ENERGY ANALYSIS IN TIRE MANUFACTURING INDUSTRIES

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ABSTRACT:
In this paper an analysis of energy use and energy analysis in the Tyre manufacturing industries is presented. It has been found that rubber industries consume a substantial amount of energy. Excessive use of energy is usually associated with many industrial plants worldwide, and rubber plants are no exception. This study is based on the realization that enormous potential exists for cost-effective improvements in the existing energy-using equipment. Through the method of a walkthrough energy audit, power rating, operation time of energy-consuming equipment/machineries and power factor were collected. The data were then analyzed to investigate the breakdown of end-use equipment/machineries energy use. The analysis of tyre curing various temperatures at different time. The results of the energy audit in Tyre manufacturing industries showed that the electric motor accounts for a major fraction of total energy consumption followed by pumps, heaters, cooling systems and lighting. Since the electric motor takes up a substantial amount of the total energy used in rubber industries, energy-savings strategies such as the use of high efficient motors, and variable speed drive (VSD) have been used to reduce energy consumption of motors used in rubber industries. Energy-savings strategies for compressed-air systems, boilers, and chillers have also been applied to estimate energy and cost savings. It has been found that significant amount of energy and; utility bills can be saved along with the reduction of emission by applying the foretold strategies for energy using machineries in the rubber industries.

Key words: Energy, Tyre Manufacturing industry, Curing, Vulcanizing and Rubber industries

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1. TIRE MANUFACTURING PROCESSES CONSIST OF:

1. Preparing intermediate products (members) utilizing the fluidity and plasticity of crude rubber,
2. Laminating the members covered with crude rubber utilizing the tackiness of the covering crude rubber,
3. Assembling the members to make raw tires, and
4. Vulcanizing them at the final stage to produce chemically stable and elastic tires.

2. RUBBER COMPOUNDING (MIX FORMULATION AND COMPOUNDING):

A variety of raw material elastomers and various compound ingredients are used for tires by mixing and compounding them for use in respective members. In former days, this compounding was carried out with open rolls, and naturally the working site was made terribly dirty due to the scattering of carbon black and other chemicals. Today, intensive mixers, including internal and Banbury mixers, are widely used. This intensive mixer is of enclosed type and computer-controlled so that raw material elastomers, various compounding ingredients, and oil are automatically fed, and. This has resulted in reducing dirt to a considerable degree. Since the properties of rubber, uncured and cured, vary greatly depending on various factors as described below, attention has been focused on producing rubber compounds to specifications with a slight variance by computer control.

The various factors include the kind, quantity, order and time of feeding, the extent to which ingredients are mixed evenly, compounding time, and temperature of raw material elastomers and compounding ingredients. In this process, high-capacity motors are used. This inevitably involves large power consumption, which accounts usually for 35 to 55% of the total power consumption of the factory. It is a common practice to recycle cooling water used in large quantities.

Following Table shows Non pro and Pro rubber standard value:

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>TEMP.(°C)</th>
<th>TIME(SEC)</th>
<th>ENERGY(KW Hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>STD</td>
<td>MIN</td>
</tr>
<tr>
<td>NON PRO</td>
<td>145–150</td>
<td>130</td>
<td>110</td>
</tr>
<tr>
<td>PRO</td>
<td>100–105</td>
<td>90</td>
<td>80</td>
</tr>
</tbody>
</table>

During Non pro mixing for 160 kg rubber temperature should be 145–150 °C, standard time 130 second and Energy produce 13–14 KWhr while in pro rubber temperature should be 100–105 °C, standard time 90 second and energy produce 6.5–7 KWhr.

3. CURING AND VULCANIZING OF TIRES:-

Molded tires are fed to a mold (a metal mold with a tread pattern, a side pattern, a marking, and a trademark carved thereon) of the specified vulcanizer, pressed against the inside of the mold from the inside, and heated simultaneously from both sides, internal and external, with heating media, such as steam and hot water, so that, after a given period, vulcanization proceeds throughout the entire tire. Thus, a finished tire with a vulcanized rubber structure is elastic and stable. Operators have only to prepare green tires and watch the process. Since synthetic fibers shrink by nature if left standing
when hot, hot tires after vulcanization diminish in size when left standing. A device (a post-cure inflator) is therefore provided, with which bias tires in which synthetic fibers are used are inflated by applying air pressure immediately after vulcanization, and cooled in an inflated state. Two types of molds are used for molding tires: one is a full mold that splits into upper and lower parts, and mainly used for molding bias tires, while the other is a split mold widely used for molding radial tires.

