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STUDIES AND INVESTIGATIONS ON THE POSSIBILITIES OF RECONDITIONING AN ECCENTRIC SHAFT

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Abstract: *Maintenance has an important role in the life of freezing equipment. Without maintenance different failings appear on the equipment, which lead to the wearing of these gears. In our case the semi-hermetic compressor suffered a failure because the oil got diluted by the freezing agent, which made the eccentric shaft fail. From a technical point of view, we can repair and recondition the compressor and the freezing compressor's gears. The bibliographic studies recommend that metallization is the most optimal method of reconditioning the eccentric shaft, which we applied with success. But to prove it in a practical way, in this study we will study other types of reconditioning as well, besides metallization, that is: welding and application of Loctite adhesive kit. We could recondition the eccentrics axis with these types as well but in the first phase we want to prove that metallization was the most optimal solution from a technical point of view. Each method has advantages and disadvantages over their applications. First of all we'll use these methods of conditioning on a test axis(specimen), according to STAS 11684/4-83 where we can define the unclearness of the methods through different concepts. Second we'll try to apply shear stress/compression over the test axis. And in the end all advantages/disadvantages and the values we get will be evaluated.*

Key words: *recondition, welding, metallization ,Loctite adhesive,research*

1. INTRODUCTION

Semi-hermetic compressor, type: DLEE-201, suffered a failure because of the dilution of oil caused by the freezing agent[1]. This failure is characterized, the oil presenting a huge affinity with the freezing oil being mixable with it. In the case of an elongated stop, it's possible to become diluted enough with the agent, to lose its lubing properties, like in our case. The damaged pieces in our compressor, because of the unequal lubing were: the eccentric shaft.

From the bibliographic studies made for the possibilities of reconditioning, we chose the solution of metallization for reconditioning, which we applied with success on the shaft in a practical way.[2][3][4]

Just to prove that metallization was the most optimal solution for reconditioning from the previous studies, in this article we'll make studies and researches over the possibilities of reconditioning in a practical way: of metallization, welding and the application of Loctite adhesive repair kit.

First of all we'll analyze the possibilities of reconditioning after the following concepts:

- processing of the surface
- time of processing
- temperature of processing
- advantage and disadvantage of the technology

Second we'll analyze the deposited layers on the test specimen axis, through a shear shock test. The configuration of the specimen used in this test corresponds to the specifications of the norm STAS 11684/4-83 shown on Fig. 1.[5]

The test consists in applying a compression load along the specimen axis until the deposited layer separates from the metallic ground due to the shear stresses acting on the interface.

The thickness of the deposited layer with metallization, welding and with adhesive is recommended to be in the range 2.0 ÷ 2.5 mm The following requirements are also specified by the norm STAS 11684/4-83:

- overall tolerances according to the international norm ISO 2768 MK;

- Ground material: S235JR and Al EN:AW2007 ISO AlCu4PbMg
- Diameter of the zones subjected to material deposition: 32 mm
- Metalized zones should be machined by grinding at the diameter: 40 mm.

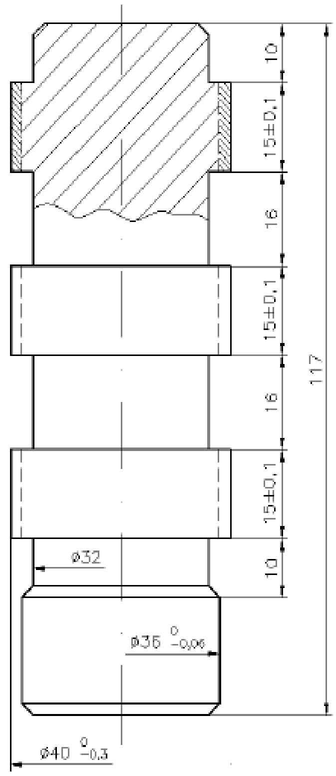


Fig. 1. Geometry of the specimen used in the tests

2.POSIBILITIES OF RECONDITIONING

2.1. Reconditioning through metallization.

Metallization is a process of covering the worn parts of the gears, a modern and complex procedure, which essentially consists in the pulverization with high speed of the molten metal on the reconditioned surface with the help of a gas or air jet.[2][3][6] The added material is the form of a string 60E13%Chrome Steel(EN 1008-1 X 46Cr13), executed with the machine ARC 140 S250-CL. The thickness of the deposited layer is between the intervals 2.0 / 2.5 mm. The metallization was applied without any problems, while the temperature of the metallization was 120 grades Celsius. After metallization the processing of the axis was applied, which was applied on the lathe. After processing the final measurers of the processing quotas were applied. The time of metallization and processing was 200 minutes.

