STUDY OF A METHODOLOGY FOR REPOWERING STEELMAKING PROCESS EQUIPMENT: FLYING SHEAR 230 TONS ANALYSIS

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Abstract. *With the increased operational requirements in the Brazilian and world industry, companies were required to change parameters of their production process. The change of these parameters such as power, materials, loads, volumes, speed, density, pressure, speed and intensity was often not provided in the original design of the equipment. The replacement of parameters in the equipment makes the projects more expensive and sometimes impractical. The use of equipment with different loads and parameters changed, in many cases, causes an increase in the number of non-conformities in them, increase in maintenance costs and increased operational damage. For a process of rolling, in steel process, major equipments are the flying shear to cut the material more robust in the process. The flying shear is the equipment responsible for cutting the billets in the rolling production line. With the increasing demand of production and the necessity of manufacture of new products, it starts to inside on this structure, loads of higher transport that conventionally is used for its original size. This cause a great number of non conformity, meaning, equipment stops, or production defects, increasing thus, the maintenance costs, reducing the useful life of the system and producing diverse operational damages. The aim of this paper is a study of the development of a methodology to repowering of the shears in question. Such methodology presents a sequence of actions that involve concepts of repowering, analytical calculations, techniques of extensometry, telemetry and finite elements method. From this process, it is possible to establish the minimum technician and financiers questions necessary for the repowering, giving higher reliability, operational security and extending the useful life of the equipment and the production system.*

Keywords*: Methodology for Repowering; Re-Engineering; Flying Shear; Finite Elements Method*

1. INTRODUCTION

Steel manufacturing is an intensely competitive global industry. In the last years, to achieve productivity improvements as well as product improvements, the manufacturers have maiden continually improves in the manufacturing processes. It has been necessary to improve equipments operational patterns like power, material, load, velocity, density, pressure, rotation and work severity. This improves can be expensive and, sometimes, unavailable.

Non-conformities on the equipment can improve if it was used with higher loads that the conventionally used for its original size, meaning, equipment stops or damages, increasing maintenance costs, reducing the useful life of the system and producing diverse operational damages.

The objective of this study is to develop a methodology to equipment repowering in steel manufacturer. The method aims to promote improves in nominal capacity and operational efficiency, and consider the components behavior and their repercussions.

This paper aims at the development of a methodology for repowering steelmaking process equipment to promote the increase of nominal capacity of operation, considering itself the impact of the alterations in the behavior of each one of the constructive elements and foreseeing its adequacy. The application of the methodology made through a study real case (flying shears), showing which had been the profits using tools of engineering for equipment evaluation where it had alteration of the operational parameters and which would be the increments for the company if they had been carried through before same of the operational changes.

The methodology is based on the use of a series of tools and follows the following phases basically: identification of unconformity, determination of operating loads, analysis of imperfections of components and structures, new calculation of the mechanical and structural components for new operating loads, reverse speed-project and specification of new components adjusted for new loads, implantation of the project of improvements.

The tools used in these stages are adjusted for each one of the characteristics of the works and the equipment, but they can include use of measurement of efforts and loads with “strain gages” (extensometer), analytical calculations, analysis of structure and components in finite elements methods.

First, the intention of this work is to consolidate the data of the operational profits with the use of the methodology and in second spreading through real data, studies and surveys the advantages of the application in anticipated way for the diverse professionals and areas of performance it equipment (operation, maintenance, engineering) and it all steel industrial sector (Yuen, 2003).

2. FINITE ELEMENTS ANALYSIS

The Finite Elements Analysis is a computational method for continuous problems analysis (Knight, 1993). It permits to study objects with many kind of geometry, shipment and shape conditions. By a way a model can be designed with physical similarity with the real studied object, this kind of mathematical modeling generates results that permit simple visualization of the object form. The method permits to turn a physical model with lots of incognitos in a finite model, that can be defined by elements and form conditions (Zienkiewicz, 1989). Initially used during the 60's, the Finite Elements Method (FEM) was used for structural calculation and nowadays it is extremely used for solve practical problems (structure, heat, fluid, electrical and magnetic fields).

Some analysis that can be implemented by finite elements software are: linear statics stress and strain (builds, bridges, towers, mechanical components, industrial tubings), dynamics (vibration modes and natural frequencies), nonlinear stress and strains (conformation, large deformations), thermal (permanent and transient heat transfer), thermal stresses (industrial tubing), fluid dynamics (aerodynamics; hydrodynamics), electrical fields (conductors, insulators, electroplating e corrosion) and magnetic fields .

When studying stress/strain each node can have six degrees of freedom in relationship to the global coordinates system. (Spirakos, 1994). One degree of freedom represents the rotation or translation node capacity in one coordinate axis. The analysis definition begins when the number of degrees of freedom for each node is determined. It is possible to do analysis even with just one degree of freedom by node.

