per kWh (inclusive of energy, demand charges, and electricity duty)
Diesel	From local market	₹ 50 per litre (price subjected to market fluctuations)

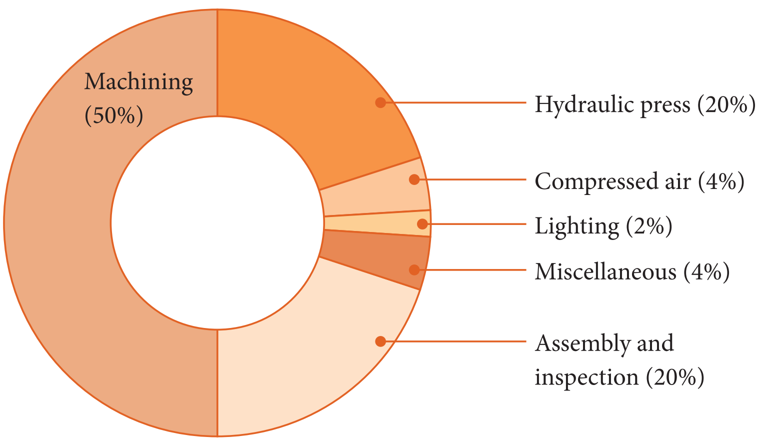
Energy consumption

Unit level consumption

The units under Category-A have LT electricity connections whereas B and C units have HT electricity connections. The power supplied at 11 kV is step down to 433V using transformer and is fed to the respective power distribution board (PDB) via LT switchgear located at main distribution. DG sets are used during unscheduled power outage.

The major energy consuming step in pump set manufacturing is machining of components. Machining alone accounts for about 50% of total energy consumption followed by hydraulic press (20%). In a typical small and medium type pump set manufacturer, the motor-driven hydraulic presses in most units are run without any control mechanism. The other important energy consuming areas include assembly, inspection, lighting, and miscellaneous. Compressed air system is an important utility in a pump-set industry. It accounts for about 2–5% of total energy depending on how well it is utilized. A few units have air conditioning in laboratory and office, but its share of energy consumption is negligible.

Typical total energy consumption of a pump set manufacturing unit varies widely based on the size of units (Table 3). The specific energy consumption (SEC) varies considerably in a pump set manufacturing depending on the type of pump set manufactured and degree of mechanization in unit. On an average, the electrical energy consumption per pump set varies between two to four units.



Typical energy use in a pump set manufacturer

Table 3: Typical energy consumption of pump set manufacturer

Production category	Electricity (kWh/yr)	Diesel (litre/yr)	Total energy (toe/yr)	Total CO_2 emissions (t CO_2/yr)	Annual energy bill (million INR)
A	6,000	240	0.8	6.5	0.1
B	80,000	2,640	9.5	85.0	0.8
C	1,200,000	10,000	113.0	1200.0	9.0

Cluster level consumption

The overall energy consumption of the cluster is estimated 3,070 tonnes of oil equivalent per annum leading to carbon emissions of 30,700 tonnes of CO_2. The overall energy bill of cluster is estimated to be ₹ 260 million, which is about 5% of cluster turnover.

Table 4: Energy consumption of the Coimbatore pump set cluster (2014–15)

Energy type	Annual consumption	Equivalent energy (toe)	Equivalent CO_2 emissions (t CO_2)	Annual energy bill (million INR)
Electricity	40 million kWh	2,580	29,400	235
Thermal (Diesel)	500 kL	490	1,300	25
	Total	**3,070**	**30,700**	**260**

Potential energy efficient technologies

Some of the major energy efficient technologies for the pump set units in the cluster have been discussed below.

CNC machines

A large number of units use conventional machining. Use of manual process and leads can lead to: (i) low precision, (ii) less consistency, and (iii) large variations in desired parameters; hence, may result in higher level of rejections. Efficient operation of conventional machine tools, such as lathes, milling machines, drilling machine is entirely dependent on operator skills and training. Manual operation consumes more time for work part setting, tool setting, and controlling process parameters such as feed, speed, depth of cut. With these constraints, conventional

Conventional machine

CNC machine

machining is quite slow and costly for repeatedly changing product shape and size. CNC machines can perform the functions of drilling, turning, and are classified according to number of axes they possess. CNC machine uses numerical data for directly controlling the position of the functioning units of a machine tool in machine operation. CNCs are computer aided and automatically guide axial movements of machine tools. The auxiliary operations, such as coolant on–off, tool change, door open–close are automated using micro-controllers.

