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MODIFIED SLOW TUNER DESIGN FOR CAVITY 1 INSIDE LCLS II CRYOMODULE *

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Abstract

Initial LCLS-II cryomodule testing at Fermilab showed microphonics on the furthest upstream cavity (number 1) at least factor 2 larger than on the rest of the cavities. Testing indicated that this was a difference in the mechanical support of cavity 1, not a local acoustic source. Further investigation pointed to the upstream beam-pipe of the cavity 1. The upstream cavity flange has a solid spool piece connection to the beamline gate valve unlike the other cavities, which all connect through bellows. The gate valve's weight was, in the original design, supported by sliding system (free in z-axis) connected to large diameter Helium gas return pipe. The tuner design was modified to transform the cavity 1/gate valve interface. The cavity 1 tuner arms were extended and became the support structure for gate valve, eliminating the connection to the helium return pipe. Modification of the tuner design and resulting microphonics mitigations will be presented.

INTRODUCTION

Testing of the first LCLS II cryomodules at FNAL revealed microphonics of cavity 1 (the most upstream cavity) was consistently worse than other cavities (2-8) by factor of 2-3. This was independent from the overall CM microphonics level, spanning an overall CM microphonics level of 100's or 10's of Hz [1].

For all cavities except 1, the cavity beamline flange on the tuner (upstream) side is connected to the neighboring cavity through a beamline bellows. Cavity 1 and the upstream gate valve are connected rigidly, with no beamline bellows (Figure 1). This gate valve is supported vertically by a bracket and sliding system, attached to the 300mm diameter Helium gas return pipe. This sliding system is required to accommodate thermal contractions of the 300mm pipe and cavities string in the horizontal (z-axis) direction. The gate valve acts as large backing weight on the dressed cavity/tuner system, lowering the resonant frequency of the longitudinal modes. In the machine, a beamline absorber will be connected to gate valve, adding even more mass to the cavity 1 system, and this could worsening the microphonics level on the cavity 1 even more.

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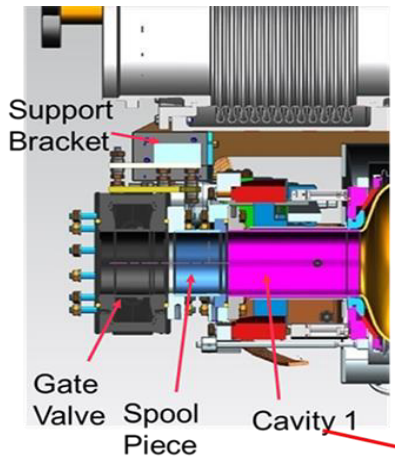

Figure 1: Picture of the "standard" interface between cavity#1 and gate valve.

CAVITY 1 MECHANICAL CONNECTION WARM STUDY

A simple setup was assembled (Figure 2) to study vibration levels for different configurations of the interface between cavity 1 and Helium gas return pipe. One LCLS II cavity and tuner was installed, mounted to 300mm Helium return pipe. The tuner's piezo-actuators were used as sensors to monitor the levels of cavity vibration versus different interface configurations. A calibrated impact hammer, equipped with piezo sensor, was used to excite vibration into the mock-up system.

Figure 2: Picture of the mock-up for warm study of the proposed gate valve/cavity#1 modifications.

Two mitigation options were tested. The integrated response of the different mock-ups are presented in Figure 3.

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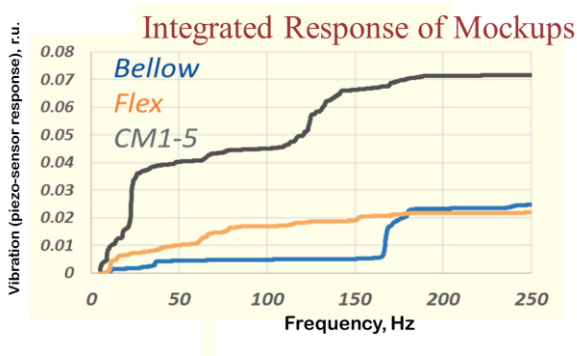

Figure 3: Summary of the warm study with cavity#1 mock-up. Integrated response when 300mm He return pipe strike with hammer.

