

ANALYSIS OF THE USE OF MACHINERY AND EQUIPMENT IN TERMS OF TIME AND ENERGY

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Abstract: This article examines the vital role that machinery and equipment play in company productivity. While energy efficiency looks at energy consumption, machine age, and the usage of energy-saving technologies, time efficiency is measured by operational downtime, machine setup time, and production speed. The article highlights how operational effectiveness, cost reduction, and environmental sustainability may all be greatly enhanced by optimizing both time and energy. The analysis illustrates the significance of energy-efficient machinery and efficient maintenance procedures using case studies from the manufacturing, construction, and time and energy consumption with more information including time energy ratio. The results show how crucial it is to take time and energy optimization techniques to improve business results and attain sustainability over the long run.

Keywords: Machine efficiency, time efficiency, energy efficiency, energy consumption, cost reduction, time-energy ratio, resource efficiency

Introduction:

Company's productivity and efficiency are greatly impacted by the use of machinery and equipment, especially in the manufacturing, construction, logistics, and numerous service industries. The optimal use of time and energy has a direct impact on the efficiency of machinery and equipment. For this reason, maximizing time and energy use can greatly increase operational effectiveness, lower expenses, and prolong the life of equipment or machine. **Time efficiency** is how well machines and equipment are used during the production cycle or operational workflow. Achieving productivity and preserving cost-effectiveness depend heavily on this. Time efficiency is influenced by a few important elements. The first cause is operational downtime, which can be brought on by repairs, maintenance, ineffective operators, or improper setup. Process efficiency may be impacted by the amount of time needed to get production-ready equipment ready, for instance, setting up controls, loading supplies, and calibrating systems. Lean manufacturing techniques, automated systems, and standardized processes can help businesses cut down on setup time. Consequently, time efficiency has some effects on the company. The first is higher throughput, companies can boost productivity by increasing the amount of production by making the best use of their time. Cost reduction is the next effect, which implies that shorter downtime and quicker production cycles save money because machinery and equipment are used more efficiently, which lowers labor costs and boosts return on investment (ROI).

The ability of machinery and equipment to transform energy into productive activity without wasting fuel, electricity, or other energy sources is called as **energy efficiency**. Energy consumption optimization is essential because of some reasons, for example to save operating

costs, improve sustainability, and support environmental goals. The following are some important factors which influences energy efficiency. The first is machine age and condition, which shows that less energy-efficient equipment is typically older or poorly maintained. The machine may need more energy to do the same tasks due to increased friction and resistance caused by worn-out parts, antiquated technology, or inadequate lubrication. The next aspect is energy-efficient machinery, contemporary machinery uses cutting-edge technologies to minimize energy usage and is constructed with energy efficiency in mind. These consist of variable speed drives, energy-efficient heating and cooling systems, and motors that use less energy. In addition to this, energy efficiency has various effects on the company. The first is cost savings, which claims that since energy expenditures frequently account for a sizable portion of a company's operating expenses, cutting energy use directly results in cost savings. More energy-efficient equipment uses less energy to do the same duty, resulting in cheaper fuel or electricity costs. The second is environmental sustainability, which means that energy-efficient equipment and procedures contribute to a lower operational carbon footprint.

Literature:

According to Hu (2014) Numerous machining systems, primarily made up of machine tools, are employed in a variety of industries. The world's machining systems use a remarkably high amount of energy overall. For instance, more than 7 million machine tools with a combined power of over 70 million kilowatts are used in China's machining industry, this is three times the installed capacity of the Three Gorges Dam, the world's largest hydroelectric power plant.

R. Neugebauer , M. Wabner , H. Rentzsch , S. Ihlenfeldt Few topics evoke as much debate in Germany, Europe, and around the world as the need for a sustainable rise in resource efficiency. The challenges in production engineering over the next 20 years will be determined by the global community's growing desire to protect the climate and the limited resources available to industrialized nations, developing nations, and the growing number of people worldwide. Within the coming years, the European Union, the economy, and organizations have set the ambitious objective of greatly increasing the efficiency of the resources used in all areas, including manufacturing, transportation, energy generation, and living.

According to Gutowski et al.'s research (EBM, 2010), the total energy needed for a machine tool's operation is made up of both constant and variable components rather than being constant as many LCA programs imply. The variable part relates to the energy required to produce a work-piece and is proportional to the amount of material removed or being processed, whereas the constant part is used to ensure the active response of system parts, such as the main driving system, the integrated electronics, or other auxiliary sub-systems (positioning servo motors, ventilators, or chillers), and is independent of whether or not a part is being produced. The machine characteristics limit the cumulative variable part's maximum value, which impacts throughput.

Methodology :

To evaluate how companies handle machinery and equipment in relation to time and energy efficiency, a number of case studies were examined from industries like manufacturing, construction, and logistics. The main emphasis was on companies that used sophisticated automation systems, had regular maintenance plans, and purchased energy-efficient equipment.

Additionally, performance measurements like Machine Utilization Rate (MUR), which calculates the ratio of idle time to active time spent on machines, were used to assess time efficiency. Understanding the elements causing inefficiencies in time and energy use also required the use of downtime analysis and cycle time monitoring.

