Study on energy consumption and indirect emission in agriculture industrial cluster

Shankara Naik, S B Mallur, Arun K V, Virupaxi Bagodi, P P Revankar

Abstract: This article explains the energy saving and emission reduction opportunities in agriculture industrial cluster of Hubballi-Dharwad in Karnataka, India. The energy audit is carried out for different small and medium scale enterprises where the welding process is highly concentrated for producing different components, which are primarily used for agricultural applications. The study the energy audit on the agricultural implements and tractor-trailer industries (AITT), as the agriculture is the main occupation of India. A total number of 15 small and medium scale industries are considered for the detailed energy audit in the present study. Among equipment used in industries energy consuming by motors and welding machine are selected for this study as these motor and welding machine are energy intensive and consume around 15% and 83% of the total energy respectively. This study is to identify energy saving and green house emission reduction opportunities in motors and welding machine by energy performance assessment to enhance their energy efficiency. The energy audit strongly indicates use of energy efficient motors can reduces 1219.56 tons of carbon dioxide annually and save 1.46 GWh of energy with payback period less than 4.11 years. Similarly, adoption of inverter welding machine can reduces 13352.34 tons of carbon dioxide annually and save 15.95 GWh of energy, and payback period less than 2.12 year.

KEYWORDS: ENERGY CONSERVATION, AGRICULTURAL IMPLEMENTS AND TRACTOR INDUSTRIES, ENERGY EFFICIENCY, ENERGY AUDIT, AND ENERGY CONSERVATION OPPORTUNITIES

1. INTRODUCTION

Agriculture is the main occupation in India with about 56% of the Indian population dependent on agriculture for their livelihood. In the recent past, tractor and its allied implements have become inevitable for the formers. This is mainly due to the scarcity of the labours. Due to the aforementioned reason, many industries have emerged in the market for the manufacture of tractors. These large-scale industries have started manufacturing tractors with specific type comprised of an engine and few associated parts. The end user requirement has diversified based on the nature of work, land and type of crop. This has been a main reason for the inception of new SME’s for the manufacture of different agricultural implements.

SMEs generate substantial employment opportunities and thus play a major role in Indian economy, industrial production, nation’s GDP, and total exports. Small and medium enterprises (SMEs) are considered as the main pillar of an economics and engines of economic development and their respective growth[1]. Their contribution to the development of large enterprises cannot be ignored, the contribution is still increasing, inspite of pronounced influence to nation being threaten to closure due to high level of pollution[2]. Energy is one of the essential inputs to any SMEs, hence for sustenance and development of SMEs, the governments must supply reliable and continuous energy[3]. Effective energy supply and its proper usage is one of the major conditions for economic development of any country[4]. The un-
interrupted energy supply at a reasonable price is one of the essentials of modern industry[5]. The large energy consumers are the major contributors to the global warming. They lack cleaner production methods. Increase in energy efficiency in SMEs not only reduces pollution but result in reduced costs. Many SMEs often ignore about energy consumption. Prominent areas of inefficiency of SMEs are not tracked and consumption pattern of primary energy needs are not understood[6]. Therefore, there arises a greater need to study the SMEs to suggest the adoption of modern technology for cleaner production as well energy efficient techniques. In other word, the adoption of energy efficient and less pollutants emitting machineries will optimise the use of energy resource[7]. It is important due to industrialization, population and energy consumption lead to rapid depletion of natural resource. Enterprises are grouped into clusters by Government of India. Clusters are geographic concentrations of industries related by knowledge, skills, input, demand, and other linkages [8]. In Karnataka state of India, 19 clusters have been identified by the United Nations Industrial Development Organization (UNIDO) [9] and [10]. According to the report, machine tools, electronic goods, leather products in Bangalore (Karnataka state, India) and agriculture implements in Hubli–Dharward (Karnataka state, India). India is the clusters potential for technological upgradation which is for energy conservation and safety needs.

