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Rehabilitation of the Case of A Reducer of the Automobile Battery Factory through Welding Processes

Osmundo Héctor Rodríguez Pérez

Faculty of Engineering, University Eduardo Mondlane, Mozambique

Abstract: The reducer is the heart of an accumulator (batteries) factory and has the essential objective of moving the mixing shafts of the mixer used for manufacturing the material used to fabricate the batteries boxes and covers. The reducer body consists of two castings: upper and lower casing, both cast, and also has a system of shafts and inner gears to perform the function for which it was designed. Due to the rupture of one of the teeth of one of the gear trains an internal pressure is produced in the equipment and a series of ruptures in the lower casing of equipment is produced, which are: No. 1 support of the bearing 4, No. 2 support of the bearing 3, No. 3 and 4 on outer body and No. 5 on inner body. The research objectives for the reducer recovery project are: study and determine the technology for reducer recovery and execution of the technology created.

In the metallographic analysis carried out under the microscope, a grey cast iron with laminar graphite of sheet size between 150-180 microns and in an amount of approximately 10% is observed, additionally it presents 2-5% of cementite which is prone to cracking. On the other hand has inclusions of oxides and large pores that are product of the technology used for manufacturing the part and were observed cracks resulting from the joints of the graphite sheets. The metal base is composed of ferrite and perlite in a 80-90%. In the project was created the rehabilitation technology for all the ruptures, this work only mentions the three namely the 1, 4 and 5.

Key words: welding, cast iron, reconditioning, technology

1. Introduction

The reducer of the mixer is the heart of the automobile accumulator (battery) factory and has the essential objective of moving mixing shafts of the mixer to manufacture the material used to fabrication the battery boxes and covers.

The reducer body consists of two parts (top and bottom casing) and a system of shafts and inner gears to perform the function for which it is designed. Due to the rupture of the teeth of one of the gear trains an internal pressure is produced in the equipment and a series of ruptures in the lower housing appear, as seen in (Figs. 1 and 3).

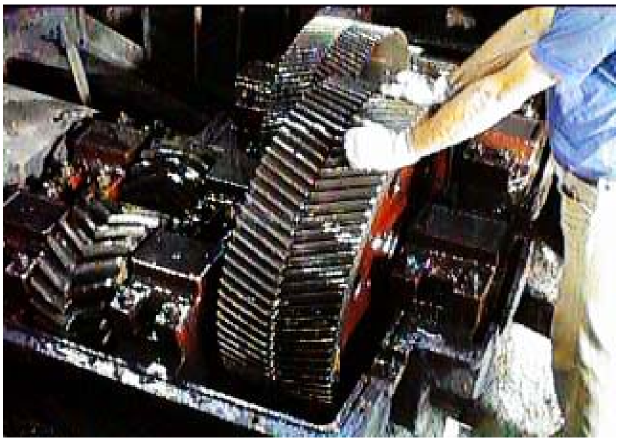

Fig. 1 Top view of the lower half of the gear unit body.

The equipment in question had two previous repairs where heat has been applied and this, together with other technological factors, caused that the lower casing, to be in a very technical deteriorated state; in addition to the bad characteristics of the castings in their initial state, that although they perform and serve for its operation, they constitute a problem to be taken

Corresponding author: Osmundo Héctor Rodríguez Pérez, Ph.D., Mechanical Engineer; research areas/interests: welding, reconditioning of pieces by welding. E-mail: hector041246@gmail.com.

into account, since it is necessary to reapply heat to this material.

The research project objectives for reconditioning the reducer are:

a) Determine the technology for reconditioning the reducer.

b) Development and execution of the technology created.

2. Theoretical Considerations for the Reconditioning of Cast Iron Parts

2.1 Problems in the Weldability of Cast Iron

The occurrence of cracks is due to the physic-chemical characteristics of the material, specifically due to its almost null plasticity, which constitutes a problem in the welding of the cast iron and establishes the relationship between heating, cooling and the mechanical properties of these cast materials [1].

