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Alteration of Coupling System of the Single-Channel Roller Kiln Drive Enaplic

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ABSTRACT: *In this article is discussed the application of a technique called terotecnologia, seeking the combination of management economics management with technology, highlighting the importance of life-cycle cost of the equipment. The main objective of terotecnologia is the search for alternative techniques, reliability studies and technical evaluations for-economic life cycles of equipment becoming less expensive. The terotecnologia has demonstrated the importance of involving users, such as operators and maintenance technicians in the design phase of the project to facilitate the maintainability of equipment. This work is intended for students in automation, professional technicians and professionals working with industrial machinery.I hope, therefore, contribute to the spread of this new concept that shows a new way of working resulting in numerous benefits for companies in the industry.*

KEYWORDS *-Automation, technology, maintenance.*

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I. INTRODUCTION

Ceramic Industries aimed at effective production, i.e. no scrap resulting from unnecessary stops throughout the production process. At the same time, there is a subsequent search by the improvement of the quality of the finished product and customer satisfaction, targeting the leadership in the market. For that to happen, the production strategies seek to ally increasingly maintenance techniques, aiming to make the most of the performance of machines and equipment that are part of the production process.

In the main sectors of the production process of ceramic coating is not convenient to stop by breakage of machinery, since the maintenance time is typically high and consequently brings in significant losses of production. To make sure that doesn't happen often, it is necessary in some equipment to analysis of the main maintenance issues, with the aim to improve the process and reduce the rate of repetitive stops for emergency interventions.

On this basis, it was examined in a production line of ceramic coating production stops due to mechanical failures in the oven the rolls.

In this type of oven the transport of ceramic coating is done by a set of motorized rollers produce a translational movement smooth and continuous. These rollers can be manufactured from various steel alloys or ceramics, depending on the working temperature, "[...] the rolls are divided into sections, each with your own engine. " (VARMA, 2002 p. 13).

Each section has two axes trees (fig. 1), which were originally United via a coupling.

Figure 1- Oven drive rolls

Source: Authors (2017)

Due to this type of coupling feature off, your natural wear and the difference of internal temperature of the oven, there is a natural phenomenon of warpage of refractory rolls. The movement of rotation of the rollers warped transmits to the refractory handling eccentric blows, reflecting directly on couplings, first in the original named current coupling and the coupling of polyamide, which came to break or fadigar. For the replacement of the same is necessary to stop the drive where the disruption occurred or fatigue, thus more rolls will starting to buckle, causing a series of harmful and unnecessary disturbances.

When this occurs the financial loss to the company is not interesting, because in addition to downtime in production the material inside the oven is thrown and numerous rollers are broken, which add a high cost.

Aiming at the improvement in the movement of the refractory furnace rollers the rollers, the development of a new coupling based on commercially available coupling types with the aim of eliminating the coupling, Consequently improving the productive yield.

II. THEORETICAL FOUNDATION

In this chapter are described some features of the production process of ceramic industry, some types of couplings that were used as the basis for drawing up a new coupling and features related to the development of this project.

Second Bristot et al. (2012) the ceramic process starts with the preparation of the mass, where ground is a homogeneous mixture of raw material, in this case clay, with the intention of acquiring necessary particle size and moisture properties, getting ideal characteristics for use. This can be done in two different ways, called mass preparation via wet or dry.

In the preparation of mass via the main equipment used dry are the hammer Mills, Mills pins (fig. 2), screens and granulators.

Figure 2-Pin mill

Source: M & S-pin mills

As Albero (2000), the prepared mass is deposited into a rigid matrix and then conformed via the resulting compression of a uniaxial pressure application. In this method of formation is prevalent the use of hydraulic presses (fig. 3) due to your high productivity, ease of automation, capacity to produce slabs of ceramic tiles of varying sizes and formats, so that the product end has the characteristics required by the industry and the consumer market.

Figure 3 – hydraulic press

Source: Authors (2017)

Bristot at al. (2012) States that the successive pressing process there is the drying of ceramic coating which happens slowly and gradually where the goal is to remove the water contained from stock preparation. The purpose is to eliminate stresses, consequently, defects in ceramic plates.

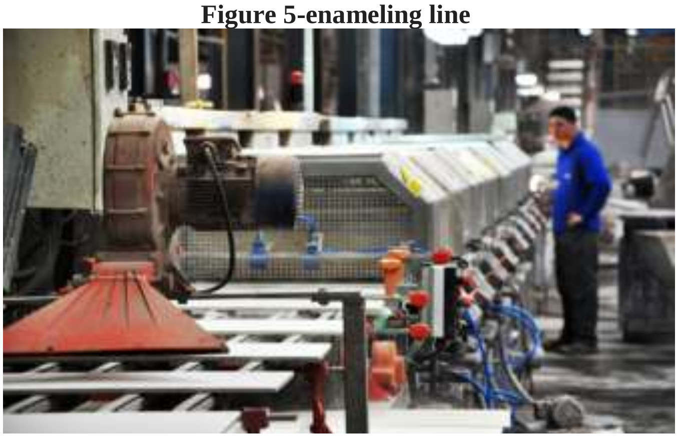
There are some types of dryers, such as: vertical horizontal dryer dryer single, horizontal dryer with two and even three channels. The vertical dryer-channel (fig. 4) is the model used in one of the production lines of ceramic tile Pisoforte LTDA. where was carried out this project.

