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APPLICATION POSSIBILITIES OF REPAIR WELDING DURING EQUIPMENT REVITALIZATION OF TURBINE NO2 AT HE GRABOVICA

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ABSTRACT
Hydro power plant Grabovica, that is one in the system of hydro power plants on river Neretva, stopped the work, caused of the failure on the turbine no 2. Because of the specific character of damage, as well as the fact that turbine was working for 30 years, management of the power plant is decided to make a general repair of turbine. General repair of turbine is very complex job, that include engagement of different profile experts and companies specialised for this kind of work. Large scale of equipment had to be replaced by new equipment, but another part of equipment can be repaired and thus significantly reduce the total costs. In this paper are presented some possibilities of usage of welding repair technologies and also surfacing by welding on some special turbine parts. In detail will be presented methods of rehabilitation of cavitations on turbine neck and NDT testing and repairs of cracks by welding on the turbine blade.
Keywords: Kaplan turbine, cavitations, welding

1. INTRODUCTION

Hydro power plant Grabovica is one of the most important from the system of hydro power plants on the river Neretva. In the plant are installed two aggregates with Kaplan turbine, which installed power is 2 x 58,5 MW. In the period of the year when hydrological conditions were optimal and reliable work of all aggregates in the system of hydro power plants of the river Neretva have allowed a maximal production of electrical energy, aggregate No 2 on hydro power plant Grabovica has started to behave “abnormal”. This abnormal work has manifested in the high level of vibration and hydraulic blast during the work, just after starting of the aggregate. The aggregate has stopped immediately and hydraulic pipeline has been clear out. Producer of equipment “Litostroj Power” has been informed and common expertise is shown that one of the shoulder blade has not been it the correct position. Just after that the turbine has been disassembly into parts and appropriate control is identified that connecting part between wrist pin of servo motor and shoulder blade is broken.

This accidence has been very complicated and for its reparation was needed disassembly of turbine into their parts, first time after 30 years of continual work. Because of the fact that the whole operation will last more than six months, the management is decided that this repair works should be make into general reconstruction of the aggregate no2, which should include detail control of all vital parts of turbine and replacement of all damaged parts.

2. CONTROL OF TURBINE EQUIPMENT

After detecting of the reason of inappropriate work of the aggregate no2, the procedure of disassembling of turbine into their parts is started. During this process it was possible to see many of its parts and assembly for the first time after the initial montage. Just after visual control, it was obviously that a lot of parts of equipment should be replaced with new parts. Another parts of equipment had to be controlled by the methods of non-destructive testing. This control has been done in the factory of producers for the removable parts, but some of parts had to be tested *in situ* in the hydro power plants by the experts from the Faculty of mechanical engineering Mostar.

2.1. Equipment control in the factory „Litostroj Power“

In the producers factory has been done control of the all shoulder blades of turbine. The first control has been done by the methods of magnetic particles, and by this control was detected some smaller porosity on the surface of the blade.

Figure 1. Shoulder blades of turbine with detected places for repairing

After control of the shoulder blades of turbine by ultrasonic testing it was detected some failures in the homogeneity of material and this locations are marked. The depth of these failures were different, from the surface defects till to the defects on the depth of 350 mm. Shape and dimensions of defects don’t refer that its repairing would be necessary.

Figure 2. Shoulder blades of turbine with detected places with material non-homogeneity

Before testing all the blades had to be cleaned, and places that are evaluated as the most critical for possible location of the material non-homogeneity, before testing has been polished, fig. 3.

Figure 3. Cleaned and polished blades with marked places that has been the first priority for ultrasonic testing

Ultrasonic testing detected that certain number of blades have linear cracks, which length has been between 80 and 110 mm. Propagation of this cracks in the future work of aggregate could cause the serious damage of the blades, but also to the serious damages on the other parts of the aggregate. Because of this all indicated location of the cracks have been marked and must be removed from material and repaired by the welding technology.