The cast irons have low resistance to bending, the unitary deformation is null excepting malleable and nodular cast irons, forgeability is only possible at high temperatures and the great fragility, especially for the perlite laminar cast iron, constitute difficulties in the welding of the cast iron, but because the plasticity is the property that presents the most problems in the welding of cast irons, especially the grey (laminar) ones, is that these are analyzed more meticulously.

The plasticity is so low that on some occasions it causes the development of internal tensions in the material and, therefore, cracking during the welding process.

With local heating in a small mass of material, as occurs in the processes of welding with heat (fusion) (Fig. 2a), dilations occur in all directions and the fibers of the material adjacent to that heated or melted mass are subjected to compression stresses which increase in value ($\sigma c_3 > \sigma c_2 > \sigma c_1$ ...) to the same extent as the heating time increases ($t_3 > t_2 > t_1$ ...) and therefore the temperature ($T_3 > T_2 > T_1$ ...). Meaning that, compression stress magnitudes or values (σ) increase in the same measure as time (t) increases.

During cooling, contractions occur in the material and then the stresses to which the mass is. During welding the material tends to increase in volume evenly in the hot spot, the mass of the material around this hot spot avoids this increase of volume due to its resistance and thus creates compressive stresses (σ_c), which act in all directions (Fig. 2a). Throughout this process there is still no problem, because the cast iron has a certain resistance to compression and also with increasing temperature, their plasticity increases; however during cooling the material which was heated, now cools down and the previously compressed fibers are now in tension (σ_t), as seen in (Fig. 2b), thus combining two critical issues of cast iron, one that cast iron has a low tensile strength and another is that with the decrease in temperature, decreases the plasticity of these materials, causing these two issues related to the appearance of cracks, both in the melt zone and in the zone of thermal influence, which constitute the fundamental problem in the reconditioning of parts by welding cast iron.

If the material is plastic, as in the case of steels, the entire process previously described takes place, but then the material does not crack because the steels have good tensile strength and greater plasticity than cast iron, which allows them to withstand the value of the tensions which develop in the heating process although after all this, these internal tensions remain in the material.

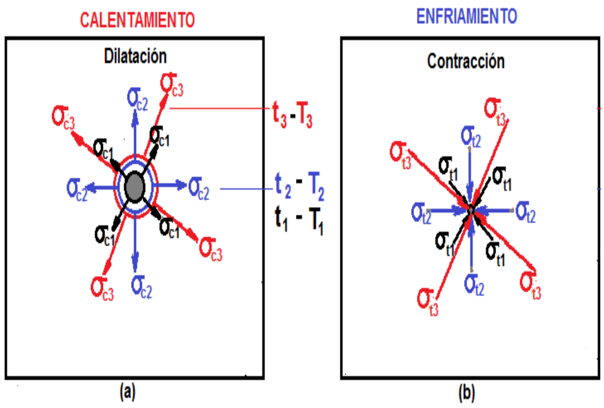

Fig. 2 Process of heating and cooling the base material.

The magnitudes of the compression and tensile stresses depend on two factors; namely:

- Heat difference (temperature) between the heated mass and the area adjacent to it.
- Quantity of the heated mass.

If a given total preheating is performed on the entire adjacent area of the heated mass, the magnitude of the stresses decrease due to the same and its adjacent area increase and decrease in dimensions in a more uniform way. This is the principle on which the methods of “hot welding” of cast iron are based.

The greater the amount of heated mass, the magnitude of the compression and tensile stresses increase, therefore another possibility would be to try to reduce them, in such a way that the stresses that are produced are supported by the strength of the material, in other words by depositing small amounts of the material. This is the principle on which the methods of “cold welding” of cast irons are based. In other words, depositing small cords in small intervals.

The presence of graphite in laminar form is a factor that favors the development of cracks [2].

The more or less localized formation of cementite (Fe_3C), which may occur, both in the melt zone as well as in the zone of thermal influence, which makes difficult the machinability of cast iron, a question often necessary in the reconditioning of some pieces made of these materials.