In the past two decades, much amount of work has been carried out on the energy management studies in rubber industry [11], poha processing industry [12] and textile industries [3,13,14]. Even though a well defined concept of energy management study has been developed by these researchers, an exclusive focus has not been made on the agriculture industrial clusters. A very less amount of work has been reported in this area, which of vital importance to the Indian economy. In view of this, the detailed investigation on the agriculture industrial cluster, engaged in agriculture implements and tractors trailers (AITT) manufacturing has been made, with an exclusive focus on the energy saving opportunities.

Methodology

The article involves a systematic auditing of SMEs involved in manufacture of Agriculture equipment in the area covering the agricultural industrial cluster Habballi- Dharward in Karnataka state of India. AITT industrial cluster has about 130 industries in that fifteen industries were selected for detailed energy audit based on which preliminary energy audit has been carried out in 130 industries for a period of three months (Oct- Dec 2017). Study on motor and welding machine to know energy consumption and greenhouse emission from each motor of different rating to calculate energy consumption and emission reduction. It is also observed during energy audit that number of working hours/day, number working hours per year, energy consumed kWh/year and average kWh are found out. This result compared with energy efficient technology for their payback period and energy saving opportunity and pollution. The standards procedure adopted for energy audit includes.

- Collect and analyze energy consumption.
- Identify the energy saving opportunities and pollution reduction.
- Perform an engineering and economic analysis of potential modifications.
- Prepare a rank-ordered list of appropriate modifications.
- Prepare a report to document the analysis process and results.

Pre energy audit phase

The pre energy audit involves preliminary communication with different levels of Industry beginning with top management to the shop floor workforce to take confidence of each section of the industry. Audit was conducted through identified set of measuring instrument to perform a scientifically proven investigation of the energy consumption pattern at the industries. The Preliminary energy audit phase recorded technical specifications and information related to machines and equipment. The available equipment and machinery operational in AITT Cluster, Hubballi are given Table 1 along with their respective power ratings. The prominent equipment in AITT industry included Arc welding machine, lathe, drilling machine, cut off saw, power hack saw, painting set up, bench grinder, and shearing machine. The auxiliary power consumption for illumination and fan load were also considered in pre audit assessment of the Industrycluster.

Detailed energy audit phase

The detailed energy audit performed for a three-month duration spanning between October to December 2017 gathered data of energy consumption of each equipment and machinery. The instruments used for the detailed energy audit included Tachometer, Tong tester, Power factor meter and Energy-meter. The Figure 1 summarizes energy consumption pattern in select sample industries in AITT Hubballi cluster during November 2017. The welding machine with 83.61% of total energy consumption was significant energy consuming equipment while grinding machine was the least energy consumer (0.59% of total energy). The working condition of arc welding machine consumed 53.23 % while in its idling condition accounted for 30.38 % of industrial energy consumption. The major losses are reported for the welding machine and electric motors connected to different equipment in AITT industries. It is observed that most of the industries found to use almost absolute technology. i.e. transformer arc welding. In most of the cases existing electric motor replaced by energy efficient motor was projected to yield substantial energy savings and emission reduction to compensate for slight damage of insulation or core along with adoption of small diameter wire in rewinding. The efficiency of a rewinded motor is affected by iron core and operating temperature that influenced copper windings. The best performance is reported for motors that were equipped with provision to regulate temperature below the safe operating limits. The present article concentrates majorly on welding machine and motor performance to analyze the energy consumption, emission and saving opportunity.
This technology. Almost all welding machines are used in this cluster are not during welding machines are operated under welding condition which is around 84% of the welding machine, which is around 84% of total energy consumption. Most commonly used welding machine is transformer arc welding of 16kVA rating. These welding machines are operated at 2.5 kW to 5kW for the voltage variation 50 to 60V during idling, while in working condition it consumes 7kW to 15 kW for voltage varies from 35-18V. This is based on different diameter (2.5 mm to 6.5 mm) of electrode melt during welding. It was also observed that alone consumed 122.71MWh of which 78.12MWh was during working condition and 44.58MWh was during idling. Almost all welding machines are used in this cluster are not working under energy efficient welding technology (inverter technology). This is due to almost all the industries found to use absolute technology (transformer arc welding). Due to this reason welding machine are consuming more energy that leads to indirect emission.