Replacing conventional machines with CNC machines would bring down rejection to a significant extent, as they operate fast and efficiently with high degree of precision. This will help in improving productivity. The investments for CNC machines will have a payback period of about four to five years.

Cost-benefit analysis of CNC machines

Particular	Unit	Value
Investments in CNC machine	₹	80,00,000
Raw material saving by reducing rejection (@ 0.5%)	₹/year	75,000
Labour cost saving	₹/year	105,000
Saving due to productivity improvement	Rs/year	1,440,000
Total annual monetary saving	₹/year	1,620,000
Simple payback period	year	4.9

Hydraulic press

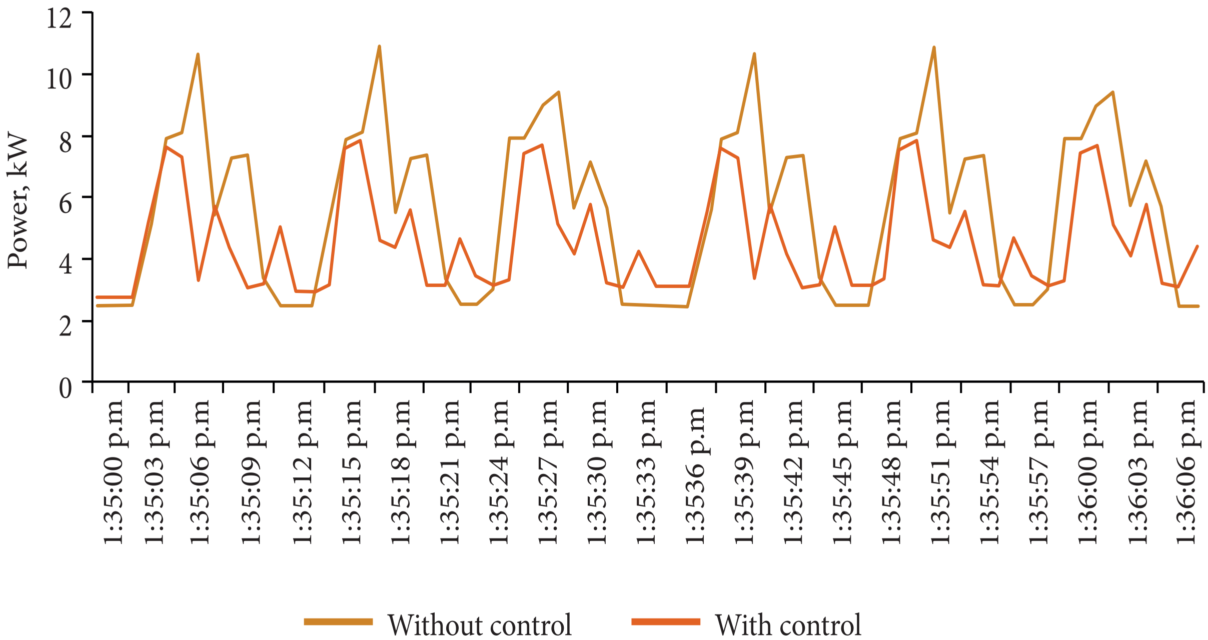
Hydraulic press has been identified as the second highest consumer of energy in pump set production units. A number of options are possible for in hydraulic press for improving energy efficiency depending on type of operation and degree of control.

Soft starter with capacitor bank

These options include: (i) soft starter with on-load capacitor bank and (ii) retrofitting motor with Variable Frequency Drive (VFD). Cost benefit analysis of soft starter with capacitor bank is given in Table 5.