The formation of pores in the molten zone, due to the high carbon content in these materials, carbon oxides (CO, CO_2) are formed, which do not have time to escape the molten bath due to the rapid cooling of the material.

The formation of a refractory film of silicon and manganese oxides during the welding process, which has a high fusion point with regard to the base metal.

The high fluidity of the cast iron, which is necessary from their manufacture point of view of, causes difficulty in welding these materials in inclined, vertical and overhead positions.

The phenomenon of growth of these materials is present when the workpiece works for long periods of time above 400°C or undergoes repeated heating above this temperature and especially above 800°C, which causes an volume increase and a great development of internal tensions in the workpiece, as for example in furnace doors, steam turbines, internal combustion engines, etc. The cause of growth of these materials is the decomposition of cementite (Fe_3C) into iron (Fe) and carbon (C), which causes the increase of volume in the material [2].

The phenomenon of infundibility (non fusion of the piece) occurs in pieces that have been in contact with oils, fats and sea water for long time periods, because they are embedded with these substances and then with the localized heat of the welding process, they come to the surface avoiding melting the metal and cause its infundibility. Therefore a correct welding bath is not achieved and the filler metal droplets disintegrate or slip on the surface or edges of the welding part.

The burning of cast iron parts consists of both superficial and internal oxidation of the material and occurs when the parts work at high temperatures (400°C). Burnt cast irons are characterized by a surface with visible oxides.

3. Function and Characteristics of the Reducer

The reducer illustrated in (Fig. 1) has a movement input starting from an electric motor and two outputs with counter-moving movements, with the objective of mixing the material for the manufacture of batteries boxes and covers.

The lower casing to be recovered is 1.6 m long, 1 m wide and 0.5 m high.

4. Deterioration and History of Reducer Breaks

The breaks are caused by the fracture of one of the teeth of the reducer gear system, which produces an internal pressure and as a result a series of breaks in the reducer cast iron casing which are shown in (Fig. 3). These are: break No. 1, in the support of the bearing 4, No. 2, in the support of the bearing 3, No. 3 and 4 in the outer body and No. 5 in the inner body.

Two previous repairs were made to the reducer, which resulted from the application of heat and the use of non-suitable materials such as the use of the E7018 steel electrode, made this last repair more difficult, it should also be noted the high degree of deterioration of break No. 1 as a result of previous repairs, now it is necessary to deposit plenty of support material which

