Solar Industrial Process Heat in Indian Automobile Industry

Anubhav Uppal*, Dr. J P Kesari^

**Masters in Renewable Energy Technology, Delhi Technological University, Delhi, India*

^ Associate professor, Delhi Technological University, Delhi, India

Abstract: **- Indian Automotive industry is under considerable strain to make their products more environmentally sound. Not only the automobile themselves, but also the whole production process has to become more sustainable to Achieve India's pledge to stop climate change at world forum. The Automobile industry is one of the major industries in India which have huge energy requirements in the form of both thermal and electrical energy. Manufacturing of automobiles and auto components involves many steps such as casting, forging, painting and electroplating etc that require heat or steam. Thermal energy in form of heat or steam accounts for around 70% of all automobile industry's total energy consumption and while solar collectors can provide a large share of this industrial process heat, the collector technology used depends upon a great deal on the temperatures involved. The use of an appropriate solar thermal technology can have a positive impact on the energy and environmental scenario of Automobile industry at a large. There are various solar thermal technologies including CST technologies that are available for Automobile industries. Flat plate collectors and evacuated tube collectors can be used with a reasonable level of efficiency at temperatures of up to around 130°C but for temperatures higher than this, concentrating collector systems such as Fresnel-Collectors, parabolic dishes and Parabolic-Trough-Collectors can give greater efficiency**.

I. INTRODUCTION

Demand of heat energy accounts for around 70% of total energy consumption in any industry, therefore solar heat for industry can be perfect application of solar thermal technology as solar collectors can provide most of this heat energy demand. Also the India has a great potential for solar industrial heat because of high solar irradiation for almost 300+ sunny days in year. Apart from these reasons, Shortage of fossil energy sources such as oil, gas or coal with rapidly rising energy consumption in developing countries like India have result in hike in energy prices. From now integration of solar thermal technology with industrial heat sources will increase India's independence from future energy price hikes and help to lessen industrial production costs. Now a day, the automobile industry is under great strain to make their products more environmentally sound in this 21st century especially after C02 emission laws made in Kyoto protocol. Not only the automobiles themselves, but the whole production has to become more sustainable. Therefore there is urgent need for more sustainable automobile production with lessened demand for energy, materials and as well as emissions.

II. PERFORMANCE OF INDIAN AUTOMOBILE INDUSTRY IN 2014-15

The Indian automobile industry is one of the largest in the world with an annual production of 2,33,66,246 automobiles including passenger vehicles, commercial vehicles, three wheelers and two wheelers in fiscal year 2014-15 as compared to 2,15,00,165 vehicles produced in year 2013-14 with a annual growth of 8.68 % . [1] The automobile industry has a very high share in the country's manufacturing gross domestic product (Gross Domestic Product). India is also a major automobile exporter, with huge export growth expectations in the near future. Sales of passenger automobiles in India grew by 3.90 percent 2014-15 from a previous year ago, according to data given by Society of Indian Automobile Manufacturers (Society of Indian Automobile Manufacturers). Sales of cars also grew at 4.99 % in 2014-15 over the last period. Figure 1 [2] shows the production trend of automobile industry in India for year 2009-2010 to 2014-15.

To match production with demand, many automobile makers have started to invest heavily in various parts in the industry in the last few months. The industry has attracted foreign direct investment worth United States $ 12,232.06 million during the period April 2000 to February 2015, according to the data released by Department of Industrial Policy and Promotion. Also The Government of India encourages foreign investment in the automobile and allows 100 percent Foreign Direct Investment under the automatic route. From now the vision of government of India is to make India as the top destination in the world for make of automobiles and auto parts.