Table 5: Cost-benefit in soft starter with capacitor bank

Particular	Unit	Value
Equipment considered: 100 tonne hydraulic press		
Power consumption of hydraulic press	kWh	8.16
Power consumption after retrofitting with capacitor bank and equipping with soft starter	kWh	7.72
Energy saving	%	5
Annual energy saving	₹/year	15,850
Investment	₹	12,500
Simple payback period	year	0.8



Power consumption with and without control

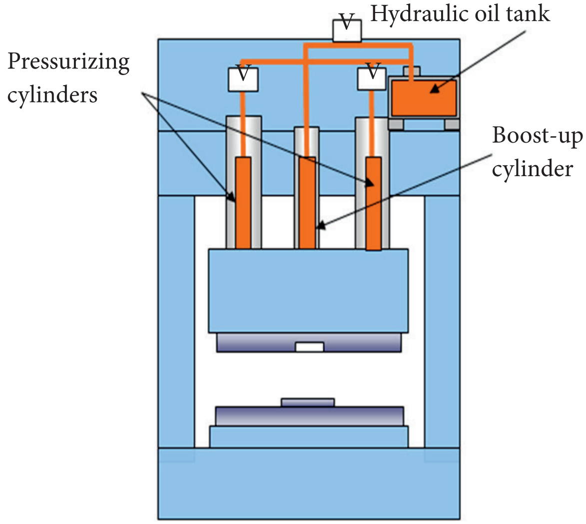
Replacement of hydraulic press with servo press

The hydraulic press is to replace them with energy-efficient servo motor driven systems. Servo presses use high electrical current when the press is cycled, but the actual amount of energy consumed is variable depending on programmed slide speed and load[1]. The servo presses consume 25–35% less energy than conventional presses. The cost benefit analysis of replacement of hydraulic press with servo press with hydraulic press shows a simple payback period of about four to five years.

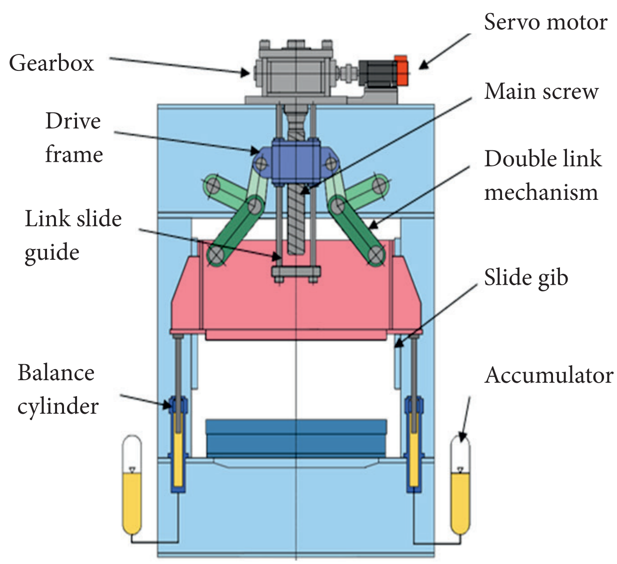
Table 6: Typical cost-benefit in servo press

Particular	Unit	Value
Equipment considered: 100 tonnes hydraulic press		
Power consumption of hydraulic press	kWh	8.16
Anticipated power consumption of servo press (100 tonne)	kWh	5.71
Energy saving	%	30
Annual energy cost saving	₹/year	88,200
Investment	₹	350,000
Simple payback period	year	3.9

1 http://www.thefabricator.com/article/stamping/sizing-up-servo-presses



Hydraulic press



Mechanical link servo press

Source: www.aminonac.ca

Replacement of hydraulic press with all-electric press

Another option for improving energy efficiency is to replace hydraulic press is with all electric press systems. Electric presses are 40–70% more efficient than conventional hydraulic press. They are cleaner as they do not have any oil circuit in the system. The cost-benefit analysis of replacing hydraulic press with all-electric press shows a simple payback period of 4 to 5 years.

Table 7: Typical cost-benefit in all-electric press

Particular	Unit	Value
Equipment considered: 100 tonne hydraulic press		
Power consumption of hydraulic press	kWh	8.16
Anticipated power consumption of all-electric press	kWh	4.08
Range of energy saving	%	40-60
Annual energy cost saving	₹/year	146,880
Investment	₹	650,000
Simple payback period	year	4.4

Compressed air system

Compressed air is most important utility in a pump industry. Air compressors are highly energy intensive as only 10–30% of the electrical consumption is usefully converted into compressed air and balance is lost as unusable heat energy. The manufacturers use out-dated reciprocating air compressors. State-of-the-art variable frequency drive based (VFD) screw type air compressors are available, which are highly energy efficient. Cost-benefit analysis of VFD screw air compressor is given in Table 8.

