DEVELOPMENT OF ATLAS LINER CASSETTE POWER FLOW CHANNEL*

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Abstract

The original Atlas upper liner cassette joint was based on the Shiva Star design and were of the cryogenic interference type. The upper joint relied exclusively on the interference of the glide plane/liner interface for electrical conductivity and structural integrity. The second-generation cassette was designed to accommodate unpredictable changes in inner power flow channel z-axis geometry by fabricating the liner and liner current joint electrodes as a single piece of aluminum. Deforming a preformed section of the liner as the cassette is assembled makes a current joint between the liner and the return current conductor. Experiments have been conducted with variations of the deformable current joint designs to better understand how the materials fit together, joint configuration, tensile force associated with the joint and the reliability of vacuum integrity at the joint and the resulting shape of the liner. Laser interferometer measurements and finite element analysis are used to analyze the joint.

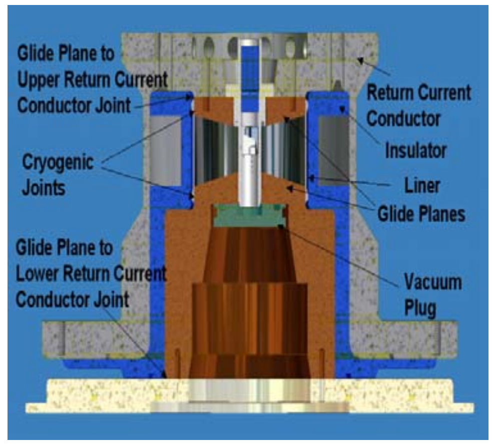

Figure 1. Old style Atlas liner cassette joint.

I. INTRODUCTION

The joints connecting the liner/glide plane assembly of the Atlas design [1, 2] are a hard bolted design that has no accommodation in the vertical direction. The cryogenic fit liner/glide plane joints of the previous design separate easily because of the Atlas power flow channel non-uniformity. These joints relied exclusively on the interference of the glide plane/liner interface for electrical conductivity and structural integrity. Slipping the liner on the glide planes accommodates deviation in the vertical direction. This displacement adversely affected some experiments. The fabrication of the glide plane/liner of the Atlas design interface could not yield predictable assembly results.

Assembly of the vacuum envelop (VE) is now a mechanically interfered joint type eliminating the cryogenic

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14. ABSTRACT
The original Atlas upper liner cassette joint was based on the Shiva Star design and were of the cryogenic interference type. The upper joint relied exclusively on the interference of the glide plane/liner interface for electrical conductivity and structural integrity. The second-generation cassette was designed to accommodate unpredictable changes in inner power flow channel z-axis geometry by fabricating the liner and liner current joint electrodes as a single piece of aluminum. Deforming a preformed section of the liner as the cassette is assembled makes a current joint between the liner and the return current conductor. Experiments have been conducted with variations of the deformable current joint designs to better understand how the materials fit together, joint configuration, tensile force associated with the joint and the reliability of vacuum integrity at the joint and the resulting shape of the liner. Laser interferometer measurements and finite element analysis are used to analyze the joint.

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fit of precision components. The upper liner/glide plane interface joint described uses wedging interference to securely join the glide plane, liner and return conductor into a strong assembly.

II. UPPER JOINT DESIGN

As shown in Fig.2, the new upper joint design utilizes a reverse taper that is reminiscent of a dovetail joint. As the parts are brought together the clearance between parts disappears and the parts are held in interference. The object of these test parts is to establish a parameter space in which the interference distorts the parts the least amount while maintaining high enough strength to perform their function.

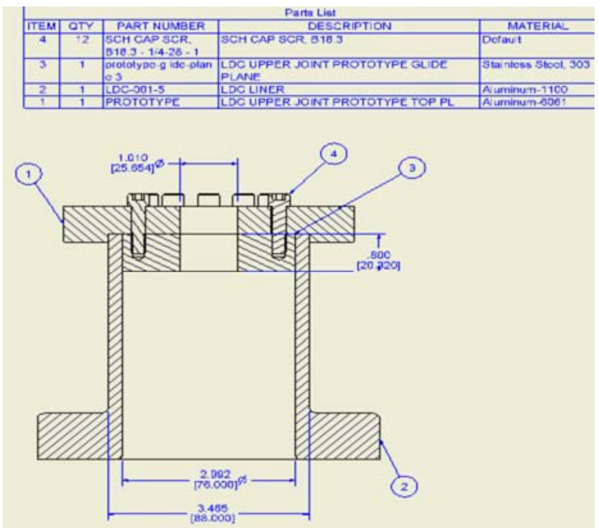

Figure 2. New Atlas upper joint design

Measurements [3] of the outer surface of the return conductor section show that the built in recess in the glide plane to return current conductor causes a substantial amount of bowing. Maximum torque requirements were established by taking measurements from the face of the return current conductor to the end of the liner. As shown in Fig.3, these readings show that a torque in excess of 50 in/lb is required to successfully assemble the part.

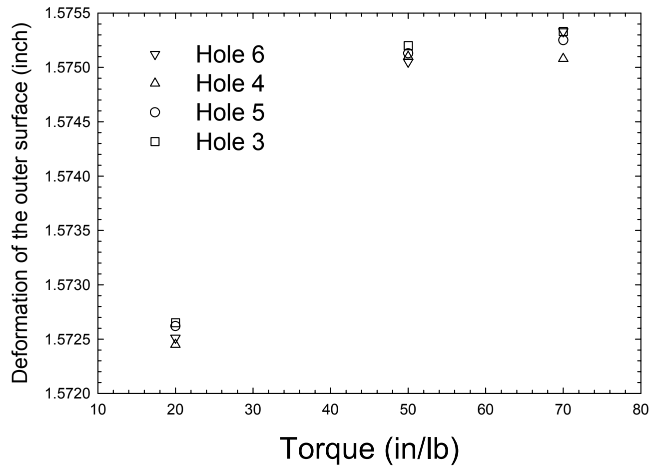

Figure 3. Distortion of return current conductor as more torque is applied

Figure 4 shows measurements made of the diameter of the liner section. The joint causes the diameter of the liner to be about 0.8 inch larger from the joint and smaller than the machined diameter further away from the joint. The design diameter was 3.4645 inch. These tests show that there is considerable distortion of the liner for some distance from the return current conductor. This distortion corresponds to the assembly clearance. Note the joint location is at *x*=0.0.