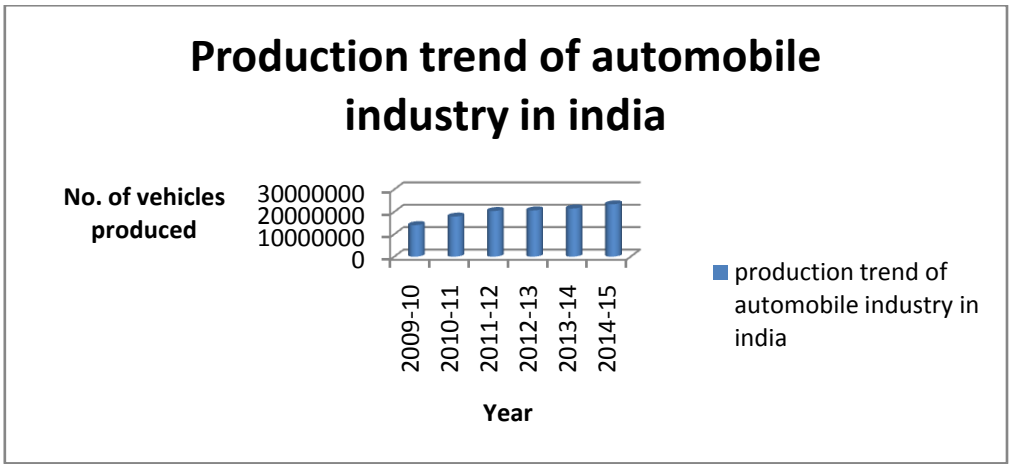

Figure1. Production trend of automobile industry in India

III. ENERGY CONSUMPTION PATTERN IN AUTOMOBILE INDUSTRY

Automobile industries have number of different production that need large amounts of energy in form of electricity or heat. Various energy sources used in Automobile for different production are mainly electricity with major share, followed by petroleum products like natural gas as second largest source and followed by others sources also. [3] Figure 2 shows to divide various energy sources used in automobile industry.

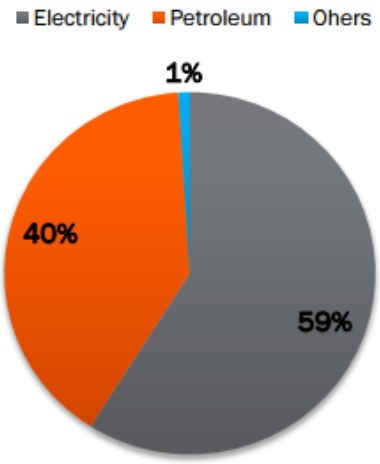

Figure2. Composition of energy sources used in automobile industry

Total energy consumed in automobile industry for automobile production divided in three Areas named Body shop, Paint shop and Assembly shop where different production takes place in a well-defined sequence leading to product. Figure 3 shows to divide total energy consumption in an automobile production in various shops on basis of total energy consumed, electricity consumed and Heat energy consumed.

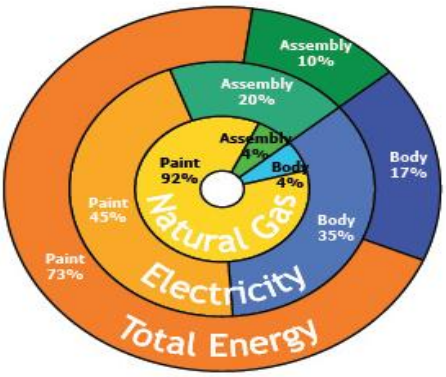

Figure3. Pattern of energy consumption in Different shops in Automobile industry

The following analysis can made from figure 3 on pattern of energy consumption in automobile industry that 73 % of total energy consumed in Paint shop, followed by 17% consumption in paint shop and 10%in Assembly shop. [4] Two major sources of total energy consumption are an Electricity and petroleum product that is natural gas in automobile. Electricity consumed mainly in Paint shop with 45%share, followed by 35% share in body shop and rest 20% in assembly shop. Other source of energy is Natural gas which consumed in Paint shop with High share of 92 %, small shares of 4% in Body shop and 4% in Assemble shop.

IV. PRODUCTION NEEDING HEAT ENERGY IN AUTOMOBILE INDUSTRY

Manufacturing automobile includes many that need thermal energy either in the low temperature range (60 – 100°C) or medium temperature range (100 – 200°C). These are suitable for integration with solar thermal Technologies to provide industrial heat. Figure 4 shows the entire flow diagram for an Automobile manufacturing. Processes marked with * need thermal energy at temperature range.