Fig.2. Metalization of the specimen and surface processing

The advantages of metallization are:

- the possibility of covering surfaces of any size with thick layers
- the added layer has a high wear resistance
- the added layer is porous and tenacious, it is improving lubrication conditions
- the reconditioned parts will not become deformed
- the possibility of depositing not just steel, but other metals or alloys as well

The next disadvantages can be mentioned:

- loss of material at the spraying cone ,and the material used can be considered expensive
- it is not possible to cut threads in the layers deposited by metallization
- insufficient or weak adherence to the base metal, especially if the surface hasn't gone through a proper preparation process

2.2 Reconditioning through welding

At reconditioning through welding of the test axis we used the type WIG welding, with the machine Syrius WIG 500.[2][3][8]

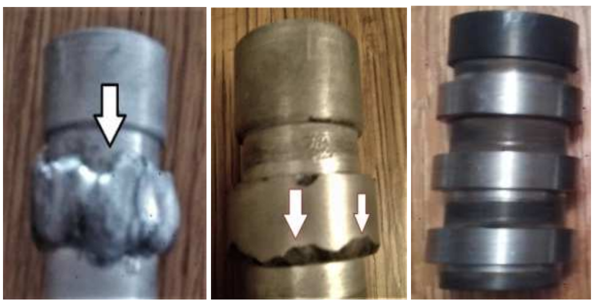
The WIG welding is a process of welding with the electric arc in an inert protective gas environment with an electrode unable to fuse.

It's applied with or without added material introduced under the form of a string in continuous or alternative electricity, the welding source having and external falling characteristic. The process can be applied in manual variant, semi-mechanized, mechanized or automated. The used electrodes diameter was 2.4mm, type

ISO W20,AWS 2%CeO2. The test axis was welded by a legitimate welder. After the first welded zone, presented on Fig. 3a. we can observe that we have drippings on the axis' edges. After welding the processing followed at the requested quotas, after which we can observe that at the axis' edges we have a deficit and measuring it we have measures under the requested quotas, presented on Fig 3b.

After verification we confirmed, we didn't get the required quota, a re-welding follows, that is, it's filled again so that we get the quota. In the end, after re-welding and processing we got the required quotas, shown on Fig.3c.

The temperature at welding was 340 grades Celsius and at re-welding 380 grades Celsius. We can observe that in this case we have higher temperatures than at metallization. After re-filling we still have the same high temperatures, which can lead to the deformation of the welded shaft. In Fig.3c we can see on the finalized test axis, that excessive overheating was produced on the specimen. The time of processing was 560 minutes.



a.) **b.)** **c.)**

Fig.3. Defects in the specimen weld

Advantages of the WIG welding

- very high quality of the welded jointing, with high grade of purity and no faults caused by the jointing process
- it is capable to weld almost any kind of metal
- the absence of the dross from the seam
- the absence of splashes
- the possibility of welding thin plates(less than 1mm, 0,5 mm being the minimum thickness)

Disadvantages of the WIG welding

- low productivity, low depositing rate
- low welding speed
- high cost of the welding process
- expensive welding tools
- the quality depends exclusively on the welding tool used,so this has to be a highly qualified one
- in the case of materials which are thicker than 6 mm this process is used just to add the base layer,and then the following layers are deposited using more productive processes

2.3 Reconditioning through Loctite Hysol 3478A adhesive

Traditional methods of repair, like welding, can be time consuming and expensive. An alternative is the *Loctite Hysol* adhesives.[7]

It can easily be applied on metal based products, they have an excellent resistance to compression and a protective capacity. It's composed of metallic bicomponent epoxidic adhesive, with high resistance to compression. It's hold of ferosilicium has an exceptional resistance to compression. It's ideal for reconditioning surfaces which undergo compression, counter pressure, impacts and harsh conditions of environment.

