DESIGNING A SYSTEM FOR OPTIMIZING ENERGY CONSUMPTION IN A POLISHING MACHINE USED IN STONE CUTTING FACTORIES

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ABSTRACT

With aim of energy consumption optimization, present paper studied one of the high-consuming devices in stone cutting factories which is the polishing machine. After lab work and trial and error on the device, mechanical mechanism of the device was changed and a new mechanical mechanism was proposed. In the proposed mechanism here, quantity of electromotors is reduced to half and a 25 percent saving on power consumption is obtained by replacement of belt and mechanism type.

KEYWORDS : Optimization, Polishing Machine, Stone Cutting Factory

Energy resources protection is a prerequisite which should be followed by all of us. This movement causes to overcome global energy crisis. In particular, developing countries are interested to increase their information about energy production efficiency and energy consumption. However, the only solution in this regard originated from wise usage of existing energy. Energy consumption optimization in all sections clearly is one of the significant and considerable policies among developed and developing countries. Therefore, the need to implement energy consumption management projects in high consuming factories and industries is specified more than ever. In this regard, applying energy consumption management in stone cutting factories is important due to following causes:

High consuming industry
A relatively same procedure in different countries
High contribution of energy in the product cost

According to about 6000 stone cutting units in Iran and the high cost paid by such factories for power prices, a system will be welcome which can reduce the consumed power by conserving available machines and changing their mechanical performance mechanism while these factories pay a high amount for the energy price after releasing subsidized energy carriers.

Given the multiplicity of stone cutting factories and process of producing all kinds of the stone where electrical energy is only used as the energy in stones production from the stone peak, optimization importance in electricity consumption of existing devices in such factories will be specified. Also, it can be expected that, by applying correct consumption management methods or correcting mechanisms of such devices which are of the goals in present paper, a considerable national saving can be obtained. Furthermore, Iran is one of the greatest building and decorative stone production countries along with Italy, China, India, and Brazil.

The stone industry can be known as of the important resources of earning foreign revenues in Iran. Economic importance of decorative stones mines is excellent for Iran so that experts consider such products as a rival for the oil. Namely, export of processed stones can be the second export pole after the oil in Iran. The minimum annual global need to decorative stones is 5 billion square meters of which 20 percent can be gained by Iran. In this regard, the more advanced extraction and processing technology and methods in stone mines and stone cutting factories, the better produced stone and higher hope to export them. In addition, waste reduction resulting from stone extraction and processing can also play an important role to increase the stone efficacy and significantly enhance the obtained resources.

In stone cutting factories, the electricity consumption of using devices is one of the important cost items so that since releasing subsidized energy carriers, the power cost of such factories has been increased considerably. In these factories, different machines are used such as peak cutting, longitudinal cutting, polishing machine, purification systems and so on among which the polishing machine is accompanied by high energy consumption. In this machine, 11 to 24 electrical motors are used to conduct stone polishing operations.

Present paper aims to design a new mechanical mechanism for the polishing machine with fewer electromotors and the same efficacy to the former device in order to reduce consumed energy.

Figures 1 and 2 show available polishing machines in most of stone cutting factories.
RESEARCH HISTORY

In contrast to stone carving, the stone cutting industry does not have a long history in Iran. The first stone cutting device in Iran (a kind of saw with iron blades and working by Silica powder) which is known by “arreh-goli” was manufactured in 1928 namely about 80 years ago coinciding with the start of construction operations of marble (Marmar) Palace of Tehran. The second stone cutting factory was founded after a short while in Mashad to construct Shrine of Imam Reza (AS). Until end of 1964, totally about 10 stone cutting factories were available in Iran among which one was founded in Mashad and one in Isfahan and the remaining in Tehran all of which had the famous saw. In 1966, the stone cutting saw was bought and installed from a foreign country which was working by diamond blades and opened the way for macro-production of stones. With higher oil price in 1970s and revenue growth, an increasing activity was conducted in building section of Iran. Expansion of building activities in this era became an important factor to apply new technology and construct more and more stone cutting units. Using new technology in cut stones quality provided a relative improvement but due to incorrect operation method of mines in this era, wastage rate was high and it was not possible to deliver high quality products to the market by increased cost. All the produced stones in this era were consumed inside Iran. In 1980s due to Iran-Iraq war, building construction and thereby stone cuttings construction trend was approximately stable. In 1990s with extensive reconstruction and modernization programs, building stone market flourished again. At the beginning of this decade by applying policy of Iranian Ministry of Mines and Industries, the common extraction method (by diamond cutting wire) was replaced with explosion method in stone mines and thereby all miners were encouraged to use this new method. This policy resulted in higher quality of imported ores to factories and lower wastage rate in mines and stone cutting factories and therefore reduced cost for them. Another policy of the ministry in that era was that everybody can contribute to operate and discover mines so that private sector also could work and invest in this industry. With increased investment of private sector, new decorative stone mines were identified and extractive production of mine stones was increased. Applying two above mentioned policies by Iranian Ministry of Industries and Mines caused to resolve problem of lack of imported stones quantity and quality in stone cutting factories and given the internal market need to the stone, growth of stone cutting...
factories construction by private sector was increased significantly. In 2000s, stone cutting factories construction found a higher growth so that currently, there exist about 6000 stone cutting units in Iran. Most of the products of such units are attracted by internal markets. The ability to have higher exports in stone cutting units is poor due to lack of international quality standards. Development of stone industry to overcome threats and using new opportunities are the fundamental needs [2 and 3].