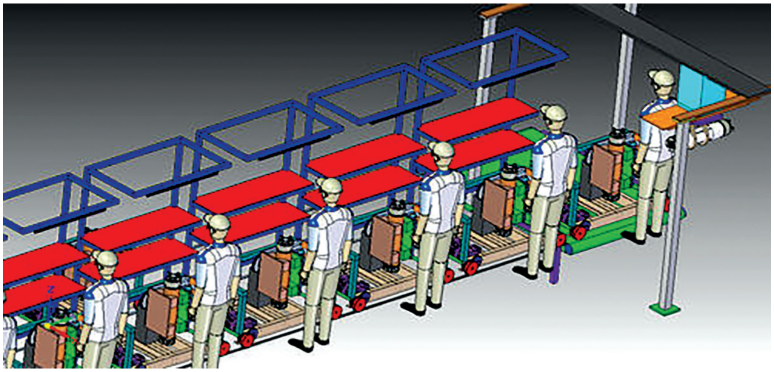
Table 8: Typical cost-benefit in VFD screw air compressor

Particular	Unit	Value
Base case: Reciprocating air compressor of 120 cfm capacity		
Base case specific power consumption (SPC)	kW/cfm	0.28
Proposed case SPC VFD type screw air compressor	kW/cfm	0.18
Range of energy saving	%	10–35
Annual energy cost saving	₹/year	321,840
Investment	₹	750,000
Simple payback period	year	2.3

Reciprocating to VFD screw air compressor
Source: Atlas Copco and Kaeser

Automation

Automation of equipment and system is intended to improve productivity and energy efficiency at various locations in a pump manufacturing industry. For example, the raw material handling at input is generally done using trolleys, which can be automated.



Automated pump assembly line
Source: www.trade.indiamart.com

The major section, where automation could play an important role, is assembly. The process of assembly including water seal, bearing press-fit, impeller press, flange plate press-fit, marking, etc., can be upgraded from manual operation of either low-cost semi-automation or a fully automated line. Mechanized assembly would provide stable production rate, which would help manufacturer plan production in better way and strategically price the product. Apart from improving productivity and quality, an automated assembly system would provide psychological reassurance and competitiveness advantages in the marketplace.

Major cluster actors and cluster development activities

Industry associations

There are several industry associations in Coimbatore pump set cluster. The major industry associations, related to pump set industry, are the following:

Southern India Engineering Manufacturers' Association

Southern India Engineering Manufacturers' Association (SIEMA) is the only association in Coimbatore registered under the Companies Act in 1952. Most of the members are engaged in manufacture of electric motors, mono-block pumps, and submersible pumps. SIEMA is the major promoter of two other organizations—Scientific and Industrial Testing and Research Centre (Si'Tarc, an NABL accredited laboratory for testing and calibration of electrical, mechanical and chemical aspects) and Coimbatore Industrial Infrastructure Association (COINDIA).

Coimbatore District Small Industries Association

Established in 1969, Coimbatore District Small Industries Association (CODISSIA) has got a diversified membership base of industries including foundries. The association has a permanent trade fair complex and was a joint promoter of the SiTarc along with SIEMA.

The Institute of Indian Foundrymen, Coimbatore Chapter

The Coimbatore chapter of Institute of Indian Foundrymen (IIF) is one of the most vibrant chapters in the Southern Region. The chapter has its own office and conference facilities.

District Industries Centre

The District Industries Centre (DIC), Coimbatore, provides incentives to MSMEs, such as capital investment subsidy, interest subsidy, venture capital quality certification, energy and water audits, and so on. There is a branch office of the MSME Development Institute (DI), Chennai, in Coimbatore.

Cluster development activities

Scientific and Industrial Testing and Research Centre (SiTarc) was established in 1987 to promote the testing, research and engineering industrial activities of this region. It was developed with assistance from Industrial Development Bank of India (IDBI) under the small industrial development fund. SIEMA and CODISSIA jointly developed the centre for the cluster.