Curing press operators place green tyres into the curing press or onto press loading equipment. Curing presses in operation in North America exist in a variety of types, ages and degrees of automation. The press utilizes steam to heat or cure the green tyre. Rubber curing or vulcanization transforms the tacky and pliable material to a non tacky, less pliable, long lasting state. When rubber is heated in curing or in earlier stages of the process, carcinogenic N-nitrosamines are formed. Any level of N-nitrosamine exposure should be controlled. Attempts should be made to limit N-nitrosamine exposure as much as feasible. In addition, dusts, gases, vapours and fumes contaminate the work environment when rubber is heated, cured or vulcanized.

The green tire is transferred for vulcanization. The tire is coated with a liquid to ensure that it will not stick to the mold. In the mold the green tire is placed over an inflatable rubber bladder. Typically, the vulcanizing machine is a two piece metal mold. The bladder forces the tire against the mold, forming the sidewall patterns and tread pattern. The molding is accomplished through the use of steam pressure or hot water inside of the bladder. The rubber components of the tire are vulcanized by steam generated heat in the mold and bladder at pressure as high as 400 psi and temperatures of approximately 200 °C for approximately ten minutes. This heat results in chemical and physical changes in the rubber compounds. At the molecular level, profound chemical changes occur during vulcanization. The “green tire” rubber components are transformed from plastic consistency to the consistency found in a finished tire. The vulcanization process chemically and physically links the various components, forming what should be an inseparable bond.

The smaller rubber molecules are linked to the long polymer chain linked molecules. When the molecules in the various components properly bond, all inter facing surfaces are obliterated forming the finished green tire. Thus, any liner pattern marks from the fabric liner used during storage should be totally obliterated in a properly cured tire. One should never see liner pattern marks on a tire that has been properly cured (vulcanized). Manufacturers use various time periods for the vulcanization process. In an effort to reduce the time required for the manufacture of a tire, manufacturers are continually attempting to reduce the vulcanizing time. One method that is utilized is radiation of components prior to vulcanization. It should be noted that under-vulcanization will result in a lack of adhesion of the components. One indication of this lack of adhesion in a failed tire can be pattern liner marks. As a result of vulcanization, the rubber becomes essentially insoluble and cannot be processed by any of the means used to manipulate the green rubber during the assembly process.

4. CURING PRINCIPLE:–
In order to minimize the disadvantages of the conventional process, nitrogen can be used as a flexible and inert pressure agent. After the steam-induced preheating, nitrogen takes over the part of keeping the system’s pressure at the desired level. The ideal system pressure and curing temperature can be selected independently from each other. The rubber cannot overheat any more because of excessive steam supply and less steam can condense in subsequent stages of the curing process.
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Principle of curing process shows in Figure 1. When tyre placed in lower mold after that upper mold closed the curing mold and pressure of steam 14 Bar are passed through outside mold then temperature of curing increase up to 190 °C to 200 °C. When temperature increases nitrogen gas with 21 Bar pressure passes through curing mold to maintain the shape of tyre. Nitrogen is inert gas it does not react with other material and improve efficiency of curing mold. After some time temperature of nitrogen gas decreases, steam pressure reduce and temperature of tyre decreases.

During curing time in curing mold we measure temperature at various point following are the location to check temperature of tyre part.

**Table 2** List of Locations

<table>
<thead>
<tr>
<th>Location</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>INNER S/W TOP-1</td>
<td>I/L C/L-1</td>
</tr>
<tr>
<td>INNER S/W BOT-1</td>
<td>I/L C/L-1</td>
</tr>
<tr>
<td>S/W S/C TOP-1</td>
<td>I/L C/L-1</td>
</tr>
<tr>
<td>S/W S/C BOT-1</td>
<td>I/L C/L-1</td>
</tr>
<tr>
<td>TS-1</td>
<td></td>
</tr>
<tr>
<td>INNER S/W TOP-2</td>
<td>I/L C/L-2</td>
</tr>
<tr>
<td>INNER S/W BOT-2</td>
<td>I/L C/L-2</td>
</tr>
<tr>
<td>S/W S/C TOP-2</td>
<td>I/L C/L-2</td>
</tr>
<tr>
<td>S/W S/C BOT-2</td>
<td>I/L C/L-2</td>
</tr>
<tr>
<td>TS-2</td>
<td></td>
</tr>
</tbody>
</table>
Chart 1: Temperature at various points