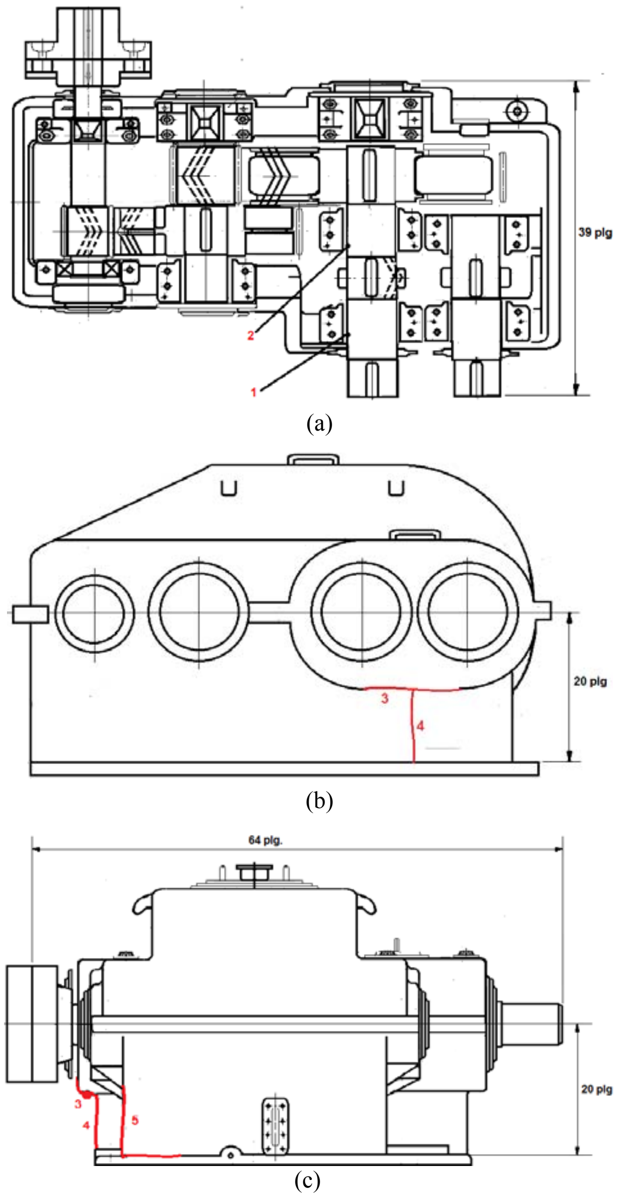

Fig. 3 Distribution of the 5 reducer fractures.

makes the restoration of bearing No. 4 support difficult and expensive.

In the previous repairs of the bearings cracks were produced, as a result of an inadequate welding technology, making their recovery even more difficult.

5. Methods

5.1 Metallographic Analysis

Samples of reductor material observed in the microscope correspond to a grey cast iron with laminar graphite of sheet size between 150-180 microns and in an amount of approximately 10%, it also presents 2-5% of cementite which increases its fragility. On the other hand has inclusions of oxides and large pores that are product of the part manufacture technology and observed cracks due to the graphite sheet joints. The metal base is ferrite and perlite in a 80-90%.

6. Results and Discussion.

This section describes the technologies of three of the breaks with the greatest difficulties from the technical scientific point of view, which are No. 1, 4 and 5.

6.1 Reductor Rehabilitation Technology

In the work in question there were 5 breaks, which were repaired according to the each characteristics, hereafter are only described the recovery of 1, 4 and 5 are they are the most representative. The most important technological considerations for reconditioning of breaks are described next [3].

6.1.1 Rehabilitation Technology for Break No. 1

The break No.1 is located in the support of bearing 4. A layout with the dimensions is shown in (Fig. 4).

In the preparation for the repair of rupture No.1 the following technological steps must be taken into account: all dirty material must be removed with an abrasive disc and at the end a metal brush should be applied and clean the part surface of grease, dirt, etc. up to a distance of 25 mm from the end of the edge.

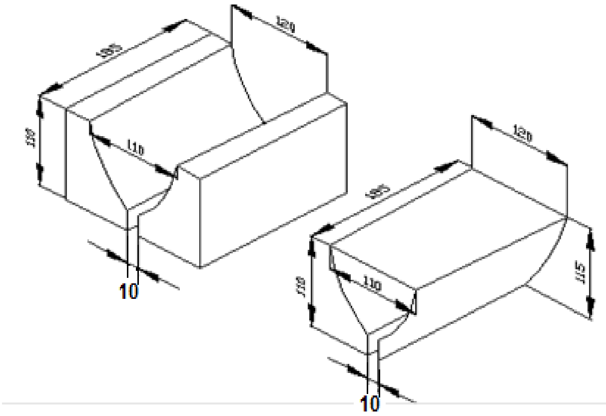

Fig. 4 Layout of the dimensions for breakage No. 1.

The cracks in the material should be well looked for and should be removed with an abrasive disc. The preparation of the edges must be U-shaped and without sharp edges.

The surface of the part must be heated up to 500°C for 5 min to remove grease and oils. Studs of 10 mm diameter should be threaded at a distance of 50 mm and 20 mm from the end at the left and right sides of the edges. Fig. 5 shows the filling of this seam, where the welding of the stud bolts on the left side and the threaded holes on the right can be observed.

A stitched reinforcing sheet is placed at the root of the seam to facilitate its filling with a cross section as shown in Fig. 6.