3. EXTENSOMETRY

The extensometry is a measuring technique to structures strain, it is traditionally knows by strain gage. The electrical bonded extensometer or “electrical bonded strain gage” is a strain-resistive sensor; it is a resistor with resistance variation in function to the imposed strain. The sensor is fixed in many points in the studied object and its electrical properties alter according to the imposed strain. The mechanical deformation imposed to the strain gage is equivalent to the object local. Applying Hooke' law for the structure is possible to determine mechanical strains at this point.

The technique is commonly used with finite elements Analysis to compare the measurement results with the calculated loads. Special points are chosen for the experiment and then the model calibration is done. This procedure approximates the model to the real dynamics and static shipment (Chen, 2007, Mohammed, 2006).

4. FLYING SHEAR

The flying shears are the machines used for cutting continuous feeding material into predefined lengths in a rolling production line (Geleji, 1967, Kolesnikov, 2004, Peric, 1990, Zyryanov, 2004). A set of nip rolls moves the material to be cut through the machine. The machine has a motor to control the rolls during the input and the output of the material. Knifes are fixed in two axles in way to permit regular cuts in multiples sizes. The flying shear uses synchronism engaged that guarantee the best position for the material in at the right moment of the cut. The Figure 1 shows a model of the cut components.

5. METHODOLOGY

The steel manufacturer industry has used new kind of material in the last years. This new materials have different shapes, geometry, and hardness. In addition, because of these new parameters it has been necessary to study the behavior of the critical components in the flying shear and to determine the needed alterations to attend the expectations of the rolling production line. For this aim, during the finite element analysis the crankshaft axis' geometry (concordance lines, plates thickness) and component material (AISI 1045 to AISI 4140) was altered.

The efforts determination for the flying shear analysis was done by extensometry measurement and analytic calculations. The extensometry measurement was done by a telemetry system with strain gages installed directly in the crankshaft axis of the shear, with radio transmission (signal generated and transmitted by FM waves).

The collected signals was treated and analyzed using specific software, the impact peak, the medium and the variance was defined by the same way the operational behavior for each size, composition and temperature of the cut material. When the diameter in the strain gages installation area is known, the torque can be defined in function of the local stress. The measurement system permits to instantaneously monitor the stresses to determine the dynamic torque efforts with precision.

During this kind of calculation is necessary to consider that the cut work is generated by the kinetic energy from the rotatory components of the system and don't consider the motor power (Oberrz, 1996). By this way, the motor have to accelerate the system from zero to the inertia necessary to cut in a property time. The axis torque in the moment of cut is determined by dissipated energy during the cut by time interval (inertia lose) more than by the motor nominal power. There is a methodology to theoretically determine the cut energy in function of temperature, thickness, rupture limit and cut angle and more others parameters. Obviously, the in loco measurement generates more precious values that be used to adjust the analytic calculation and the finite element model.

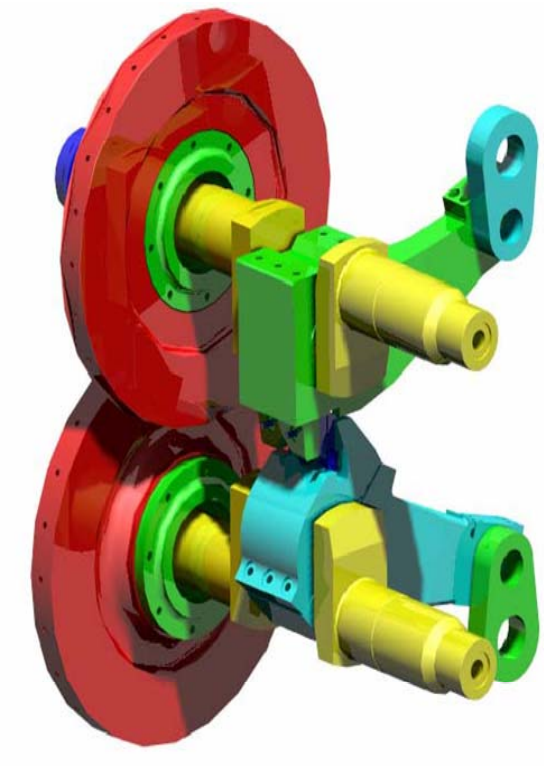

Figure 1. Flying shear cut components.

The finite element model and the effort calculation were calibrated using the extensometry results. The crankshaft axis was modeled using 3D solid finite elements; see Fig. 2, with enough discretization for precisions math representation.

