Regenerative Load Gain With Braking Systems İn Elevators

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Abstract

The basic methods of measuring energy consumption and labeling efficiency in elevator systems are explained in ISO standards. With the guide published by the German Engineers Association in 2009, the annual energy consumption of existing and newly commissioned elevators can be calculated and compared. Thus, the elevator energy efficiency class and usage category can be determined. In addition, the ISO standard for measuring and evaluating the energy performance of elevators has been published. The VDI guide has been prepared in relation to the energy efficiency of elevators. The purpose of this guide is to evaluate and classify the energy consumption of elevators according to a standard criterion. This guide is mainly planned for the energy efficiency classification of newly installed passenger and freight elevators, and is also used for determining the energy efficiency of existing elevators, objectively examining the energy consumption values given by the manufacturers, and estimating their energy consumption. The "energy efficiency class of elevator systems", which is determined by the results obtained using the methods foreseen in the guide, is registered with a document by the notified body. Studies will be carried out within the scope of the standards specified in this master's thesis.

Keywords: regenerative, ISO, energy efficiency

1. Introduction

As it is known, all kinds of electronic devices, tools or machines that we use around the world work with electrical energy. Over time, as the area of use of electricity has increased, the need has arisen to reduce the cost of electricity, convert it or use it for different purposes.

The following are the achievements that we aim to achieve in accordance with these needs.

- Generating electricity through thermoelectric generators (TEG) from the friction energy generated from the mechanical braking mechanism of elevators.

-Storing the generated energy in the capacitors and allowing the engine to reuse it.

Studies have been carried out on converting the inert heat energy released in the conventional system into electrical energy with the regenerative braking system of elevators. [1] In contrast to the regenerative braking system, we aim to directly use the heat energy released in the mechanical braking mechanism of the elevator engine.

2. Materials and Methods

2.1. Regenerative Braking Energy and Recovery

Before examining energy efficiency in elevators, it is necessary to examine the energy flow in a typical elevator drive system. Elevator motor can generate electrical energy or heat depending on some situations. These situations can be exemplified as the direction of movement of the motor or the load condition. The figure in 1 shows a typical energy flow in an elevator operating cycle. The area painted in gray represents the energy drawn from the grid during the motor phase. The notched area represents the energy produced in the braking phase of the motor. Since diode rectifiers that do not allow free energy flow in both directions are used in conventional elevators, braking energy is consumed as heat in the braking resistor and there is a significant energy loss. In elevator drive systems where a fully controlled IGBT converter is used instead of a diode rectifier, it is possible to recover the regenerative braking energy to the grid

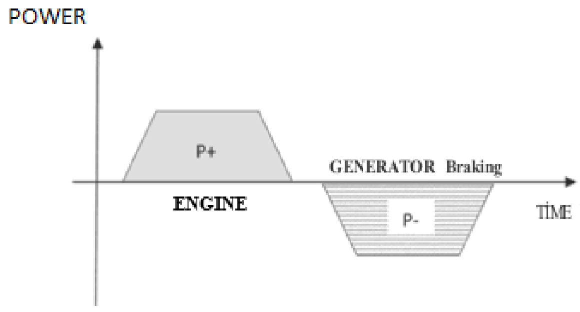


Figure 1. Engine and generator operating zones in the elevator operating cycle

The operating phases of the AC motor (motor, generator) are shown in the graph named 2.2 in the 4-zone coordinate plane. The regions where electrical energy is transferred to the motor as motion energy are called "motor operating zone". (Zones I and III) In these regions the power is positive. Zones 2 and 4, where the motion energy is transferred to the motor as electrical energy, are called the "generator or braking zone". This is due to the inertia of the load. In these regions, the charge is negative. In these cases, the energy released is consumed as heat energy on the brake resistor. In another possibility, it is fed back into the grid as electrical energy via the regenerative unit (AFE). Thanks to the regenerative units, II. and IV. Significant energy savings are achieved by reusing the braking energy generated in the regions. Thus, a positive contribution is made to the efficiency of the elevator. Energy work, motor operating phase (I. and III. regions) and generator operating phase (braking) (II. and III. regions) in elevator drivers are indicated in the figure named 1.2. There are two types of reverse energy work in the generator operating phase. The first is the consumption of braking energy as a heat ejection on the resistor. The second is the transmission of braking energy to the grid in the form of simple heat via the regenerative unit.