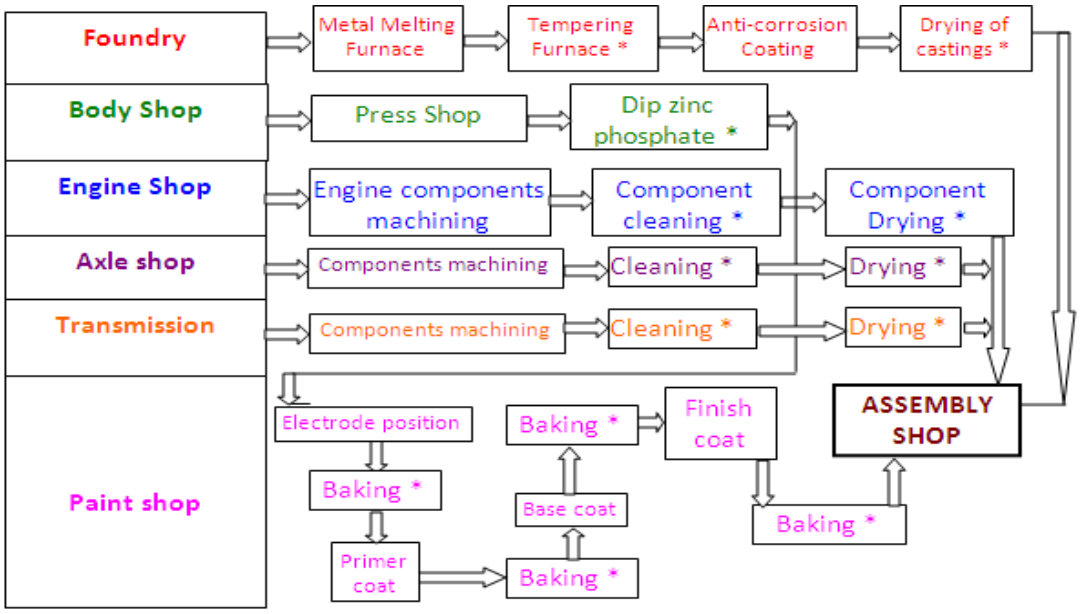

Figure4. Different processes needing thermal energy marked by * in automobile industry

Body shop includes process needing thermal energy like Drying of castings and parts, part cleaning, etc. Paint shop includes processes like Dip Zinc phosphate or 7 tank processes, baking of paint in ovens, etc.

V. SOLAR THERMAL TECHNOLOGY APPLICATIONS IN AUTOMOBILE INDUSTRY

Some of the typical processes in the automobile manufacturing industry needing thermal energy as shown in figure 4 now explain below in some details with temperatures needed in process and application media used like Hot water, hot air or pressured steam. [5]

5.1 Part Cleaning, washing or Degreasing

Pressured Hot water at a temperature of about 90°C sprays over the automobile engine parts to remove the dust content. The hot water needed for spraying is heated either by electrical heaters or natural gas based heating sources.

5.2 Drying of washed parts after Degreasing

The cleaned parts from Degreasing are dried in the hot air chamber in which the hot air is blown at 90°C. The hot air used is heated by using electrical coil heaters or natural gas based burners. The heating cycle depends on the size of the part to be dried.

5.3 Dip zinc Phosphating or 7 tank process

A standard 7 tanks or DIP ZINC PHOSPHATING process is used to achieve good paint adhesion and corrosion resistance on automobile body before painting is done. All heated tanks are heated directly by electrical immersion hot water heaters or closed steam coils. Table 1 shows the 7 processes involved in the 7 tank process with the Temperature involved and Dip time needed.

Table1. Steps involved in 7 tank process with temperature and dip time needed

Step	Temperature in °C	Dip time in seconds
Degrease	95	15
Cold water rinse	25	5
Derust	70	10
Cold water rinse	25	5
Zinc phosphate dip	80	5
Cold water rinse	25	5
Passivation	70	10

5.4 Mould Drying

The casted or moulded automobile parts are coated with anticorrosion coatings for improving life and overall performance. These parts are then dried by hot air blown by hot air blower at high temperature of 100°C.