Analyse :

Table describes time and energy consumption with more information including time-energy ratio. To find time-energy ratio we will use the following formula:

$$\text{Time-Energy Ratio} = \frac{\text{Time Taken to Complete the Task (hours)}}{\text{Energy Consumed (kWh)}}$$

Machine A completes the task in 4 hours, and consumes 30 kWh of energy. With a time-energy ratio of 0.13 hours/kWh, meaning that relatively quick in comparison to the amount of energy it uses. Machine B, on the other hand, takes 6 hours to finish the task while using 20 kWh of energy. It is less efficient than Machine A as it is time-energy ratio of 0.30 hours/kWh. Machine C finishes the task in 3 hours but consumes 15 kWh of energy, resulting in a time-energy ratio of 0.20 hours/kWh, indicating a more balanced efficiency. Machine D takes 5 hours to finish the task, using 10 kWh of energy, but with a higher time-energy ratio of 0.50 hours/kWh, making it less energy-efficient in comparison to other machines. Machine E is the quickest one, requiring only 2 hours, and consumes 12 kWh of energy. With a time-energy ratio of 0.17 hours/kWh, it strikes a good balance between speed and energy consumption, meaning it is one of the most time-efficient and reasonably energy-efficient machines.

Time and Energy Consumption Table

Machine	Time per Task (hrs)	Energy Consumption (kWh)	Time-Energy Ratio (hrs/kWh)
Machine A	4	30	0.13
Machine B	6	20	0.30
Machine C	3	15	0.20
Machine D	5	10	0.50
Machine E	2	12	0.17

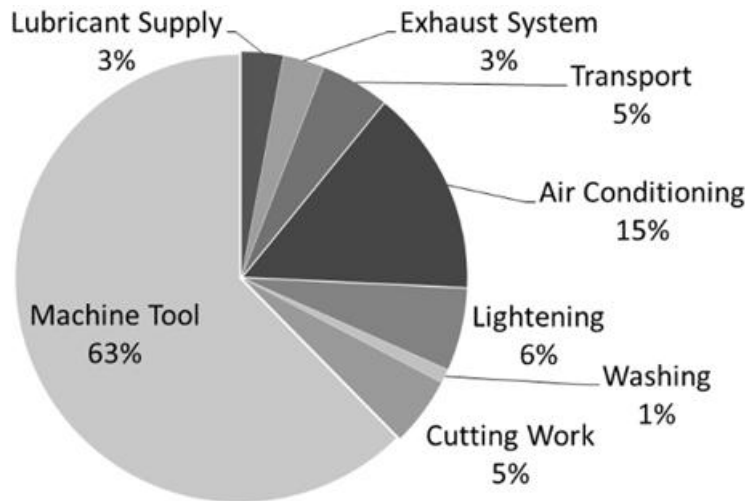


Figure 1: Breakdown of Energy consumption for machining a turning work piece.

Figure 1 shows the complete allocation of the electrical energy consumption for machining a turning work piece. As it is visible from the pie chart, machine tool consumes the largest portion of energy, accounting for 63%, while the average is for air conditioning, which is 15%. Other indicators consumes less than 6% of energy.

Figure 2 displays the operating expenses for a representative machine tool. The overall cost of ownership, comprising purchase investment expenditures and yearly accruing charges for a ten-year period under consideration, is depicted in the left column of figure 2. Figure 2's right column shows the distribution of this machine tool's yearly operating expenses.

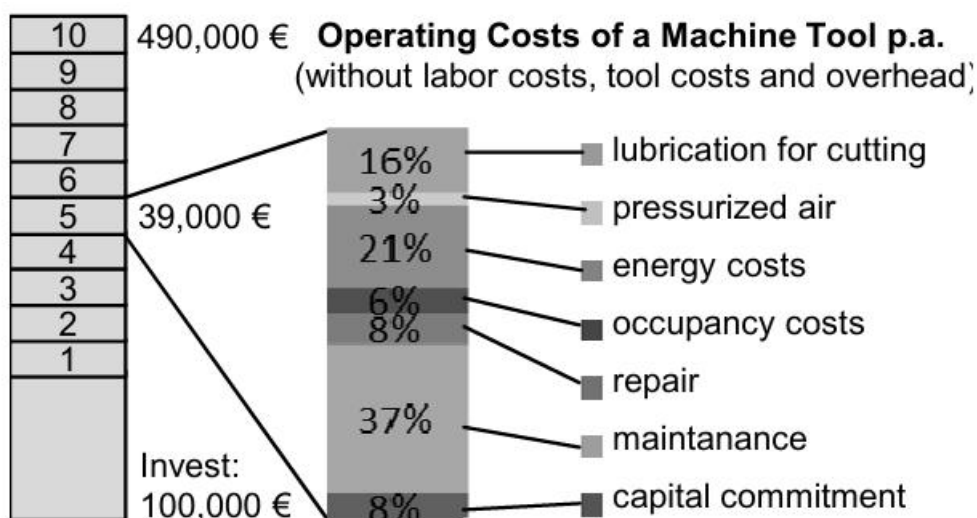


Figure 2: Operating cost of a machine tool.

Conclusion:

In conclusion, increasing productivity, cutting expenses, and promoting sustainability initiatives depend on making the best use of machinery and equipment in terms of both time and energy. Businesses can increase efficiency significantly by concentrating on avoiding downtime, cutting setup times, and implementing energy-efficient technologies. The significance of combining routine maintenance, automation, and energy management systems to optimize time and energy use is highlighted by the examination of case studies from a variety of industries. In the end, companies that put these efficiency on first place are more likely to experience long-term success through more output, lower costs, and a favorable environmental impact.

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