Figure 4 – horizontal Dryer

Source: Authors (2017)

As the technical information of the Brazilian Association of ceramics (2014) after the dry material, products which are enameled exists the enameling line (fig. 5), where ceramic flooring boards receive a thin layer and remains a material called enamel, composed of natural raw materials and chemicals or vitreous compounds. In many cases the material is decorated, where the digital screen printing and the rolls are the most used methods in applying the paints which acquire final features only after firing.

Figure 5-enameling line



Source: Life of the Architect – How Ceramic Tile is Made

Subsequent to the process of enameling coating ceramic plates are ready to be burned.

There are several types of burning, however the most used today for the low cycle time, together with the quality of the final product is the mono-quick burning in the single-channel roller (fig. 6).

The burning step in the manufacturing process of ceramic coating plate consists of a heat treatment in which the ceramic mass undergoes several micro-structural changes as allotropic transformations, reactions in the solid state, formation of phase NET, among others, in various temperature ranges. (VARMA, 2002, p. 17)

The maintenance of the single-channel roller kiln requires special attention especially in the mechanical Assembly that involves the movement of the rollers, the reason of this refractory any emergency intervention can result in a series of losses such as the disposal of the material that is in the channel, refractory and rolls break the drive mechanism itself.

Figure 6-Oven rolls

Source: Ceramics-Sacmi Organization Group

Second Generous (2009) coupling is a mechanical Assembly consisting of elements of machines intended for the transmission of torque and rotational motion between two shafts.

Norton (2004) explains that a variety of shaft couplings is commercially available, ranging from rigid couplings to elaborate designs that use gears, elastomers or fluid to transmit the torque from one axle to another axis or other device in the presence of various types of misalignment.

Broadly coupling can be divided into two categories: hard or complacent (flexible). Compliant means that the coupling can absorb some sort of misalignment or vibration between the two axles, have the drive implies that none is permissible misalignment between the two connected shafts.

Coupling models similar to those that were used in the project are cited below as your category.

Rigid couplings connect two axes allowing relative movement between them, where some axial adjustment can be done only in the Assembly. Are used on machines that have long axes where require precision in movement of rotation, and the relationship of movement between the motor device and the device moved should be kept accurately. (NORTON 2004, p. 527)

Generous (2009) States that the rigid Union for flange is a classic method of joining axes, where the flange hub is embedded with interference on the shaft having a keyway in each. The flanges are connected with screws (fig. 7) capable of supporting the load to which they are being subjected. Is used in low-speed transmissions and high power. Do not absorb shock or vibrations from misalignment of the machine or engine starting.

Figure 7 – rigid coupling with flanges screwed

Source: Metalflex Couplings

According to Generous (2009), compliant or flexible couplings make smoother the transmission of rotation and torque on shafts that have sudden movements or vibrations. Allow the functioning of the Assembly to be coupled with misalignment: axial, angular or parallel (fig. 8).

According to Norton (2004) an axis can have an angle of up to six degrees in misalignment with respect to a second axis.

Figure 8 – angular misalignment, axial and parallel.

Source: Metalflex Couplings

Source: Metalflex Couplings

The flexible coupling is an example used in the ceramics industry, consists of two gears are attached through double roller chain (fig. 9). According to the catalogue Transmitech (2014) this is a simple coupling, your flexibility is resulting from the break between the current and the gear teeth, parallel and angular misalignment absorbing.

Figure 9 – current flexible coupling

Source: Transmitech Gears

Source: Metalflex Couplings

There is also the flexible coupling of single-disc or two-disc (fig. 10). According to Gouveia (2014) this model is basically built with two cubes that unite the two shafts and a floppy disk responsible for Union of the set screw. This coupling type admits a certain degree of misalignment between the shafts. The elastic disk allows relative movement between the axes also serving as a kind of mechanical fuse, because if the torque is too high for some reason there is occasional disruption of not damaging the axes.