Cutting and polishing techniques are considerably effective on the stone quality. In Italy, using so efficient methods and appropriate machinery caused this country to produce its mineral products and also import a considerable amount of slate from other countries in order to work and provide suitable plaques and thereby export them. Furthermore, hiring a suitable technique for cutting and polishing plays a considerable role in the thickness uniformity, oblique sides of the stone, boulder-sized plaque, plaque thickness and luster rate of the stone.

Iran owes rich resource of building stones so that after China, India and Italy, it is in fourth rank of building stones production from the mines. The competition between Iran and Italy is so close so that in 2007, with decreased productions of Italy and increased productions of Iran, Iran obtained rank 3. The stone types exchanged in global markets include granite, marble, marmarite and travertine stones among which export of granite and marble stones are of higher importance.

It is noteworthy to say that stone cutting factories are in charge of precision and elegance in cutting and polishing stones. By an assessment on polishing machines manufactured by European countries and Turkey, most of such machines use belt and pulley mechanism so that each electrical motor only rotates one polishing head.

MATERIALS AND METHODS

In present paper, after designing an appropriate mechanism for the polishing machine by trial and error and examining different designed mechanisms, we will reach the proper desired mechanism which causes to reduce motors number and power consumption. As the limitations, we can refer to unavailable proper device to implement the plan and high expenditure to rent or purchase polishing machine to implement designed mechanical mechanism as well as trial and error.

A description for polishing machine performance

The polishing machine is a device which is in charge of polishing the stone and can polish the stone in different dimensions. This equipment has several electrical motors that each motor moves one polishing head which moves rotationally and causes to polish the stone. Therefore, the exported stone from the polishing machine becomes flat, smooth and shiny according to occurred polishing rate.

The polishing machine includes chassis, table, electromotors, polishing heads, drums, tape, tape drive system, wind system, jacks, plates, bits, electrical system, and sweep system of the table.

The table is installed on the chassis, polishing heads (between 10 to 24 heads) and electromotors are placed on the table. In order to move these heads, 10 hp electromotors are employed so that number of heads is same as the electromotors number. Pulley and belt system is used to transfer the movement (Figure 2). In order to adjust the round, the difference between diameter of the pulleys installed on electromotors and polishing heads is used. In this system, initially electromotor transfers the round to pulley (mounted on polishing head) by the belt and moves the shaft in the middle of this pulley (this spline shaft is engaged with pulley) and causes to transfer the round. This shaft is connected to polishing head plate and causes to remove head plate. The polishing bits are placed on the plates that the stone is polished due to bits contact with the stone. Movement direction of polishing heads differ from each other in such a way that if the former head circles to right (clockwise), the latter circles to left and this difference is stable as one among until end. One of the possible causes of this event is that the stone moves directly towards forward.

The diameter of electromotors’ head pulleys is between 14 to 16 cm and heads pulleys is between 26 to 28 cm whose number of belts is also between 3 to 4 which are V-shaped and A-type. The distance between heads from head to head can be 40 to 55 cm. Figure 3 and Figure 4 show polishing head pulley and electromotor pulley of polishing machine, respectively.

Figure 3. Polishing head pulley
In order to polish the stone, heads need to move bits with a given pressure on the stone which is performed by pneumatic (air pressure) and jacks whose pressure can be adjusted by valves. Such jacks are used to lower and lift the heads.

Plates and bits are fastened on heads by bolts and nuts whose diameter is variable according to the distance between center to heads center. Polishing machine bits while polishing the stone is shown in Figure 5.

Figure 5. Polishing machine bits while polishing the stone

Movement system of the stone under the polishing bits

In order to move the stone under the polishing bits, conveyor belt system is used. Conveyor belt is placed on the main body of the machine such that in both sides of which (i.e. input and output sectors), there are two drums one stimulus and the other one mobile. The tape movement system is in such a way that one electromotor provides the variable round of initial movement and provides the gearbox with the next round. This transmission is performed by the chain and after reaching the round to gearbox, it causes to move the drum which is mounted on the gearbox outlet and thereby conveyor belt (placed on the drum) moves and the stone on the tape begins to move towards forward under the polishing bits.