From above value we plot a graph temperature v/s time with different point.
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Graph 1 Curing temperature v/s time at various compound parts

5. ENERGY LOSS DUE TO FOLLOWING REASONS:-

Table 3 Energy Loss

<table>
<thead>
<tr>
<th>PROCESS</th>
<th>WASTE STEAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curing</td>
<td>Energy loss</td>
</tr>
<tr>
<td></td>
<td>Un-insulated steam pipe lines</td>
</tr>
<tr>
<td></td>
<td>Power failures</td>
</tr>
<tr>
<td>Waste water</td>
<td>Water leaks in the pipelines</td>
</tr>
<tr>
<td></td>
<td>Release of wastewater to the drain</td>
</tr>
</tbody>
</table>
5.1. Following are Reasons for Energy Losses:-

5.1.1. Piping
There were many complex piping parts and naked pipes by installations.

5.1.2. Traps
There were some traps having an excessive discharging capacity against the loading, resulting in generating an energy loss. Further, such traps were located at a place where the inspection work was hard to carry out, and their actuation was sometimes difficult to be judged.

5.1.3. Heat insulation
The main pipes were fairly heat-insulated, but some of flange valves, pressure reducers and covers of the curing cans were not.

5.1.4. Loading equipment
1. The loading might be light in the case of operating the one machine, but its fluctuation became violent in the case of operating the multi-equipment in parallel at the same time. Therefore, the boiler loading sometimes got 18 t/h at the maximum against its capacity of 10 t/h, resulting in decreasing the boiler pressure and in interfering with the production.
2. There was some curing equipment which threw away the steam each time when the curing processing was finished.
3. There were leaks of the steam.

5.1.5. Valves
There were marked leaks from the ground parts of valves for a high pressure and from the parts of bonnets.

5.2. Blow Point:-
The blow point is the limiting cure time which bubble no longer form when tire is cured.

5.3. Other Benefits
1. The employees are experiencing more comfortable working conditions inside the factory, due to reduced heat loss from steam pipelines and moulds.
2. Reduction of cycle time because heat loss of moulds was reduced, and therefore production was increased.

6. ENERGY ANALYSIS AT TIRE MANUFACTURING FACTORIES:-
From the Table 3, the process which consumes lots of fuel is the curing process, and both the refining section and the driving section consume the electric power prominently. The key points to improve the manufacturing processes from the viewpoint of carrying out the energy conservation are as follows.

6.1. Mixing:
Heating up the crude rubber, Investigating on the peptizer, Investigating on milling conditions, circulating the warm water, Exhausting fan.
6.2. Extruding:
Temperature of the warming sheets, Investigating on the roll size (face length and number of roll), Heating the mouth rings, Controlling the remolding amount, narrowing the width of cooling conveyor.

6.3. Sheeting:
Same with extruding.

6.4. Vulcanization:
Controlling the outgoing radiation, improving the curing method, preheating the die assembly, Shortening the time for exchanging the die assembly, Investigation on the blowing air, improving the ventilation fan.

6.5. Driving:
Rising the temperature of boiler feeding water, Drain recovery, jointing the steam and the warm water systems, miniaturizing the boiler, withdrawing the disused pipings, Reducing in the number of air compressor.

6.6. Others:
Natural illumination, Controlling the steam and air leaks, Reducing in the idling time, Inspecting the optimum capacities of equipment and motors, Installing the instruments and gauges.

7. CONCLUSION:-
One of the subjects for the international problems to be solved in parallel with the energy analysis is at present the establishment of countermeasures for the environmental problems. In the process that the earth warming is advancing, various subjects of such as reducing in carbon dioxide and so are being discussed. We believe that the clean earth can be regenerated only when we use effectively the valuable energy. Therefore, the countermeasures for the energy analysis and for the earth warming should not be separately considered and discussed.

REFERENCES:-

[1] Energy conservation in rubber industry by united Nations Industrial Development Organization