5.5 Tempering of parts in a Furnace

Hardening and tempering are normally done to improve the wear resistance, strength and toughness of the automobile parts. Some typical application of tempering in automobile industry are low temperature tempering

(150°C-200°C) of steel bearing, medium temperature tempering (350°C-550°C) of carbon steel and high temperature tempering (550°C-650°C) of medium carbon alloy steel.

5.6 Paint curing process in baking ovens

After each coat of paint on automobile, the paint is baked in baking oven using hot air heated either by electrical coils or gas burners. The temperatures needed in baking ovens range around 200 °C.

Table 2 shows the process with possible integration with proper solar thermal technology depending on the temperature range achieved by different solar collectors and temperature needed for process provided by heat application media. It also shows the current energy source or fuel being used to achieve these processes.

Table2. Applications of solar thermal technology in different automobile production process

Process steps	Energy or fuel being used	Application media	Temperature need °C	Recommended solar technology
Degreasing of automobile parts or part cleaning	Natural gas	Pressured Hot water	90	Evacuated tube collectors
Drying of cleaned parts	Natural gas	Hot air	90	Parabolic trough collectors with air as working medium
Dip zinc phosphating process	Electricity	Hot water	80	Flat plate collector
Mould drying	Electricity	Hot air	100	Solar air heaters
Tempering in furnace	Natural gas	Hot air	200	Solar air heaters with Concentrating collectors
Paint shop Preconditioning that is Hot water rinsing of automobile body in paint shop	Electricity	Hot water	40	Flat plate collector
Paint shop that is curing of automobile paint in paint baking ovens	Natural gas	Hot air	200	Linear Fresnel concentrating collectors
Paint shop air-conditioning of wet paints in the paint shop	Natural gas	Hot or Cold air supply	50	Evacuated tube collectors based chillers
Paint shop evaporation drying	Natural gas	Hot air supply	100	Solar air heating

VI. CASE STUDIES

India has already number of automobile manufacturing plants all over which has installed different solar thermal technologies for providing industrial process heat. Some prominent Solar industrial process heat applications has been presented as a case study with each study having different manufacturing process in automobile industry requiring thermal energy provided by optimum solar thermal technology.

6.1 Mahindra Vehicle Manufacturers limited (MVML), Chakan, Pune

This Greenfield manufacturing facility of Mahindra was set up in 2007 at Chakan, Pune district and is spread over 700 acres to manufacture multipurpose vehicles (MPV), sport utility vehicles (SUV) and commercial vehicles.[6] MVML has installed dual axis tracked Fresnel paraboloid solar concentrator called ARUN dish for generating hot water for running washing machines to wash engine components. The system delivers pressurized hot water at

120 degree Celsius for seven hours daily which is utilized in degreasing process of the engine components.

The ARUN dish system at MVML has been installed at a cost of Rs 39,00,000/- including balance of system costs like piping work, civil construction, etc. Total subsidy approved and granted by the MNRE for this system was Rs 10, 14,000/-. Therefore overall project cost minus the subsidy granted from MNRE is 28,86,000/-. Also additional benefits of Accelerated Depreciation of 80 % of project cost can be availed by the unit owner under the IT act. This helps to reduce tax outflows in the first year of expenditure.

The project payback period was around 2 years due to savings made in electricity purchase costs and project life cycle was for 25 years. Thus SIPH system is the model case study for other automobile industries in the region to for these CST based systems.