Figure 10-disc double elastic Coupling

Source: Industrial Mechanical

Source: Metalflex Couplings

III. MATERIAL AND METHODS

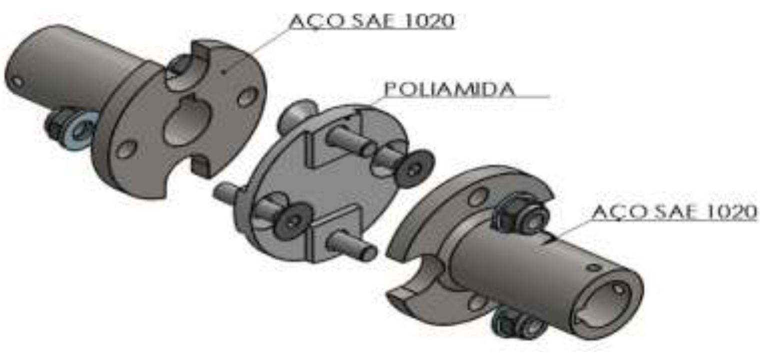
The ceramic coating plates along the oven burning rolls happens through the movement of rotation of rollers. This motion is performed by motor assemblies (fig. 1) distributed throughout the oven, the rolls. Each set consists of two axes-trees which are attached via a coupling.

As the history of the company, the original coupling was flexible. Due to the clearance between the gear teeth and the dual roller chain coupling existed a relative movement between the axes. This movement along with the difference of internal temperature, top and bottom of the oven resulted in a natural phenomenon of warpage of refractory rolls starting a chain problem, because the eccentric blows absorbed by the resulting set of roller warped created more furloughs in the coupling, and so on up to the ruptured.

Recognizing the problem, to replace the current flexible coupling, developed a new flexible coupling coupling with polyamide disc (Figure 11), for the reason there is a misalignment between the shafts-tree.

The new developed coupling had two metal flanges and a polyamide disc in the Centre, attached with two screws each flange (fig. 11).

Figure 11 – exploded view flexible coupling with polyamide



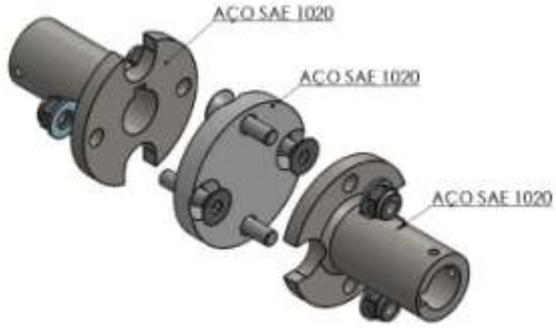
Source: Authors (2017)

With time the polyamide disc suffered a natural wear and tear from the conformation of the material relative to the screw tightening, getting clearances in the holes where they fixed the disks in this flange off generated the same problem of warpage of refractory rolls When was used the flexible coupling.

Being one of those responsible for mechanical maintenance of the company, noted the problem and this resulted in emergency interventions, consequently stops and losses in the productive process, there was the need to analyze and study a solution.

To eliminate the recurring problem, in September 2013 mechanical maintenance team took the initiative to design a new model of coupling. We decided to develop a rigid coupling, with the intention to eliminate the existing gaps in the models used previously. To design the new model, was used as the base polyamide flexible coupling, as this answer the need of geometric machinery. The solution found was to replace polyamide disc by a machined disk SAE 1020 steel, type of steel used in axes of rotation motion transmissions, yields a rigid coupling (fig. 12).

Figure 12- Exploded view of the rigid coupling with SAE 1020 steel disk



Source: Authors (2017)

In December of the year of 2013, the new couplings were already ready to be replaced, but to deploy the new coupling would require the alignment of axes-trees, because they don't admit misalignments. To perform the replacement procedure of the couplings, the downtime necessary was infeasible to implement immediately, because it would interfere directly in the production process.

Then in the first week of February 2014, taking advantage of a halt of production, it was possible to deploy the project, making the replacement of polyamide flexible couplings for rigid couplings SAE 1020 steel. In this way were made all the necessary adjustments in machinery and from this started the activities with the new model.

IV. ANALYSIS AND RESULTS

When it was used in the oven the polyamide flexible coupling, as the historic provided by PCP sector (production planning and control) took place in a period of six months the total of eight stops, from the problems related to coupling.

On average each stop takes place during a period of 4 hours, these necessary to perform maintenance of equipment as replacement of refractory rollers broken, damaged couplings, cleaning the oven burning channel rolls and the reheat the same.

The cost to perform this procedure, as labor costs, maintenance parts and the time required for maintenance there was a direct reflection on productivity of ceramic tiles and consequently in monthly revenue for the company.

More specifically we can analyze the production losses from the values provided by ceramic tile Pisoforte LTDA. Noting the tab. 1, at every stop of 4 hours for a productive loss of 3,532 m^2 of floor boards ceramic.

