CAVITATION AND SHOT PEENING

Djozic Salko
Public Enterprise GSKG
Zagreb CROATIA

ABSTRACT

The appearance of cavitation at places where some liquids, mostly water, streams with high velocities, is very well known. On the River powerhouses many parts like dams, water gates, butterfly valves, Lap valves etc. find cavitation. It is a big problem for investors and maintenance service during operation of power house. Spiral and siphon pipe in water turbine are places to be checked during yearly inspection against Cavitation. Shot peening is a process to be taken into consideration for increasing mechanical requirements. Specially surface hardness must be adequate to resist cavitation attacks. Fig. 1., 2 and 3 shows places where initial cavitation occurs.

Fig. 1. Seal Ring with Hemispherical Bulk head

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Fig. 2. Detail of Welding joint on the seal beam for gate placement

Fig. 3. One section of seal ring with cladding steel plate as protection of corrosion
KEYWORDS
Shot peening, surface hardness, cavitation effects, dams streaming of water, velocities, water turbine, yearly inspection of spiral and siphon pipe.

1. INTRODUCTION

Appearance of cavitation in some hydraulic plants is one thing undesired. It is known that cavitation causes damages not only on metallic but as well as on concrete surfaces. It is necessary to keep in mind that it is necessary to protect such surfaces in the powerhouses on the rivers, namely. Cavitation comes as an undesired quest on the mechanisations and devices where there is flow of water. On some parts of dams penstocks, speedways cavitation is continuous. Naturally it is in big form and size if project of some such plant omits it in some calculation. In any case this phenomenon is necessary to prevent to make its pressure for causing erosion on the surfaces. To have successful protection against cavitation the remedy is shot peening. With shot peening it is possible to achieve better hardness of metallic surface and layer below surface. In ship building and sea technology cavitation is always present in the heads of staff considering as one danger very harmful for equipment which is in contact with flowing water. There is cavitation appearing that means design of such structures must be made without any possibility to create such water streaming and after commencement cavitation. Blades of rotor and water turbine, pumps, ship propellers are one of the most known areas subject to the attacks of cavitation. We have to find exactly how we can apply shot peening as a step to prevent cavitation.

Cavitation occurs when the pressure at any point in the flowing water drops below the vapour pressure of water. The relationship which produces cavitation is between vapour pressure, barometric pressure and not effective head of ten expressed by the Thoma Cavitation Coefficients in water turbine plant. For us to have exact or nearly exact data it is necessary to have investigation of the models. Such research of mechanics cavitation on damages is caused by it. This is a reason to have adequate quality material with cavitation resistance. Draft tubes are very important in power houses on the rivers in the area that is on the cavitation attacks. This material has various resistances to cavitation.

The wide range illustrates the importance of material selection with respect to life expectancy under cavitation conditions. In large power plants developments at different measurements are taken to prevent all cavitation. In many of these installations many items are prewelded with stainless steel at areas where greatest cavitation occurs. It is necessary to analyse elaborate details to find exact way of shot peening to prevent cavitation. In accordance with published literature the most preferred resistance materials for hydraulic equipment are welded or cast stainless steel 18% CR, 8% N, rolled stainless steel 18% C, 8% N cast stainless steel 14% CR, 1% N, 0.33% carbon cast steel, Manganese Bronze and Cast Iron. To avoid cavitation in draft tube it is very important to
change the geometrical dimension.

2. ESSENTIAL CAVITATION

The term cavitation refers to condition within hydraulic equipment where local pressure drops, cavities fill with vapour. These cavities collapse as soon as the vapour bubbles reach regions of higher pressure on their way through piping. Cavitation may appear along stationary parts. The reduction of the absolute pressure to that of vapour tension may be merely local. The general reduction may be produced by: an increase in static lift, decrease in atmospheric pressure, decrease in the absolute pressure in the system when pumping from a vessel and an increase in the temperature of liquid. Local decrease in pressure may be caused by dynamic means: An increase in velocity by speeding up the pump, a result of separation and contraction of flow to a sudden change in a direction of flow. The signs of cavitation are: Noise and Vibration, Drop in Head Capacity and Efficiency curves and vane impeller pitty. Cavitation conditions can also appear as a result of vibration of parts in contact with water without an apparent local pressure drop or high velocity of flow. Water is unable to follow frequency of the vibrating body and at deflection vapour filled cavities are formed which collapse on reversal.

Therefore it is necessary to know this area of cavitation, and apply shot peening with exact choice of all parameters.