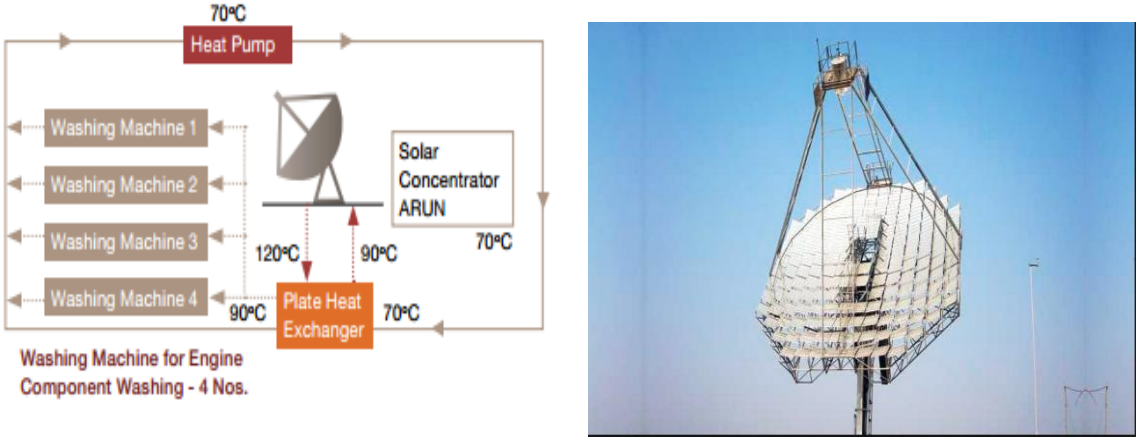

Figure5. Layout of the SIPH system at MVML, Chakan, Pune

6.2 Branded cycle manufacturing unit, Chennai, South India

Heated air required for curing of paint used in all automobiles manufacturing units ranges from temperature of 80 °C to 180°C and mostly petroleum products like furnace oil, diesel or kerosene are used to produce hot air by combustion which is blown inside ovens. The unit installed solar air heater of 292 m2 area to heat the air up to temperature of 112 °C. [7]

Solar air heater installed were formed using aluminium extrusions, v shaped corrugated special aluminium absorber, thick toughened glass, mineral wool insulation, silica sealent and EPDM rubber. The heated air collected from solar air heaters is passed through insulated metal duct till fresh air inlet points of the oven using suction blowers.

Financial analysis with considering MNRE subsidy, tax savings under accelerated depreciation scheme and fuel savings made against the investments gave payback period of around 1.3 years.

Figure6. Solar hot air for paint shop at manufacturing unit , Chennai, South India

6.3 Wheels India Limited, TVS group, Chennai

Wheels India limited is a vehicle wheel manufacturer under TVS group located in Chennai. Metal wheels manufactured through casting are cleaned and washed in 4 tanks i.e. hot water at 55 °C in tank 1, knock off degreaser at 70°C in tank 2, Degreaser 1 at 60°C in tank 3 and Degreaser 2 at 60°C in tank 4. Heat required for hot water is supplied by furnace oil burner.

Solar water heating system of Evacuated tube collector type was installed in April 2013 with area of 1365 m2 to heat up tanks for washing and cleaning metal vehicle wheels.[8]

Total investment cost for the solar systems was Rs 2,10,00,000/- with subsidies and tax benefits. Payback period was around 2 years.