Description for sweep system of the polishing table

The sweep system is composed of following parts:

1: Electromotor, 2: Helical gearbox, 3: The round adjustment pulley, 4: Chain, 5: Transmission shaft, 6: Gear comb

The sweep system works in such a way that initially electromotor transfers the round to helical gearbox by the belt and then by reducing round number of electromotor and through gear sling, gearbox transfers the round to the shaft installed on the table by bearing. In both sides of this shaft, two simple gear wheels are installed and also a gear comb is mounted on the machine body under the polishing table in both sides and the simple gears installed on the shaft will be engaged with the gear comb and cause to move the polishing table.

Electrical cutters are used to determine the table course and a 3-position pulley (with different diameters) is employed to adjust the round. By inversing the electromotor round, the sweep movement is occurred. Figure 6 shows using wheel and chain to provide sweep movement of the machine table.

Figure 6. Using wheel and chain to provide sweep movement of the machine table
Present paper studies 12-motor polishing machines due to their wide usage. In this machine, 12 electrical motors are placed together and conduct the stone polishing operations. However, the designed mechanism for this device can be readily generalized to the machines with higher number of motors. Each of the employed electrical motors in existing devices has a power of 10 hp, 7.5 kW and a rotation speed of 900 rpm. That is, energy of 120 hp and 75 KW is used to trigger a 10-motor polishing machine. Mechanical performance mechanism of available devices is in such a way that each electrical motor only moves one polishing head by the belt connected to top of the motor through the pulley. In this device, each polishing head is rotated by a 10 hp electrical motor.

Description of the occurred trial and error to reach an appropriate mechanical mechanism

The stone polishing machine consumes a high rate of electrical energy. For this reason, present paper tried to review stone polishing machine from the initial steps and return to the industry with less power consumption. This system had taken some stages of trial and error in order to reach a result.

First of all, we opened the machine and studied the parts completely then reached an optimal plan after several stages of trial and error and different designs.

After studying performance mechanism of available polishing machines in stone cutting factories, several stages of trial and error were conducted on different mechanical mechanisms in order to design a proper mechanical mechanism by which we can reduce number of machine motors to decrease power consumption. These ideas are addressed briefly as follows (Gharehchahi, 2013).

1.1. The idea of using round conversion gearbox

This system works with 10 electrical motors (10 hp) but by using a round conversion gearbox, 10 electrical motors will be converted to one 40 hp motor. This motor brings its power to a gearbox and it divides its power among all polishing heads. But this idea was rejected due to lack of feasibility and low ability during the round conversion.

1.2. The idea of using gearbox and median shaft

We decided to connect that 40 hp dynamo to a shaft during some different designs using helical mechanism and wheel so that median shaft can reach its power along a direction to all polishing heads. But, this plan was failed too.

1.3. The idea of using wheel chain

Using that 40 hp dynamo, we decided to provide wheel chain with the motor power, but this plan was also failed due to make a lot of noise.

1.4. The idea of using one among belt system

The plan of one among belt system was failed due to the belt type and we decided to hire double belt system (A-type belt). This plan was not also feasible due to using A-type belt (Figure 7).

1.5. Double 4-belt system with B-type belts

Using this system which is the last stage of trial and error, we could trigger the polishing machine employing one 2-head 15 hp dynamo. In current polishing machine, each polishing head works with a 10 hp motor. But by using this system in stone cutting machine, we could reduce power consumption by 25 percent.

As it can be seen from Figures 8 and 9, both polishing heads move through a 15 hp electromotor and the belt type has been changed from A to B. It is noteworthy to say that since...
the belt is changed so it was necessary to manufacture pulleys compatible with B-type belt which was performed by ordering for related sites in Isfahan.

Therefore, in a 10-motor polishing machine where head is moved by ten 10-hp electromotors, it will be possible to reduce power consumption by 25 percent instead of using ten 10-hp electromotors, we can use 5 15-hp electromotors through replacement with new design and changing pulley and belt type (Gharehchahi, 2013).

This system can also work with 10-hp dynamo (instead of 15-hp motors) but we received 13.5 Amperes from 10-hp dynamo which is a limited ampere. In this system, using 15-hp dynamo, we could receive 22 Amperes which is a standard ampere.

It is noteworthy to say that this system has been registered with number 70866 in Iranian Industrial Ownerships Office after assessment and judgment by mentioned office as “Optimization system of energy consumption for polishing machine in stone cutting factories”.

CONCLUSION

After conducting experimental tasks on polishing machines of stone cutting factories which mostly use mechanical mechanism where each polishing head is moved by a 10-hp electromotor; we concluded that, using mechanical mechanism presented in present work where by changing V-shaped belt from A to B-type and hiring 15-hp electromotors which moved both polishing heads by an electromotor, it will be possible to save 25 percent of energy consumption in such devices.

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