In the rehabilitation by welding the cold welding method must be applied as follows: a little preheating of 60°C should be given to the cords that are first deposited and welded flat. The electrodes to be used must be 3 mm and with the lowest possible current intensity, the polarity of the current must be inverted

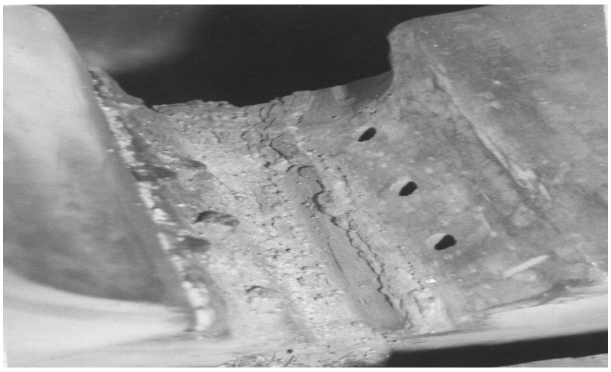

Fig. 5 Holes for threaded studs.

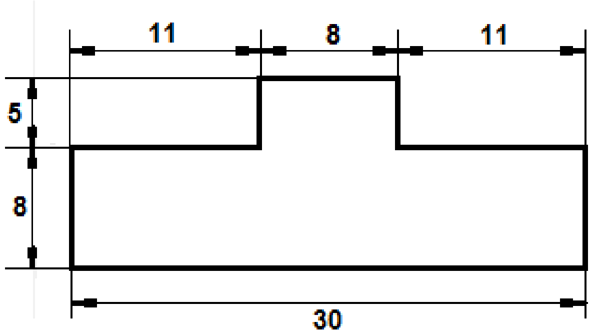

Fig. 6 Cross-section of the reinforcement sheet of break No. 1.

and welding should be in a short arc. The maximum length of the cords should be 30 mm and the width of 6, these should be deposited straight, looped and hammered hot from the end to the beginning of the cord. At the root of the seam the cords should be deposited with the technique of lacing from behind. The place where the welding is carried out must be airstream free. If pores are observed they must be removed. The combination of pure Ni and Ni-Fe electrodes are used and always the Ni cord is deposited in the cast iron. When reaching the studs they should be deposited with concentric cords and then interlaced as shown in (Fig. 7).

The last cords should be welded with nickel based cords because the seam needs to be machined [4].

A slow cooling is assured throughout the weld.

6.1.2 Rehabilitation Technology for Break No. 4

Break No. 4 is located in the left outer support of the reducer housing, it is perpendicular and in the center of the support of bearing No. 1 and reaches the base of the reducer (Fig. 3b).

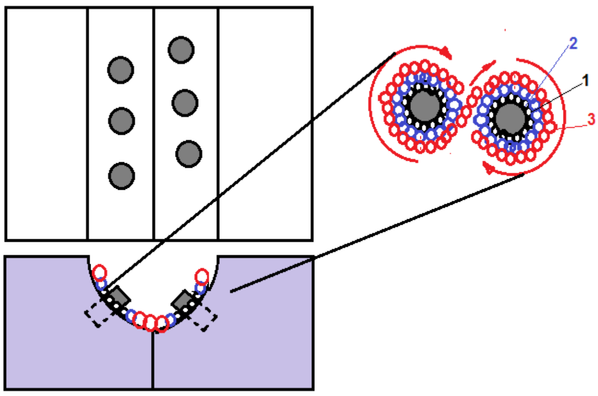

Fig. 7 Concentric cords on the studs.

The dimensions of the prepared edges are shown in Fig. 8 and although their cross-section is variable in the figure they are given their average dimensions. The length is approximately 370 mm.

In the preparation of rupture No. 4 some of the technological steps that were applied in No. 1 are repeated and hereafter are only presented those that differ from them: cracks in the material must be looked for and eliminated with an abrasive disc and observe well their start and end with a magnifying glass. The opening of the edges should be 60°-75° and U-shaped without sharp edges. The surface must be heated to 500°C for 5 min to remove grease and oils.

