17th International Research/Expert Conference
”Trends in the Development of Machinery and Associated Technology”
TMT 2013, Istanbul, Turkey, 10-11 September 2013

REPAIR OF A DAMAGED PART ON HYDRAULIC TRACT KAPLAN TURBINE WITH "LIQUID METAL"

Fuad Ćatović, prof. emeritus
Edin Džiho, MSc
University „Džemal Bijedić“
Mostar, BiH

Mustafa Šehić
Hydroelectric power plant Neretva
Jablanica, BIH

ABSTRACT
During 2011 on unit no.2 reparation work was carried out aimed at fault removal on Kaplan turbine impeller, while extending the lifespan of the entire installed equipment. The overhaul included all vital parts, replacement of all gasket compresses, machine processing to achieve the required tolerances, NDT equipment control according to "Quality Control Plan", repairing equipment, etc.
This paper describes the recovery of defects on the blades of the guide vanes using epoxy masses.
Key words: Kaplan turbine, overhaul, repair, "Liquid metal".

1. INTRODUCTION

The Hydroelectric power plant Grabovica is the peak of the project "Middle Neretva" located 12 km downstream of Jablanica. Adjacent to the plant is a concrete gravity dam, with a capacity of 19.77 x 10^6 m^3 which provides daily flow equalization. During 2011 on unit no.2 reparation work was carried out aimed at fault removal on Kaplan turbine impeller. The reparation work resulted in dismantling the entire unit, which led to the opportunity to do a complete overhaul and so eliminate the aforementioned defect, with the intention to extend the lifespan of the installed equipment.
The overhaul included all vital parts of equipment which were in service about thirty years, replacing seal packs, machining to achieve the required horizontality, NDT equipment control according to "Quality Control Plan", repairing equipment, and other works.

2. THE REPAIR PROCES

Modern trends in the field of materials in the 21st century constantly require intake of new technologies, all with the goal of captivating more quality, durable and economical materials. This primarily includes new composites with improved physical - mechanical, technological, exploitational and other characteristics compared to existing materials. One of the most important products of this developing trend in the field of mechanical engineering are "liquid metals". In this relatively broad group of composites, we can also classify "metal putty", and various adhesives based on epoxy resins with fillers of metal dust, which by their composition, structure, manufacturing technology, and most of the physical mechanical properties belong to the same class of composite materials.
In this paper the technological process of repair of the damaged blades of the guide vanes using liquid metal will be demonstrated. Based on the selected procedure a plan of action was chosen which included:

- defects inspection of damage,
- choice of repair,
- selection of additional material,
- preparation of basic and supplementary material for the application,
- grinding swells,
- polishing the repaired spot,
- control and testing of hardness.

2.1. Inspection of damage

In all technological processes the first phase of repair of parts and assemblies is the inspection of damage which is necessary in order to determine the detailed dimensions of the defects on the equipment which is being reviewed. On the blades of no. 18 and 24 on the guide vanes a damage on the inside of the blades was observed. Dimensions of the damage were Ø 5 [mm up to Ø 7 [mm diameter, and with a depth of h - 2 [mm to h - 6 [mm, shown in picture no. 1. The damage, on one hand, should be repaired with as less heat input and machining as possible, and on the other hand, the repaired part is supposed not to affect the reliability of the unit in the future.

After the visual inspection and recording of damage of the blades of the guide vanes, an ultrasound examination of the blades has been required. Ultrasound examination was performed in order to determine the exact shape of the defects, or whether and to what extent the surface damages left its mark below the surface of the blades. After the results of the ultrasound examination, no further grinding of surface below the defect was necessary, the structure of the material below the defect surface was in a satisfactory condition.

Picture 1.

2.2. The choice of repair

Although welding is the oldest and most common way of repairing worn and damaged parts and assemblies, in practice we encounter cases where we have to resort to other methods of repair. In certain circumstances, due to the high heat input, in addition to the reasons mentioned above, by welding it is possible to cause damage that can result in long delays in the production of machinery, such as damage to seals, various straps which disassembly takes a long period of time, and the heat input can cause damage which can result in a complete breakdown.

Modern technology reparation with "liquid" metal finds its place where traditional methods of repair are impossible, slow or expensive, due to stopping the production process. Excellent mechanical properties, high chemical resistance and the ability of application in very difficult conditions give almost unlimited possibilities of use, which justifies the increasing presence of these materials in the maintenance of equipment.

2.3. The choice of additional material

To repair the damage to the blades of the guide vanes "metal putty" - Loctite 3471 was selected. It is a multi-purpose two-part epoxy that is most commonly used for repairs to damaged mechanical parts, repairing cavitation, etc. It is characterized by a slight shrinkage after cure (0.1%), high compressive strength and workability entrenching tools. Features are given in Table 1.

Table 1.

Volume / Mix ratio by weight	1:1
Timing	45 min.
Fixture time	180 min.
Shear strength	20 N/mm^2
Compressive Strength	70 N/mm^2
Operating temperature range	-20 to +120 °C

2.4. Preparation of basic and supplementary materials for application

Although the surface of the damaged parts is relatively small, it is necessary to provide adequate surface roughness to which the repair mass is inflicted. To achieve adequate roughness rotor - cutters were used. Surfaces to which it is applied or surfaces to be bonded should be coarser, so that the surface roughness is in the treatment class of 7 to 9. To assess the surface roughness, in mechanical engineering, usually an arithmetic mean deviation of the profile R_a is used, which is equal to the arithmetic mean of the absolute values of the height profile of unevenness on the measuring length *l*.

$$R_a = \frac{1}{n} \sum_{i=1}^{n} |y_i|$$

Where: R_a [µm] - arithmetic mean deviation of the profile, *l* [µm] - measuring surface of roughness length, *y(x)*, *yi [µm]* - profile height roughness due to the high reference line, *n* - the number of points of assessing height profile along the measuring length

As for the preparation of supplementary material, or material for repair at a temperature of 24 ° C degrees, Loctite 3471 components were blended at a ratio of 1:1. Picture no. 2 shows the application the final layer on the repaired surface.

Picture 2.

After the curing of liquid putty, grinding of bumps or swells was performed, finishing the surface with sanding polishers (sandpaper).

2.5. Testing of hardness

After repairing the damaged surface blades of the guide vanes measurement of hardness of the repaired spots was done. This measurement was done because we did not have experience on the hardness of repaired spots using Loctite 3471. Measurement was conducted with the ultrasonic hardness GE - Krautkramer MIC 20 device, wherein an UCI probe was used, type H and workload of 98 N. Measurements were done multiple times, which led to the conclusion that the hardness of supplementary material was much higher than the hardness of the base material. While the hardness of the base material was approximately 255 HV, the hardness of the repaired spot using "liquid putty" Loctite 3471 was at approximately 950 HV.

3. CONCLUSION

After hundreds of hours of work in a variety of modes, six months after the release of the unit in operation, the first review of the hydraulic tract was carried out. In addition to all the details that are the subject of this review, a review of repairs on blades no. 18 and no. 24. was done. It led to the conclusion that there was no damage on the repaired parts. Results proved us right when we decided to use this way to repair the damage, and that the use of mass-based epoxy resins can achieve results that will not jeopardize operational readiness and be on the same level as the repair procedures that use heat input.

4. REFERENCES

[1] www.loctite.hr

[2] Catalogue: „Rješenja u obradi površina“

[3] I. Beker, „Tehnologije u održavanju“

[4] B. Kraut, „Strojarski priručnik“