BEAMLINE BELLOW BETWEEN CAVITY 1 AND GATE VALVE

To mitigate the propagation of mechanical vibration from HGRP to cavity 1 and minimize contribution from the heavy gate valve, we introduced a short beamline bellows between cavity beamline flange and gate valve. In order to replace the sliding bracket that supported the weight of the gate valve, we modified/extended the tuner arms (Figures 4 and 5) [2]. The extended tuner arms took the weight of the gate valve via the cavity 1 helium vessel (Figure 6). This required an additional new element, a gate valve support cage (Figure 5 and 6). This rigidly connected the gate valve to the extended tuner arms.

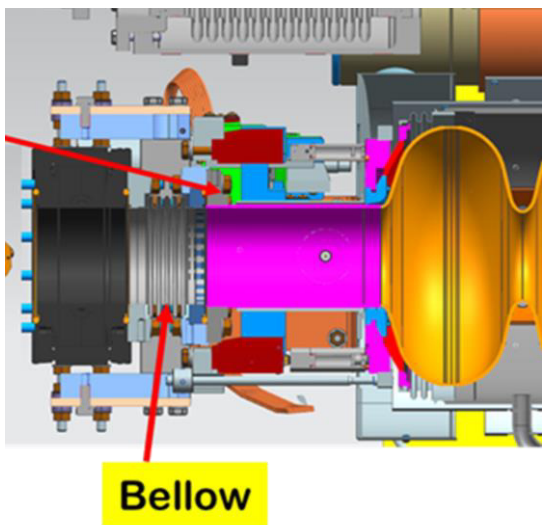

Figure 4: Drawings of the modification of the gate valve/cavity 1 interface, including short bellows introduced between cavity beamline flange and gate valve.

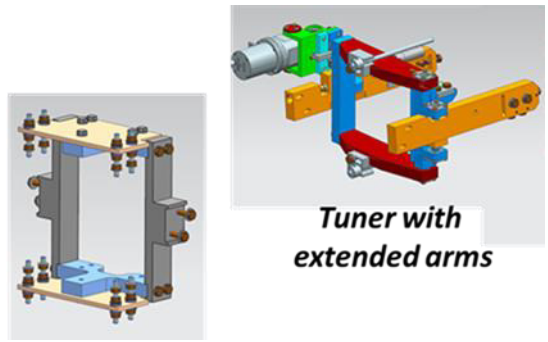

Figure 5: 3-D model of the LCLS II tuner with extended arms (right) and gate valve support bracket (left).

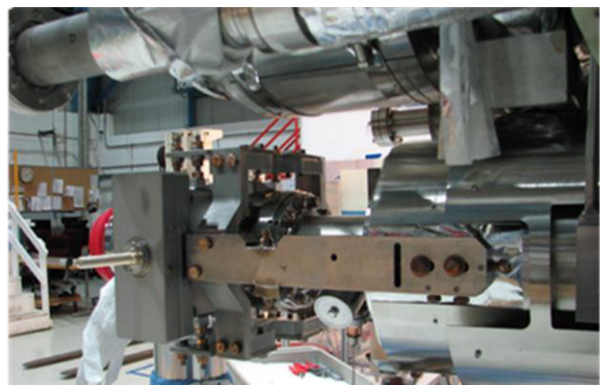

Figure 6: Picture of the cavity 1 and gate valve assembled on cryomodule 6 with bellows. Extended tuner arms attached to the He vessel of the cavity 1. The support cage is mounted on the arms and supports the gate valve.

SOLID CONNECTION BETWEEN CAVITY 1 AND GATE VALVE WITH FLEXABLE JOINTS INTERFACE.