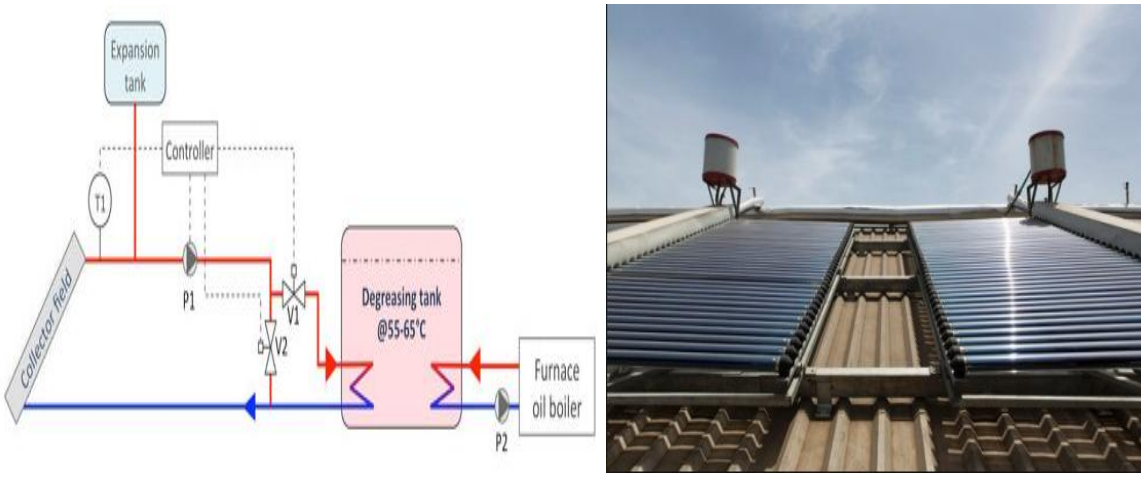

Figure7. Layout of solar water heating system at Wheels India Ltd

6.4 SKF technologies Private ltd, Mysore

SKF technologies private ltd owns manufacturing facility for sealing solutions used in automotive applications at Mysore. They installed a parabolic trough based solar concentrating system for process heat application to generate pressurized hot water at 130°C. Total collector area is of 256 m2 and is installed on plant rooftop. The system is provided with diesel fired back up generator.

Parabolic trough collectors heat the water used for circulation through treatment tanks for phosphating process where the desired temperature required is 95°C. Phosphating on metal parts helps in reducing probability of rust formation.

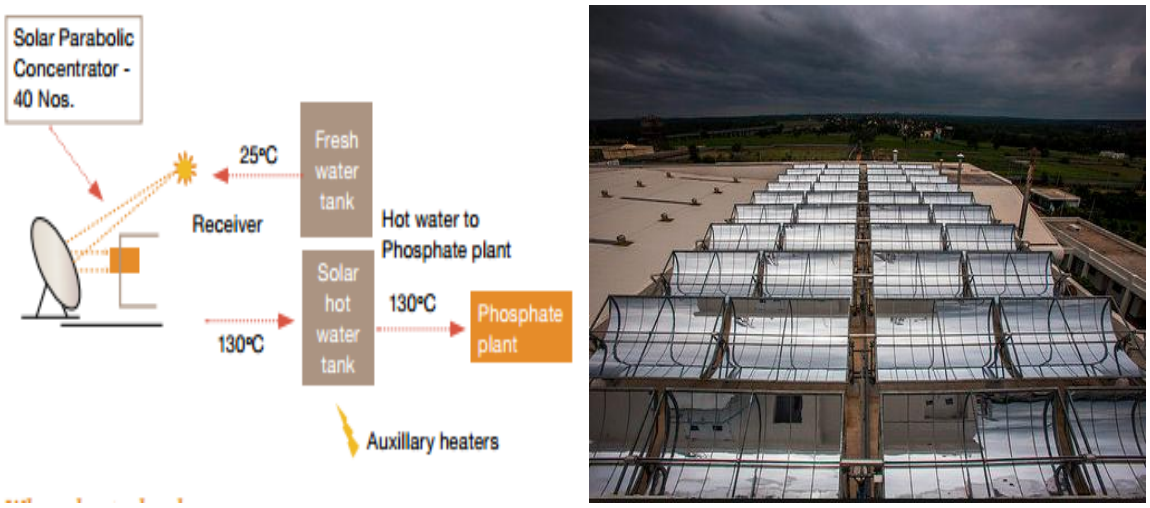

Figure8. Layout of the phosphating plant at SKF industries Pvt ltd. Mysore

Parabolic trough collector based system cost was around Rs 70,50,000/- including balance of system costs like piping and civil works, etc. Total subsidy approved and granted by MNRE was aroud Rs 13,84,500/- . Therefore overall project cost was around Rs 56,70,400/- incurred by the unit owner. Also extra benefits of 80 % accelerated depreciation scheme under IT act will also lead to reduced tax outflows in the first year itself. Hence payback period for the entire project was 4 years due to huge saving for the owner against diesel fuel used earlier for heating purposes. [9]

VII. CONCLUSION

Thus solar thermal technology can be installed in the most automobile industrial sectors to lower consumption of fossil fuels, cut production costs, preserve environment by lessening CO2 emissions. Also Commercial viability of solar technologies is much higher for industries using furnace oil, coke or captive diesel based electricity. However Major challenges before solar industrial process heat market development in India are like (i) low payback period expected by the industry,(ii) missing awareness about this technology in industry,(iii) lack of policy by the

government and (iv) missing pilot projects showing these technologies here in India.

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