TABLE 1 – TABLE of PRODUCTION LOSS PER STOP

LOSS OF PRODUCTION PER STOP		
AVERAGE TIME	PRODUCTION PER HOUR	TOTAL WASTE
4 HOURS	883 m^2	3,532 m^2

As the period for the trouble spread in six months, we can measure what was also the production loss during this period, tab. 2.

TABLE 2 – TABLE of PRODUCTION LOSS PERIOD SIX MONTHS

LOSS of PRODUCTION/PERIOD of six MONTHS		
TOTAL CHARTS	STOP LOSS	TOTAL WASTE
8	3,532 m^2	28,256 m^2

Consequently if fails to produce or lose what is already in the process, the industry is financially harmed by not being able to Bill the product and have to meet expenses on the maintenance of the machinery. We can size values (tab. 3), the cost of each stop, adding the value of lost production with necessary expenses such as manpower and new parts.

TABLE 3 -COST TABLE PER STOP

COST PER STOP		
LOST PRODUCTION	LABOR/NEW PARTS	COST TOTALS
R $24,017.60	R $6,250.00	R $30,267.60

And for six months, there were a total of eight stops, we total the cost of all the stops, tab. 4.

TABLE 4 -COST TABLE in the SIX-MONTH PERIOD

COSTS/6 MONTHS PERIOD		
TOTAL CHARTS	COST PER STOP	COST TOTALS
8	R $30,267.60	R $242,140.80

Thus we can see that the failures arising from the flexible coupling model with polyamide, was generating an unnecessary cost to the company.
With the implementation of the new model of rigid coupling, these maintenance costs until then were not longer needed and there is no more loss of material produced as a result of the break-up of coupling problem.
To put the new project up and running, with the rigid coupling, it was necessary to an investment by the company (tab. 5), which comprises the acquisition values of the new couplings and the labor required to replace them in the oven.

TABLE 5 – PROJECT INVESTMENT

PROJECT INVESTMENT			
	QUANTITY	MARKET VALUE	TOTAL
NEW COUPLINGS	50	R $200.00	R $10,000.00
LABOR/HOURS	240	R $30.00	R $7,200.00
		GRAND TOTAL	R $17,200.00

From the replacement of couplings and adjustments to the machinery made in February 2014, there was no production stop referring to problems that had been going on to date.
In this way we can do a comparative analysis of how long the company will be the return on investment. To make this calculation were used as a basis the data already submitted to loss of production and costs per stop.
The first value to be checked was the amount of hours without stops there for the return of the investment industry. To achieve this result was used the total value of the investment (tab. 5), and shared the same by the average cost of each hour stop, being that it was calculated using as the basis of the values taken from tab. 1 and tab. 2, riding so the equation 1.

(1)

$$\frac{\text{VALUE OF THE INVESTMENT}}{\text{COST PER HOUR STOP}} = \text{AMOUNT OF HOURS}$$

Applying the values into the equation 2, we can conclude that in 2.25 hours non-stop we can obtain the return of the amount invested.

(2)

$$\frac{\text{R \$17,000.00}}{\text{R\$ .60 7,566 COST PER HOUR STOP}} = \text{2.25 HOURS NONSTOP}$$

So we can scale a second value, the value that the company would lose production and spend on maintenance per month. Then use as the basis for calculating the Tab. 1 and Tab. 2 to check the amount of hours stops within six months and divide this value by the number of stops that occurred in this same period, thus obtaining the average 5.333 hours of standing in a oven give me n. Multiplying this number by the cost of hour stop (tab. 3), we obtain the desired value. In Equation 3 is observed more exemplified the calculation described.

(3)

(32 ÷ 6) x (7,566 R$ .60) = .80 40,356 R$

It is observed that the value obtained is considerably high, based on this value we can calculate the last and main value, in how many months without any stop occasioned by the problems described in this article, the company will have the return of the amount invested in project.

The 4 equation was developed by dividing the amount invested by the value of the second equation, which is the value of gain per month without stopping.

(4)

$$\frac{\text{INVESTMENT}}{\text{COST PER MONTH OF HOURS CHARTS}} = \text{RETURN TIME}$$

Applying the values into the formula we can find the desired value (equation 5).

(5)

$$\frac{\text{R \$17,000.00}}{\text{40,356 R\$ .8 PER MONTH}} = \text{0.42 MONTH} = \text{13 DAYS}$$

So in less than a month without stops the company will have the return of the amount invested in the implementation of the new model of coupling.

V. CONCLUSION

Craving a ceramic production with minimal waste resulting from faults in the production process, production and maintenance techniques have walked together, to analyze and eliminate these faults which interfere directly in the product over and in general development of the company.

The new model developed based on existing commercially couplings answered so far operating equipment needs no new flaws, where the financial value invested for deployment of machine generated right cost, but When compared to the lost production by failures that occurred with the old model of coupling introduces a significant result in no time.

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