The advantages of using the Hysol kit:

- remaking of channels until and assembly of channels
- reconditioning of chambers, connections with clasps, elements of tension, cogs, axes,etc.
- duration of action: 20 minutes, duration of fixing: 180 minutes
- working interval temperature: between -30 grades and +120 grades Celsius

Taking in consideration that with Hysol 3478 we can apply on surfaces of two types, shown on Fig 4.

Fig.4. Two possibilities of surface processing with adhesive

On knurled surface, where the adhesive deposits better on surface, and the pure surface where the solution deposits but won't have any longer resistance

After preparing the surface, the adhesive were mixed and introduced on the specimen surface's. After fixing the adhesive follows the processing of this. Through processing we get the required quotas, without deformations on the edges. Working temperature was room temperature 20 grades Celsius , while the time taken was 250 minutes.

Fig. 5. Using the Loctite Hysol 3478A adhesive on the speciment

3.TESTING EQUIPMENT AND EXPERIMENTAL METODOLOGY

The specimen together with the tubular support must be placed on the bed of the universal tension/compression testing machine as presented in Fig. 6.

A tubular support is needed when performing the shear/compression test.The shape and dimensions of the tubular support are also specified by STAS 11684/4-83.

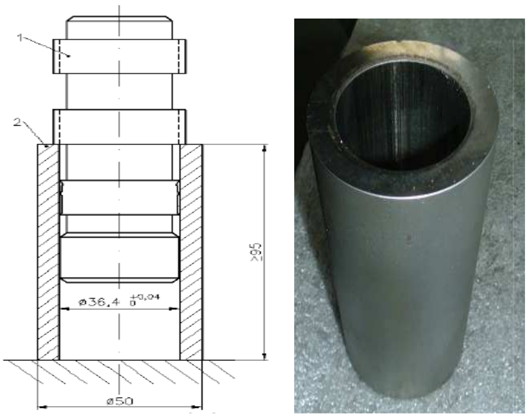


Fig. 6. Experimental setup of the shear test:
1 – specimen, 2 – tubular support (heat treated)

The operator should care- fully check the perpendicularity of the compression force on the upper surface of the tubular support.

The specimen is loaded with a uniformly increasing axial force until the layer deposited on the lower ring separates from the ground.

The value of the axial force corresponding to the moment when the separation occurs is recorded. The loading speed of the specimen should be kept constant at about 8500 N/s.

The specimen must be removed from the testing machine and the layer separated from the first ring must be evacuated from the tubular support. After performing these maneuvers, the compression test may continue in a similar way for the layers deposited on the middle and upper rings, respectively.

The shear test must be performed using at least two specimens except for the cases when other requirements are specified by the technical documentation of the product. According to the specifications of the normSTAS 6300-81, the test must be performed at room temperature.

The adherence resistance resulted form the shear test can be computed using the relationship :

$$\tau_{ad} = \frac{F_{max}}{S} \; [N/mm^2] \qquad (1)$$

in wich:

- F_{max}:maximum value of the compression load applied to the specimen N;
- S:area of the surface subjected to the shearing $[mm^2]$.

5. EXPERIMENTAL RESEARCH

The adhesiveness of the deposited layers through metallization, welding and with Hysol adhesive was evaluated using processed samples from two types of specimen:

- with steel: S235JR
- and aluminum of Al EN:AW2007 ISO AlCu4PbMg

At metallization were covered by string:

- at steel: 60E13%Chrome Steel(EN 1008-1 X 46Cr13)
- at aluminum:01E Aluminium EN ISO14919:2001

At welding we used electrolytes of:

- steel type: ISO W20,AWS 2%CeO2;
- aluminum type:Tigrod 5356 EN ISO 18273 S Al5356 AWS A5.10:R5356.

At Hysol Loctite adhesive:

- at steel and aluminum:Loctite Hysol 3478A ISO 9001:2008.

The shear tests have been performed on a universal tension/compression testing machine Instron model 1343,with testing program Testexpert 10.11,shown in Fig.7.

Fig. 7 Tension/compression testing machine Instron model 1343

The numerical results of the shear tests are listed in Table.1.Where specimen 1,2 was metalized with 60E13%Chrome Steel and 01E Aluminium,specimen 3 and 4 was weld with W20 and Tigrod 5356 ,and specimen 5,6 was used Loctite adhesive Hysol 3478A.