COINDIA, a 'special purpose vehicle' (SPV) created under Government of India guidelines for implementing this project under Government of India Guidelines for Industrial Infrastructure Upgradation Scheme (IIUS), was conceived and promoted by SIEMA with the support of IIF-Coimbatore Chapter, COSMAFAN and COFIOA. The project costing about ₹ 60 crore was implemented for growth and improvement of competitiveness and export capability of pumps, motors, and casting manufacturers in the Coimbatore cluster. Foundry park in two locations—Arasur and Manikkampalayam—were developed along with common facilities. A modern tool room and rapid prototyping machine was also set up. The testing facilities at Si'Tarc were also strengthened under the project.

TERI with support from United Nations Industrial Development Organization (UNIDO) has organized a series of technical training workshops for foundries in the cluster. Detailed energy audits were conducted for select foundry units. A comprehensive best operating practices guide was also prepared and disseminated in the cluster.

Abbreviations

Abbreviation	Full form
CODISSIA	Coimbatore District Small Industries Association
cfm	cubic feet per minute
CNC	Computerized Numerical Control
COFIOA	Coimbatore Foundry & Industry Owners Association
COINDIA	Coimbatore Industrial Infrastructure Association
COSMAFAN	Coimbatore Tiny & Small Foundry Owners Association
DI	Development Institute
DIC	District Industries Centre
HT	High Tension
IDBI	Industrial Development Bank of India
IIF	Institute of Indian Foundrymen
IIUS	Industrial Infrastructure Upgradation Scheme
kL	Kilolitre
kWh	kilowatt-hour
Lit	Litre
LT	Low Tension
MSME	Micro Small and Medium Enterprises
NPSH	Net Pressure Suction Head
OEM	Original Equipment Supplier
PDB	Power Distribution Board
SEC	Specific Energy Consumption
SIEMA	Southern India Engineering Manufacturers' Association
SiTarc	Scientific and Industrial Testing and Research Centre
SPC	Specific Power Consumption
SPV	Special Purpose Vehicle
t	tonne
TANGEDCO	Tamil Nadu Generation and Distribution Corporation
toe	tonne of oil equivalent
VFD	Variable Frequency Drive
VMC	Vertical Machining Centre

About TERI

A dynamic and flexible not-for-profit organization with a global vision and a local focus, TERI (The Energy and Resources Institute) is deeply committed to every aspect of sustainable development. From providing environment-friendly solutions to rural energy problems to tackling issues of global climate change across many continents and advancing solutions to growing urban transport and air pollution problems, TERI's activities range from formulating local and national level strategies to suggesting global solutions to critical energy and environmental issues.

The Industrial Energy Efficiency Division of TERI works closely with both large industries and energy intensive Micro Small and Medium Enterprises (MSMEs) to improve their energy and environmental performance.

About SSEF

Shakti Sustainable Energy Foundation (SSEF), established in 2009, is a section-25 not-for-profit company, which aids design and implementation of clean energy policies that support promotion of air quality, energy efficiency, energy access, renewable energy and sustainable transportation solutions. The energy choices that India makes in the coming years will be of profound importance. Meaningful policy action on India's energy challenges will strengthen national security, stimulate economic and social development, and keep the environment clean.

Apart from this, SSEF actively partners with industry and key industry associations on sub-sector specific interventions towards energy conservation and improvements in industrial energy efficiency.

About SAMEEEKSHA

SAMEEEKSHA (Small and Medium Enterprises: Energy Efficiency Knowledge Sharing) is a collaborative platform set up with the aim of pooling knowledge and synergizing the efforts of various organizations and institutions – Indian and international, public and private – that are working towards the development of the MSME sector in India through the promotion and adoption of clean, energy-efficient technologies and practices. The key partners of SAMEEEKSHA platform are: (i) Swiss Agency for Development and Cooperation: (ii) Bureau of Energy Efficiency: (iii) Ministry of MSME, Government of India and: (iv) The Energy and Resources Institute.

As part of its activities, SAMEEEKSHA collates energy consumption and related information from various energy intensive MSME sub-sectors in India. For further details about SAMEEEKSHA, visit **http://www.sameeeksha.org**

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