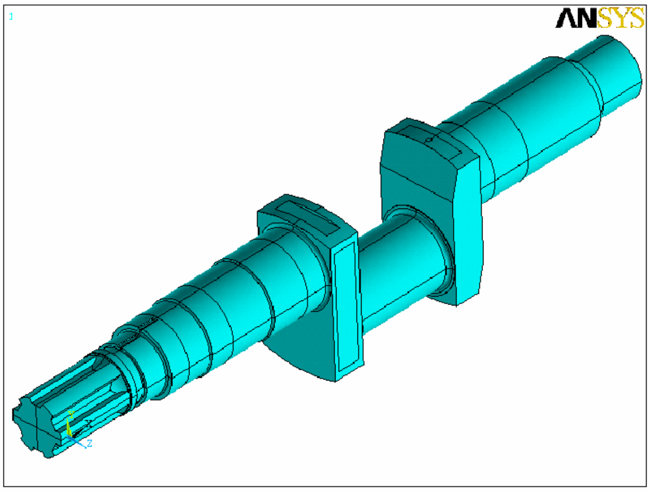

Figure 2. Flying shear 3D model

The shipment cases applied to the models was done based on the extensometry results. The stresses on the crankshaft axis was directly determined by the finite elements model and compared to admissible boundaries for static resistance and fatigue, by this way the failure mode of the new axis was determined. The changes when necessaries for cut effort adequacy were done by interactive evaluation by the finite element method, this procedure guarantee the best relationship performance/intervention. The figures 3 and 4 show respectively the load distribution and the mesh type used for the crankshaft axis' tip and for the crankshaft axis' rod.

With exception of the extensometry, all procedures was done first for the original structure and then for the repowered condition. It was done to refine the results, testing all the methodology for an existing condition and then using this to resize the equipment.

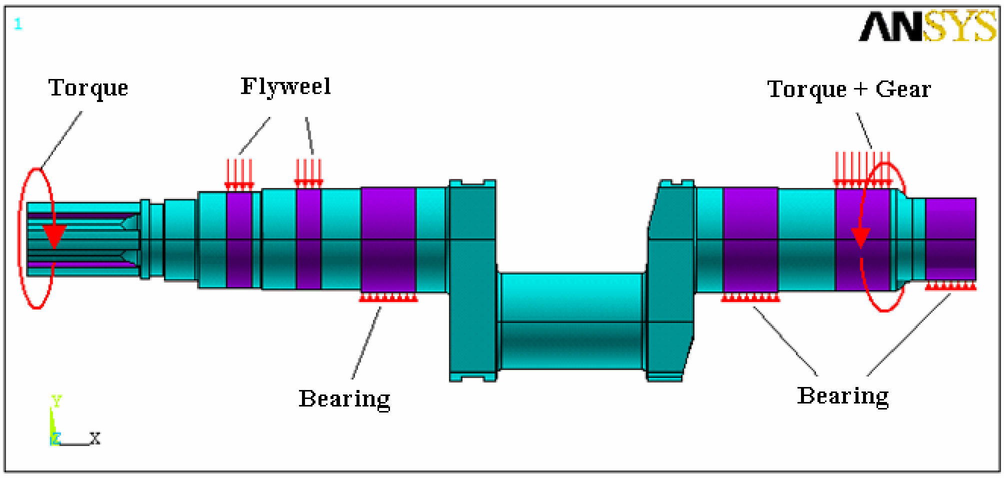

Figure 3. Shipment distribution through the flying shear axis.

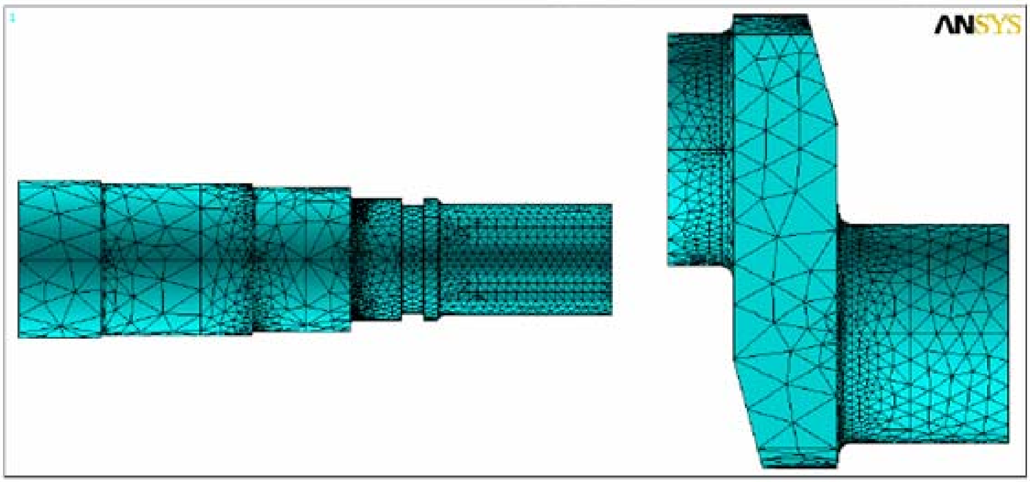

Figure 4. Mesh of crankshaft axis' tip and crankshaft axis' rod.