The short bellows in the beamline need to be introduced during assembly of the cavity string into clean-room. This modification could not be employed on already assembled cryomodules. A different modification was designed that preserved the solid short spool piece between cavity 1 and gate valve (Figure 7). The same extended tuner arms hold a cage that will support gate valve. The system that supports the gate valve inside cage needs to accommodate cavity's slow tuner stroke that could be up to 2mm. Flexible joints were introduced to allow slow tuner cavity tuning to nominal frequency. ANSYS simulations were conducted to select the detailed design of the flexible joints. In the new design, the tuner system will operate against cavity plus flexible joints. To preserve the preload on the piezo-actuators below 4kN, the stiffness of the flexible joints need to be below 3kN/mm [2, 3].

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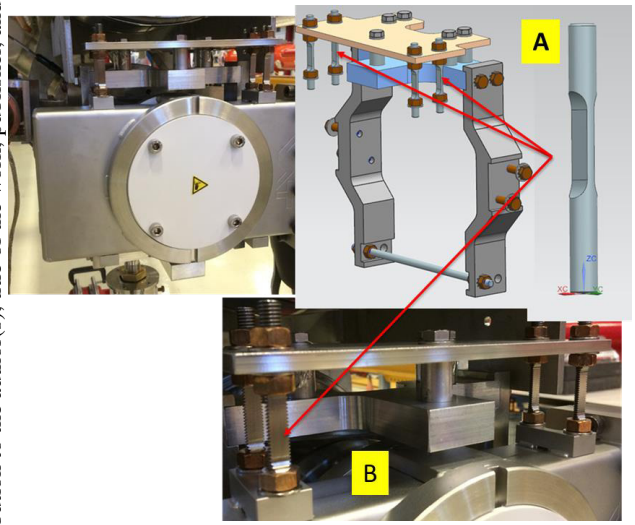

Figure 7: Tuner modification with flexible joints. (A) 3-D model of the cage to support gate valve. (B) Photo of the gate valve mounted with flexible rods.

MODIFIED GATE VALVE /CAVITY INTERFACE COLD TEST

Cryomodule F1.3-06 was first cryomodule that was built with short bellow in the beamline. Microphonics measurements on all the cavities confirmed that the modification with short bellow fixed problem. The level of the microphonics on cavity 1 was the similar to the rest of the cavities (Figure 8). During the test of F1.3-02 (no modifications), the microphonics levels on cavity 1 were a factor of three worse than the rest.

The tuner arms/support frame with flexible rods was introduced in cryomodules F1.3-4&5. Unfortunately, this flexible interface between cavity 1 and gate valve didn't made any significant improvement of the microphonics level of cavity 1 compared with the rest of the cavities. At this moment there is no explanation as to why we observed improvement when measured with the flexible configuration during mock-up testing but no improvement on the real cold CM.

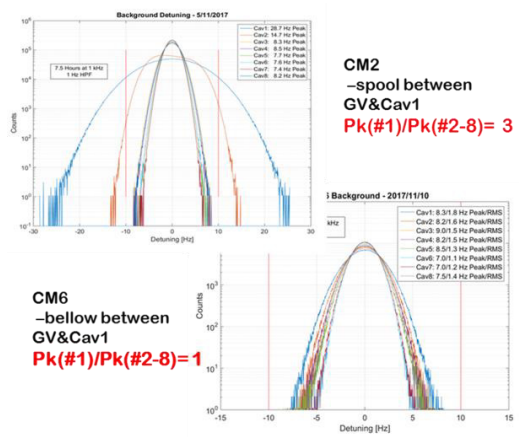

Figure 8: Microphonics measurements of cryomodule F1.3-02 and cryomodule F1.3-06. F1.3-02 had no gate valve/cavity 1 modifications. F1.3-06 had the extended tuner arms and bellow between gate valve and cavity 1.

CONCLUSION

Passive suppression of the higher (factor 2-3) microphonics on the cavity 1 was achieved by modification of the interface between the cavity 1 upstream beamline flange and gate valve. It was done by replacing the solid (through spool piece) connections on the short bellow & (2) by extending arms of the tuner to support gate valve.

A second mitigation option (supporting gate valve from tuner's extended arms with flexures and keeping spool piece/no bellow) was designed as a retrofit that doesn't require beamline modification, but it didn't suppressed microphonics as expected.

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