3. SHOT PEENING IN FUNCTION OF PROTECTION OF ACTIVE SURFACE ON THE SEAL RING OF HEMISPHERICAL BULKHEAD

In fig. 1 is visible only one detail of water tight joint on a gate on the dam. Heavy steel structure of hemispherical bulk head is moving downwards and upwards. On the top of tower are concrete operating decks with dogging jacks for lifting and lowering hemispherical bulk head connected with chains. On the centre line on the bottom of hemispherical bulk head is installed valve assembly for discharging water during lifting of gate. In that phase water forms dam water collection flowing out. In that phase after that starts bubbling and cavitation. In the picture is visible gaskets on the seal ring. On the top of seal ring is cladding steel by stainless steel as protection against corrosion. Appearance of corrosion and cavitation is on the metallic and concrete surfaces. For this reason all round seal ring is to be treated by shot peening for stiffening and hardening of metallic surface. Shot peening is possible by hand pistols also. In the figure is indicated when lifting of steel structure commences, turbulent water streams which is the appearance of cavitation. During yearly inspection in dry it is possible to see some effects of cavitation on the peripherical area.

For this reason it is necessary to provide shot peening on all faces of bulkhead and ring. Where it is water tight joint by gasket normal steel material going in the first and second stage of concrete it must not be treated by shot peening. To avoid such cavitation it is necessary to provide shot peening of this cladding steel by stainless steel surfaces.
In fig. 2 is presented details of welding joint. On the upper plate of carbon steel is welded stainless steel plate by method of betterment. It is known in practice of welding on many work sites where comes joint carbon and stainless steel. Seal ring as steel profile is connected with many anchor bolts as visible in fig. 1.

On the bottom, C.S. plate and other embedded part is to be fixed in design position. After all measurement, welding and correction is possible to get allowance of surveyor that is in correct position and start pouring of second stage of concrete. Welding of upper and bottom plate is performed in supplier workshop and transported to the sight. All edges, surfaces during trip to the site and during local transfer on the site must be covered by plastic paper to prevent any water to enter it. Welding on site during assembly is shown in fig. 2.

In fig. 3 is an upper view of a section of seal ring coming on the site to be assembled. In this figure is presented where it was recorded the initial cavitation during streaming water. Therefore it is necessary to provide on the site some machines for shot peening by pistols. Lot of job has to be done before finishing this big structure. Special welding staff is to be instructed and educated to exactly follow welding sequence, because thickness of plates are over 100 mm. Special preheating, checking and post weld heat treatment for releasing residual stresses are becoming necessary during welding.

4. CAVITATION DISCOVERED ON THE HEMISPHERICAL BULK HEAD STEEL STRUCTURE AREA.

Hemispherical bulk head we are considering as active part because it has movements lifting and lowering by chains of this big steel structure enabling some conditions to create cavitation. Special under water lamps with camera can catch first appearance of small bubbles around whole water neck. Vibration of any part of seal ring can be because of cavitation. PH value has influence on the initial corrosion that can cause cavitation. For this it is necessary to give larger explanation but professional staff will very well understand it. In brief, fatigue of metallic material on surface ring can cause as well initial cavitation. To be in short corrosion, erosion support development of cavitation. Turbulent streaming of water is more convenient for cavitation than the laminar steaming. On the seal ring it is necessary to avoid such conditions as far as possible. Gas bubbles move and their volume increases suddenly and after that the next moment they disappear. In these bubbles on the ring there is balance between outside and internal pressures. Internal pressure is sum of many small gas and vapour partial pressures. Surface of spheroid stress in bubbles are formed. When bubbles come in area of lower pressure, balance disappears. Bubbles become larger because they fill with steam of water drops. Outside liquid in a moment comes in bubbles space. In that moment there are strong shocks on the metallic surface. Damages are visible. For certain time these shocking is continuous. It is necessary to remark that bubbles from these points don't participate in cavitation. Selection of better material and proper design of hemispherical bulk head steel structure can avoid this undesired phenomenon.
Making more resistant surfaces on the cavitation is a big task on the site before putting it in operation.

5. DISCUSSION

Author of this paper participated on the construction of many new hydraulic power houses in different countries. In many cases appearance of cavitation has been presented. Some damages by cavitation were very huge. Therefore work has been stopped for certain period of time. Cavitation caused many damages in the penstocks and dams in Pakistan and India. Effect of shot peening on the annuling or decreasing of cavitation on some contact metallic surfaces was necessary. But to have more safety operations of all hydro mechanic equipment on the power house, it is necessary to make some investigation. This is connected with making and preparing models or templates for investigation to find where is the source of first bubbles in water flow. Main power house project must have and provide on the site investigation during assembly of big pieces on the dam. Shot peening must be introduced in this phase of installation on the site in the connection of different sections of gates, seal rings, penstocks and other pipings, draft tubes, turbines and pumps.

This paper in smaller form with drawing has been published in Italy in proceeding book of second Italian National Congress for Fluidothermic Transfer some years ago in Bologna. I use this occasion to express thankfulness to the Italian Editor staff.

Author of this paper as small review of thinking: connection shot peening and cavitation, wishes to find group or institutions for further investigation.

6. REFERENCES

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