In the rehabilitation by welding the steps are the same as for the previous break, as well as the cooling at the end of the welding.

6.1.3 Rehabilitation Technology for Break No. 5

Break No. 5 is located at the bottom of the reducer housing and rises perpendicularly to a cavity below the bearing support, which in this case provides free expansion. A layout is shown in Fig. 9 and as can be observed it goes from one side to another of the thickness.

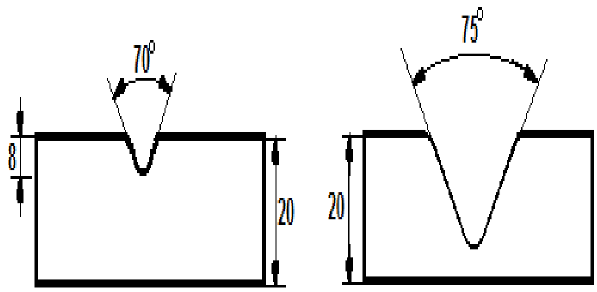

Fig. 8 Average dimensions preparations of the edges break No. 4.

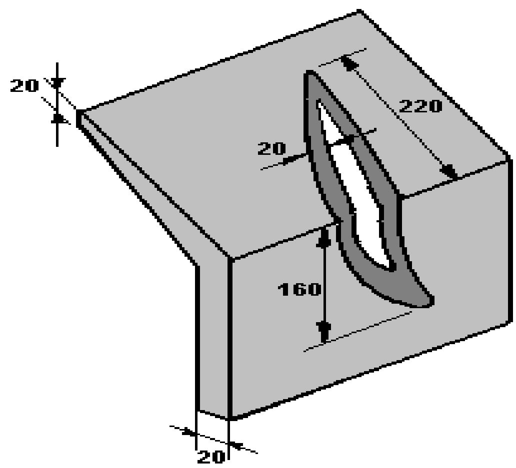

Fig. 9 Diagram of the dimensions of the break No. 5.

In the preparation for repairing break No. 5 some of the technological steps that are applied for No. 1 are repeated with the difference that the preparation here is in asymmetric X, where the largest opening is at the bottom and as soon as it folds at 90° is reversed and the largest opening is now inwards.

In the rehabilitation by welding for this rupture the same technological steps are applied as in seam for No. 1, with the difference that the cords and filling of the seam should always be performed from the embedded bottom end and towards the cavity that is below the bearing, the cooling must be slow.

This work was reported to the factory to avoid considerable economic losses and also the interruption of labor by factory workers for a period of time of 4 to 6 months.

7. Conclusions

The main conclusions of the study are the following:

a) Metallographic analysis shows that the material is a grey cast iron with laminar graphite and sheet size between 150-180 microns in an approximate amount of 10%, it also presents 2-5% cementite. On the other hand has inclusions of oxides and pores of great size that are product of the technology used for part manufacture. The metal base is ferrite and perlite in a 80-90%.

b) In the preparation of the breaks edges the following technological steps must be applied: all the dirty material must be removed with an abrasive disc and metal brush, in addition the surface of the piece must be cleaned of grease, dirt, etc. The edges preparation must be U-shaped and without sharp edges. The surface must be heated to 500°C for 5 min to remove grease and oils. Studs of 10 mm diameter should be threaded in case of bearing breaks.

c) In the welding rehabilitation the cold welding method must be applied with a small preheating of 60°C in the cords that are deposited first and welded flat. The electrodes to be used must be 3 mm and with the lowest currents possible, the current polarity must be inverted, the maximum length of the cords should be 30 mm and with a width of 6, they should be placed straight, looped and hammered while hot from cord end to start. The combination of pure Ni and Ni-Fe electrodes is used and the Ni cord is always bonded to the cast iron. When reaching the studs these should be covered with cords concentric to them and then interlaced.

d) The technologies proposed and developed for the five reducer breaks are considered to be correct, especially to No.1 which, as a result of previous repairs, was applied a special technology that combined studs with the conventional methods of superimposed layers of nickel electrodes and nickel-iron.

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