6. RESULTS

The figures 5 and 6 report the results for computational modeling for severe shipment. The stress analyses in the crankshaft axis' critical points were presented for the original structure and for the reinforced one.

Applying the methodology, the results showed that the original structure for the flying shear is not able to support the efforts generated by the material needed to be cut. The crankshaft axis stresses exceeded the fatigue boundaries for the flying shear material.

7. CONCLUSION

Changes on the original structure of the flying shear were proposed based on the analysis results. The section changes concordances are changed by reinforcements and the axis material has been changed. (AISI 1045 to AISI 4140). The method improved the operational trust, equipment aggregated value and, consequently the industries patrimony value, evenly reduces/interrupted the non-programmed stops for repairs and increased the operators safety and others employees.

8. ACKNOWLEDGEMENTS

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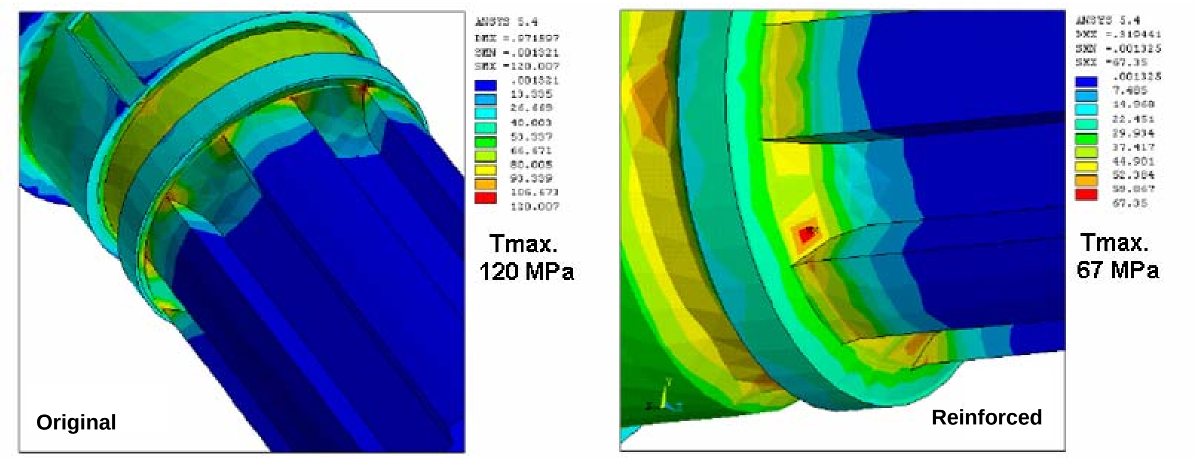

Figure 5. Maximum tension in the tip of the crankshaft axis to the original geometry and the proposed strengthening.

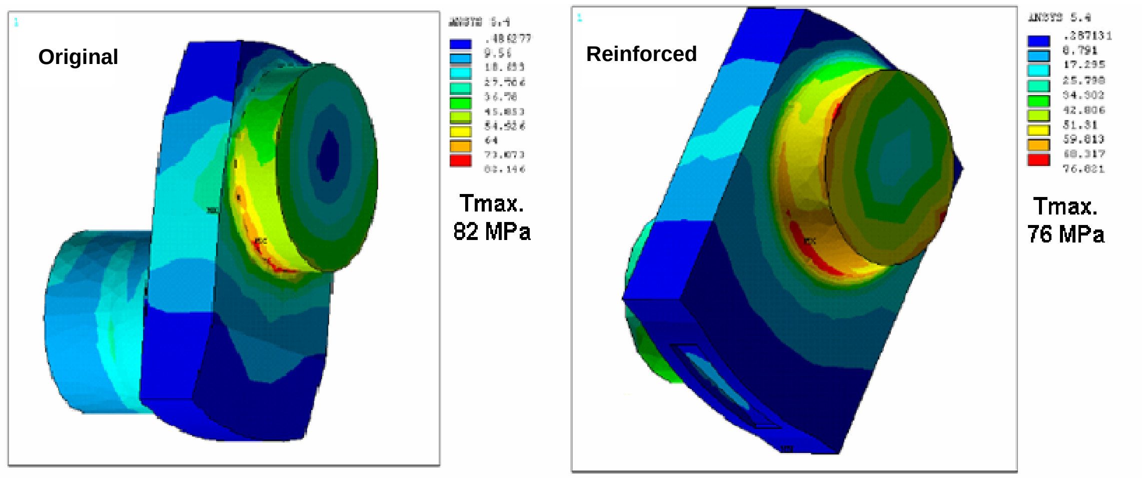

Figure 6. Maximum stress in the crankshaft axis' rod for the original structure and for the reinforced one.

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