### 3. Energy Saving and emission reduction Possibilities in AITT industry

**Energy consuming by welding machine**

In the agriculture industrial cluster, major amount of energy is consumed by welding machine, which is around 84% of total energy consumption. Most commonly used welding machine is transformer arc welding of 16kVA rating. These welding machines are operated at 2.5 kW to 5kW for the voltage variation 50 to 60V during idling, while in working condition it consumes 7kW to 15 kW for voltage varies from 35-18V. This is based on different diameter (2.5 mm to 6.5 mm) of electrode melt during welding. It was also observed that alone consumed 122.71MWh of which 78.12MWh was during working condition and 44.58MWh was during idling. Almost all welding machines are used in this cluster are not working under energy efficient welding technology (inverter technology). This is due to almost all the industries found to use absolute technology (transformer arc welding). Due to this reason welding machine are consuming more energy that leads to indirect emission.
drive the bending and shearing machines. These motors are used to drive majority of the lathe machines and 10hp and 15hp motors which are used to drive grinding machine and power hacksaw machine. The 1hp motors are used to drive different equipment/machines such as bench grinder, power hack, painting setup, lathe machine, bending machine and cutting machines. The 2hp motors are used to drive majority of the holomachines and 10hp and 15hp are used drive the bending and shearing machines. These motors of different rating are working under the energy efficient motor leads to indirect emission.

**Energy consuming by different rating motor**

In the agriculture industrial cluster second major amount of energy is consumed by different rating motors which are used to drive different equipment/machine is around 14% of the total energy consumption. The most commonly used different rating of motor are 1hp, 2hp, 3hp, 5hp, 10hp, 15hp, which are used to drive different equipment/machines such as bench grinder, power hack, painting setup, lathe machine, bending machine and cutting machines. The 2hp motors are used to drive majority of the holomachines and 10hp and 15hp are used drive the bending and shearing machines. These motors of different rating are working under the energy efficient motor leads to indirect emission.

**Emission by agriculture industrial cluster**

Emissions are classified into direct (on site emissions) and indirect emission (electric energy consumed, which is generated at different station). Most of the AIIT industries are using electrical as the main source of energy which is leading to indirect emission. These indirect emissions are almost 0.0043kgs of NO, 0.93kgs of CO, 0.0046kgs of CO₂, and 0.0070kgs of SO₂ per KWh of energy generation from coal [15] and [16].

The survey almost all welding machines and motors are operated below the energy efficient technology, hence it is essential to replace energy efficient technology to reduce the
energy consumption and indirect emissions. The working condition of transformer arc welding machine consumed 53.23% while during idling condition accounted for 30.38% of total industrial energy consumption. The existing welding machine efficiency are various from 35% to 45%, whereas inverter welding machine efficiency is more than 90%. The existing welding machine energy consumption during idling condition varies from 2kWh to 5kWh whereas in inverter welding machine consumes 0.1 kWh. The replacing the existing TAWM with IWTM in studied industries and agriculture industrial cluster can save 1.2 GWh (Table 2) and 15.95 GWh (Table 3) respectively, with payback period is 2.20 years. The replacing the existing TAWM with IWM in studied industries and agricultural industrial cluster one can reduces 102.71 tons of CO₂ and 13352.43 tons of CO₂ respectively, with payback period is 2.20 years. This is due to almost all the industries found to use almost absolute technology, i.e. transformer arc welding. Similarly, existing motor operating below the energy efficient motors, by replacing with EE motor can reduced emission and saves energy as shown in Table 2 and Table 3. Table 4. shows the emission reduction and energy saving by replace defective existing motors with EE motor with their payback periods.