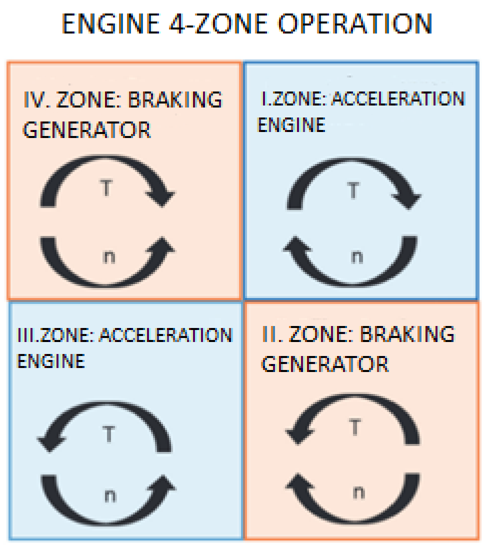
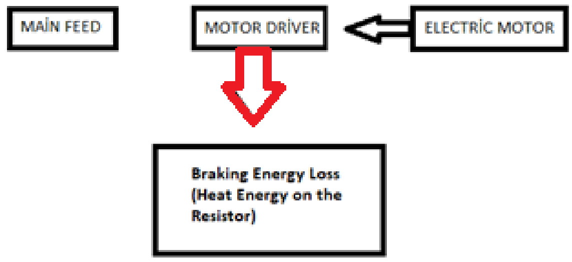


Figure 2. 4-Zone Operating Phases of AC Motor (T: Moment, n: Nominal Speed)[2]

2.2. Energy Flow in Elevator Command and Control Systems

Engine Working Phase (Zones I and III)

Generator Operating Phase (Zones II and IV) Energy Loss



Generator Operating Phase (Sections II and IV) Energy Recovery (Regenerative Solution)

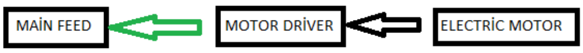


Figure 3 Energy flow in elevator drives; Engine running phase (zones I and III) and generator starting (braking) phase (zones II and IV). The reverse energy flow can be in two ways during the generator operation phase; (a) consumption of braking energy in the resistor, (b) push back to grid via regenerative unit[3]

Depending on the cabin load and the travel direction, the AC tWik unit works in two ways; engine or generator. In the motor stage, electrical energy is consumed by being drawn from the grid. In the motor braking phase, the regenerative braking energy generated feeds the DC source of the drive. In the bidirectional regenerative elevator driver design proposed in Figure 3, the regenerative unit (AFE, active-front-end) works as a rectifier in the motor phase, providing energy flow from the AC network to the motor. In the motor braking phase, it works as an inverter and provides the flow of regenerative braking energy produced in the motor from the DC source to the AC network.

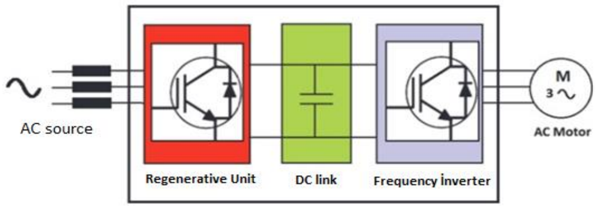


Figure 3. Key Components of Elevator Drive System with Regenerative Unit (AFE)[4]

In Figure 3, a sketch block diagram of a proposed "ultra capacitive storage unit" supported drive design for regenerative braking energy recovery is given. In this design, the regenerative braking energy generated in the braking phase and loaded on the DC bus of the driver is stored in ultra-capacitive power storage units via a suitable DC/DC converter unit with bidirectional energy.

If the energy is stored in ultra-capacitors, it can be reused in the motor phase of the elevator drive unit, making a positive contribution to the energy efficiency of the elevator. Thus, it will be more economical. Considering all these, the braking energy spent on the resistor as waste heat in traditional elevator control systems is reused in the motor phase and the energy is recycled.

2.3. Regenerative Brake Applications

Regenerative braking is used especially when drivers need to brake and slow down frequently. It is most beneficial to keep the high potential energy charge to a minimum at a constant rate. Motors that drive electric trains, elevators, cranes, and other loads employ regenerative braking to manage their speed. The engine cannot be stopped using regenerative braking.[5] One of the uses of regenerative braking is to control the speed above the no-load speed in engine driving. The main condition for the regeneration of EMF conditioning is feedback from E. For the armature current to be reversed, it must be greater than the supply voltage. This also applies to the change of operating mode from engine to production.

The following equations contain useful braking calculations in detail. In the first of the equations below, the power transferred to the battery and supercapacitor connected in parallel as a result of useful braking is expressed as Pb,in. In order to calculate the expression Pb,in, the results of the second, third and fourth equations must be found first. The moment of inertia of the wheel group in the second equation, the aerodynamic drag resistance force in the third equation, and the rolling resistance force in the fourth equation are calculated.