2.2. Testing of equipment on hydro power plant Grabovica

In the scope of the general repair of aggregate no2, some parts of equipment which were stayed in the hydro power plant Grabovica has been controlled by methods of non-destructive testing NDT (blades of stator, segments of bearings and similar parts). Visual control of some segments of turbine and parts of diffusers is shown a certain damaged areas by the cavitations. The period of the reparation of aggregate no2 is used for reparation of all these damaged elements. Usual methods for the repairing of this damaged areas is welding surfacing and for this case of repairing shielded metal arc welding (SMAW) procedure was chosen.

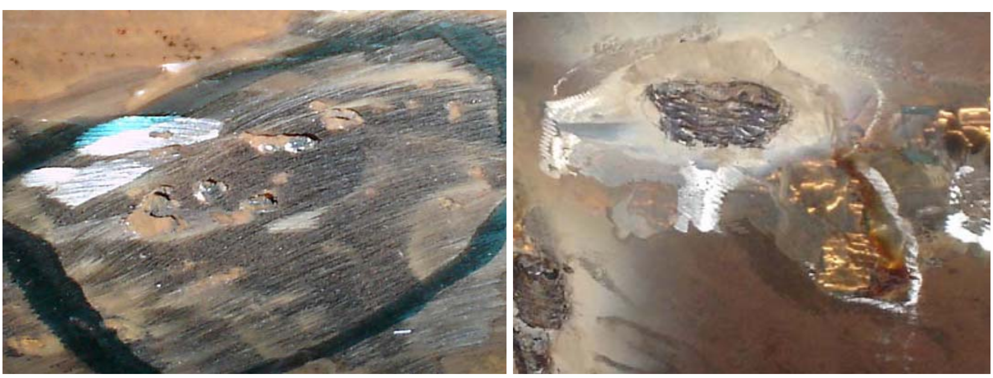

Figure 5. Marked areas with cavitations

The main influence to the filler material selection for surfacing of areas damaged by cavitations have chemical composition and mechanical properties of the base material, table 1 and 2, as well as exploitation conditions of turbine.

Table 1: Chemical composition of base material

Material	Chemical composition, mas. %							
	C	Si	Mn	Al	Ti	Cu	P	S
ČL.0501	0,35	0,5	0,8	0,1	0,1	0,25	0,09	0,06

Table 2: Mechanical properties base material

Material	Mechanical properties		
	Yield strength N/mm^2	Tensile strength N/mm^2	Toughness (DVM) J
ČL.0501	255	510	31

On the base of chemical composition and mechanical properties of the base material, the logical choice would be an electrode that will give welded deposit with approximately similar chemical composition and mechanical properties like base material. However, taking into account really difficult conditions for welding, as well as relatively high humidity, basic coated low alloyed electrode could not be appropriate choice. Because of the corrosion problems and requirements for improvement of mechanical properties of welded joints, high alloyed electrode INOX R18/8/6 Fe was chosen. This kind of electrode is recommended for the following case of welding:

- high strength steel,
- welding of non alloyed steel with stainless ferrite and austenitic steel,
- repairing of the cavitations.

Taking into account all factors it was decided that damaged areas should be repaired using shielded metal arc welding (SMAW) procedure by coated electrode. In respect to the carbon content of base material and thickness of the parts, preheating temperature is calculated in accordance to the Seferian method and it was about 250 ^{O}C. Before the welding all damaged areas was prepared by mechanical grinding. Technological parameters of welding are given in the table 3.

Table 3: Technological parameters of welding surfacing

Electrode type	Electrode diameter mm	Welding current A	Arc voltage V	Welding speed cm/min	Heat input kJ/cm
INOX R 18/8/6 Fe	2,5	100	26	10	14,4

3. CONCLUSION

In this paper are presented some of details from the really big operation of repairing of aggregate no2 on hydro power plant Grabovica. Results given from the non-destructive testing of the most important parts of turbine, and its repairing by the welding methods, should prolong working cycle of aggregate and assure all technical precondition for its safe and reliable work for the longer period. In the same time, economical reasons are considered, so it can be concluded that non-destructive testing and repairing damaged parts of turbine by welding methods satisfy both technical and economical aspects.

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