4. Conclusions

The investigation of emission reduction and energy saving in the agriculture industrial cluster through the widespread survey on major amount of energy are consuming devices has indicated that the total potential of emission reduction are 14571997.07 tons of CO₂, 109681.70 tons of SO₂, 67375.90 tons NO, 72076.54 CO and energy savings is of the order of 17.41 GWh on annual basis. The study showed that, the replacement of existing welding machine and electric motors of different rating between 1hp to 15hp with inverter welding and energy efficient motors savings energy consumption by 53.57% (15.95 GWh) and 23.97% (1.46 GWh) respective. This is over the energy consumed by the existing welding machine and motor, and reduction in 14571.99 tons of CO₂, 109 tons of SO₂, 67.37 tons of NO, and 72.07 Tons of CO. The present work strongly suggests replacement of the defective motors identified during the survey by EE motors. This has resulted in significant minimum payback period of 1.87 years. His work highlights the environmental benefits for the implementation of energy conservation.

Abbreviations:

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dd</td>
<td>Industry D motor operated by drilling machine</td>
</tr>
<tr>
<td>Hb</td>
<td>Industry H motor operated by bench grinder</td>
</tr>
<tr>
<td>Lh</td>
<td>Industry L motor operated by power hacksaw machine</td>
</tr>
<tr>
<td>Jp</td>
<td>Industry J motor operated by painting setup</td>
</tr>
<tr>
<td>Ld</td>
<td>Industry L motor operated by drilling machine</td>
</tr>
<tr>
<td>Cp</td>
<td>Industry C motor operated by power hacksaw machine</td>
</tr>
<tr>
<td>Ed</td>
<td>Industry E motor operated by drilling machine</td>
</tr>
<tr>
<td>Np</td>
<td>Industry N motor operated by power hacksaw machine</td>
</tr>
<tr>
<td>Ci</td>
<td>Industry C motor operated by lathe machine</td>
</tr>
<tr>
<td>Gl</td>
<td>Industry G motor operated by lathe machine</td>
</tr>
<tr>
<td>KI</td>
<td>Industry K motor operated by lathe machine</td>
</tr>
<tr>
<td>Ed</td>
<td>Industry E motor operated by drilling machine</td>
</tr>
<tr>
<td>Es</td>
<td>Industry E motor operated by shearing machine</td>
</tr>
<tr>
<td>Fs</td>
<td>Industry F motor operated by shearing machine</td>
</tr>
<tr>
<td>AITT</td>
<td>Agricultural implements and tractor/trailer</td>
</tr>
<tr>
<td>EE</td>
<td>Energy efficient</td>
</tr>
<tr>
<td>SMEs</td>
<td>Small and medium enterprise</td>
</tr>
</tbody>
</table>

CONFLICT OF INTEREST

There are no conflict of interest for this work and publication.

References:


[13] Chan, David Yih Liang, Kuang Han Yang, Chung Hsuan Hsu, Min Hsien Chien, and Gui Bing Hong.


Prof. Shankara Naik, has 16 years of teaching experience. He is doing research in the area of energy management, under VTU, Belagavi. He has published research articles in the international journals/conferences.

Dr. Virupaxi Bagodi, has completed his doctoral degree from IIT Kharagpur in the year 2008. He has published many research articles in the international journals/conferences. Has an academic and research experience of more than 27 years. Presently deputed as the principal, Government engineering college, Talakalal, Koppal dist.

Dr. Arun K V has completed his doctoral degree in the year 2007, in the area of fracture mechanics. He has published many research articles in the international journals/conferences. He has 19 years of teaching experience and around 16 years of research experience.

Prof. S B Mallur, has completed his doctoral degree in the year 2012. He has teaching experience of around 27 years. Presently serving as a professor and chairman, Department of studies in mechanical engineering, UBDTCE Davangere. He has published many research articles in the international journals/conferences.

Prof. P P Revankar has research interest in the area of thermal engineering and renewable energy. He has published research articles in the international journals/conferences. He has 22 years of teaching experience and around 06 years of research experience.