“$P_{b,in} = n_{m/G}\, V \left[n_t n_f \left(k f_b \left(F_{aero} + F_{rr} + \left(m_v + 4\, \frac{1\frac{w}{t}}{r_{r^2}} \right) a_x \right) + 1_{driveline} \frac{N_{t^2} N_{f^2}}{r_{r^2} a_x} \right) + I_{M/G} \frac{N_{t^2} N_{f^2}}{r_{r^2} a_x} \right]$ **(1)**

$I_{w/t} = m_w r_{w^2} + m_t r_{t^2}$ **(2)**

$F_{aero} = \frac{1}{2} p C_D A V^2$ ***(3)***

$F_{rr} = \left[C_{rr,front} m_f + C_{rr,rear} (1 - m_f) \right] m_v g\ cosa$ ***(4)”***

2.4. Conversion Of Inert Heat Energy in Elevators

The biggest problem of our time is the rapid depletion of energy resources. As a solution to this problem, the use of renewable energy sources has been increased over time and energy saving methods are being sought in the vehicles used. One of these ways of saving is the recovery of inert energies released from the energy used. One of these inert energies, thermal energy, is currently used in thermoelectric generators recovery is possible through it.

In this study, a double-shoe brake mechanism that allows elevators to slow down and stop when they arrive at the designated floor we will consider the recovery of the released inert heat energy through TEG.

As a result of our research on this problem, we found that energy conversion can be done using a regenerative braking system. In contrast to this study, we will provide the inert heat energy from the friction energy that occurs in the mechanical braking system. If we briefly refer to the regenerative braking system, then

Before starting energy efficiency studies in elevators, it is necessary to study the energy flow in a typical elevator drive system. The elevator motor can either consume electrical energy (motor phase) or generate it (braking phase) depending on the direction of movement and load condition. [2]

Since diode rectifiers that do not allow free energy flow in both directions are used in conventional elevators, braking energy is consumed as heat in the braking resistor and there is a significant energy loss. In elevator drive systems where a fully controlled IGBT converter is used instead of a diode rectifier, it is possible to recover the regenerative braking energy to the grid. [2]

2.5. Mechanical Braking System

There are many systems used for braking in the elevator system. These systems have been described in detail in accordance with TS-EN 81-20 [4] and their standards have been established. In the scope of this study, the braking mechanism that we will touch on is the double-shoe engine brake, which allows the elevator to slow down and stop when it approaches the designated floor. The methods and tools to be used in this system are as follows.

This drum to keep the heat and convert it to electrical energy (figure 2.1) behind high thermal conductivity copper plate (figure 2.2) and this plate thermoelectric generator (TEG) will be placed. The heat energy released as a result of friction will be converted by a thermoelectric generator (TEG) and transmitted to capacitors. (Figure 2.3)capacitors.(Figure2.2)

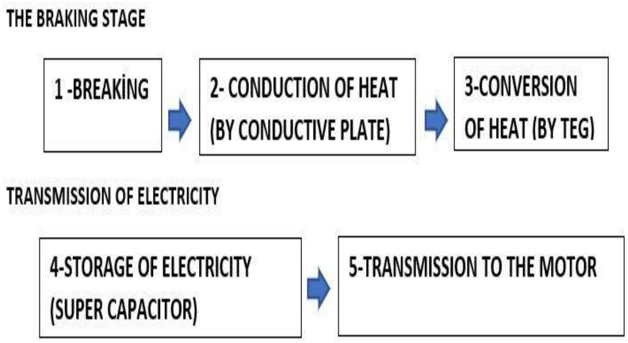


Figure 4. Heat to electricity

Figure 5. Brake

If we first study the brake mechanism, thenthere is a brake disc, which is connected by pads and drive connected to the engine. This system is activated some time in advance when the elevator needs to slow down and stop, and the pads approach the disk, which allows the engine to slow down and then stop. At this time, a heat generated by the friction force Dec the pad and the disc occurs.

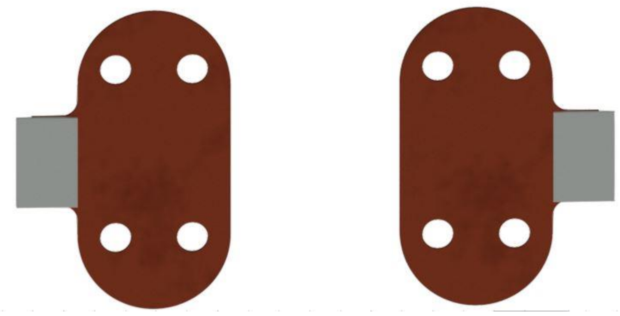


Figure 6.Brake plates

The copper plate Fr be made of Cu-ETP (electrolytic copper) alloy. Fr-ETP is a material with very high thermal and electrical conductivity in accordance with TS EN 13601 standards.