Three separation mechanisms can be identified when examining the manner in which the deposited layer has been removed from the background:

• Adhesive separation
• Cohesive separation
• Mixed separation.

The shear stress τ_{ad} characterizes the adhesive separation at the interface ground-underground. The cohesive separation may occur either at ground or underground levels and can be also characterized by the τ_{ad} parameter. As for the mixed separation, this phenomenon can be localized at the ground or underground levels.

Results of the shear tests *Table 1*

Specimen no/Operation.	Ring No.	Shearing area	Force [N]	Avarage τ_{ad}
		$[mm^2]$	[N]	[N/mm^2]
1 Metalization S235JR	1.1 1.2 1.3	1696.46	154000 162000 208000	103.96
2 Metalization Al	2.1 2.2 2.3	1696.46	91000 110000 112000	81.66
3 Welding S235JR	3.1 3.2 3.3	1696.46	244000 194000 220000	136.99
4 Welding Al	4.1 4.2 4.3	1696.46	244000 194000 220000	136.93
5 Adhesive S235JR	5.1 5.2 5.3	1696.46	154000 162000 208000	100.32
6 Adhesive Al	6.1 6.2 6.3	1696.46	91000 110000 112000	78.83

7. CONCLUSION

Firstly, we can say the following:

Using metallization and Loctite adhesive, we were able to process the surface of the specimen without any defects, at medium temperature and in a short time.

At welding we had problems because of the flowing of the edges, which we could not process at the required elevation and gaps appeared between the edges. But here we must mention the high temperature at welding too, which can cause deformations of the shaft.

The same things appears on the aluminum specimen as well as on steel specimen axes.

Secondly, in the compression test three types of processing have received good results. We have to mention here ,that metallization and Loctite adhesive gave about the same values but the metallization layer was better at compression test .Welding gave high values, because the specimen were resumed.

Through this study we can define that the metallization and the use of Loctite adhesive are favorable for the eccentric shaft refurbishment, because with these methods we can refurbish the surface of the shaft without any defect or deformation .With the welding method we wouldn't able to achieve that, because it produces high temperatures, and gaps appears at the edges.

Finally, we can say that the metallization and the use of Loctite adhesive correspond to the refurbishment of the eccentric shaft. But here appears a question :does not the compressor oil and the refrigerant dissolve the adhesive?

It is known that metallization has proven to be a very powerfull process in several areas (automotive, steam industry, etc), so it is resistant to both. We can say that the adhesive can be used for fast refurbishment and for long refurbishment as well.

But to investigate further, we will attempt to run with a metallised specimen shaft and with a Loctite adhesive shaft which will be subjected to oil and refrigerant work ,and we will check their wear in the oil space refrigerant and cold agent.

check if they have fatigue in the oil space refrigerant and cold agent.

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STUDII ȘI INVESTIGAȚII ASUPRA POSIBILITĂȚILOR DE RECONDIȚIONARE A ARBORELUI EXCENTRIC

Mentenanța are un rol important în viața echipamentelor frig.Fără mentenanță apar diferite defecțiuni asupra echipamentului,care conduce la uzarea pieselor acestuia.În cazul nostru compresorul semi hermetic, a suferit o defectare din cauza diluării uleiului de către agentul frigorific,unde sa defectat arborele excentric.Din punct de vedere tehnic,putem repara și recondiționa compresorul și piesele compresorului frigorific.Studiile bibliografice prezice că metalizarea este cel optimă metodă de recondiționare a arborelui excentric pe,care l-am efectuat cu succes. Dar ca să dovedim în mod practic, în acestă lucrare vor fi studiate și alte tipuri de recondiționări în afară de metalizare,adică: sudarea și kitului de loctite.Și cu aceste tipuri am puteam să recondiționăm arborele excentric,dar în prima fază vrem să dovedim că metalizarea a fost cel mai optimă soluție din punct de vedere tehnic.

Fiecare metodă are avantaje și dezavanje asupra utilizării lor .În primul rând aceste metode de recondiționări vom utiliza asupra unor axe de probe,conform STAS 11684 / 4-83 unde putem defini neclaritățile metodelor prin diferite concepte.În al doilea rând vom efectua încercări de forfecare/presiune asupra axelor de probă.Iar la final toate avantajele/dezavantajele și valorile primite vor fi valorificate.

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