Depending on the surface temperatures of the thermoelectric module, electricity generation is carried out in thermoelectric generators. As the temperature difference Dec the surfaces increases, the measured voltage values increase. 7.80V electrical energy is generated when the surface temperature of the thermoelectric module reaches 80^{o}C. The power generated from the thermoelectric generator is set to 5W depending on the temperature difference. [3]

3. Results and Discussion

In order to foresee to what extent the studies performed meet or may meet the expected results, calculations have been made with certain formulas. There are two important standards to follow when designing brakes. These;

1- $F_{Fr} \ = (P+Q)$ of the braking force . 16 be (EN 81-1 Article F 3.3.3.1) and
2- The limit values of the braking acceleration are 0.2.based on g and 1 g, the average braking acceleration is $g_0 \ = \ 0.6.g$ is. [2]

Determination of braking force:

- Kinetic energy of the cabin, which is falling at v-speed:

$$E_K = m\frac{v^2}{2} \quad [4]\ (1)$$

- Braking force:

$$F_{Fr} = F_N.\mu \quad [4]\ (2)$$

- The braking force in the cabin, which slides up to L distance under the influence of the braking force, is what it does:

$$E_{Fr} = F_N.\mu.L \quad (W) \quad [4] \quad (3)$$

F_N: The normal force between the brake elements,

μ : Dec coefficient of friction between the elements and

L: This is the sliding distance of the cabin from the start of braking to the stop.

The coefficient of friction μ is determined by experiments for the system to be used in the design. This value is usually around 0.2. Of course, it is worth noting that the rail is oily or dry that is changing.

If the elevator cruising speed is v m/s, the initial speed that will require braking:

$$V_0 = 1{,}15\,.\,v\ \frac{m}{s} \quad [4]\ (4)$$

Since kinetic energy will be absorbed by the braking work:

$$E_K = E_{Fr} \qquad (5)\ \text{so,}$$

$$\frac{m.{v_0}^2}{2} = F_N.\mu.L \quad [4] \quad (6)$$

From these expressions, the normal force that should apply the brake element to the disk:

$$F_N = (P+Q).\frac{V^2}{2}\,.\mu.L \quad [4] \quad (7)$$

it will be obtained as follows.

If the sliding distance of the cab during braking is L,

$$L = \frac{{V_0}^2}{2.a} \quad [4] \quad (8)$$

the braking acceleration in the expression a = 0.6.it is found by taking g.

As a result of these equations, we can calculate the work done by the friction force caused by braking by replacing the pads in the equations of normal force that they apply to the disc as a result of stretching the springs in a double-shoe braking system. With the work done, the thermal conductivity coefficient of the materials used in the linings can be multiplied and the heat energy can be calculated.

The axial forces exerted by the lugs are selected according to the dimensions of the brake pulley in accordance with the double-lug brake assembly, the braking moment and the DIN 15435 standard attached to it.[5]

Calculations are made according to the values taken according to the pulley dimensions contained in this catalog [5].

$$P_B = \frac{M_B}{d_B.m_B}\ daN \quad [6] \qquad (10)$$

Where d_B denotes the diameter of the brake pulley; mB is also the coefficient of friction. According to the pairs of materials used, usually m_B = 0.3 ... it is taken as 0.35. [6]

b_0 cm is the width of the shoe;

l_0 cm is length of the shoe

When the heat changes caused by the friction energy are measured and examined, it is assumed that the energy values obtained from the temperature differences that will be released as a result of braking will be as follows.

The difference between the first temperature measured and the last temperature Dec;

The current that will be generated if it is

-12 C is 38.5 A, 3.78 V and 145.53 mW [7]

If it is

-14 C, then the current is expected to be 39 A, 3.9 V and 152.1 mW.[7]

It is foreseen that if the temperature difference increases, the current voltage and power values to be generated will also be increasing.

3. Result and Discussion

The amount of heat energy varies depending on the determining parameters such as the material from which the pad is made, the braking distance, the amount of pressure exerted by the pad on the disc, and the number of friction Decays between the materials. By testing the brake system with experimental methods, it is possible to measure the heat energy released as a result of the friction caused by the brake disc. As a result, as a result of mathematical calculations and studies, it is possible to recover the heat energy generated from the double-shoe brake system. The resulting energy can be used for elevator lighting, intelligent control systems and engine power supply.

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