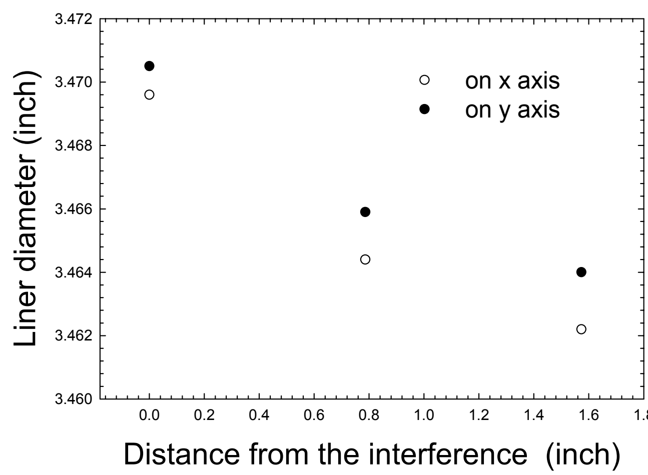

Figure 4. Distortion of the atlas liner due to interference joint

New test parts were designed using information gathered in these tests. The recessed area between the glide plane and return current conductor was removed. The groove recess for the heads of the bolts was removed. The entire liner length was replicated to determine the effect of the joint on the contour of the liner. The interference was determined to be a 0.175 inch in length. Wall thickness was varied from 0.03937 inch to 0.315 inch. The effect of a longer glide plane was investigated. As shown in Fig. 5, the effect on the liner diameter was also investigated.

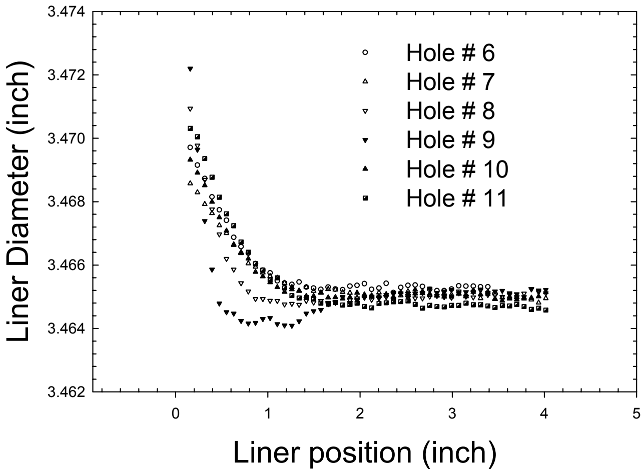

Figure 5. Distortion of the liner diameter as a function of liner position caused by the interference joint

Liner wall thickness was also investigated for it's effect on the distortion caused by the joint. Distortion for the liners of 0.23622 inch and 0.314961 inch was 0.001575 inch larger than the machined diameter at the end of the glide plane (0.623031 inch). The distortion for a 0.11811 inch wall thickness was 0.000472 inch larger and for a 0.03937 inch wall thickness the distortion was 0.00122 inch smaller. This data shows that the new design has an insignificant effect on the liner shape near and around the return current conductor.

III. FINITE ELEMENT ANALYSIS

The finite element program ANSYS® is used in assisting designing targets and target systems. Using computer simulation allows the system designing and optimization to be more streamline with better diagnostic clarity. As a result, the material cost and response time of designing and optimization have been dramatically reduced. As shown later, a better understanding of the system is achieved by using this finite element analysis (FEA).

A joint made of steel and aluminum parts is deformed under pulling forces. The outstanding questions need to be answered are: 1) What is the limit of the force causes the material failure or structure rupture; 2) What is the force and deformation relationship; and 3) What is the maximum stress experience by the joint. As shown in Fig. 6, FEA is used to answer those questions.

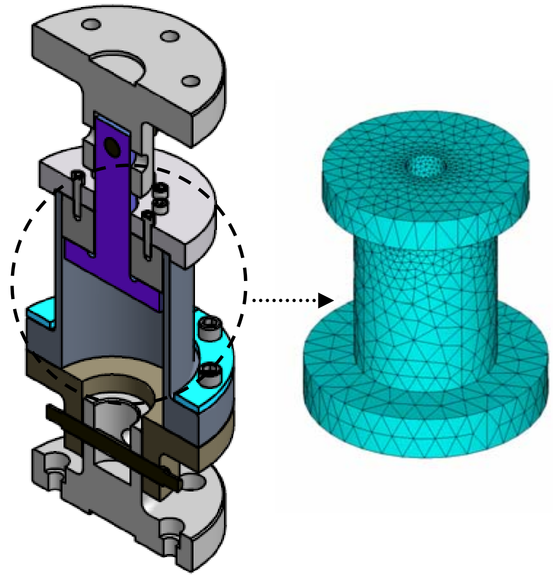

Figure 6. FEA analysis for upper Joint

Figure 7 shows there is a linear relationship between the force applied on the joint and the maximum deformation. The maximum deformation is the distance that the steel travels under the pulling force. The upper joint can sustain over 22,000lb pulling force which is the limit of the pulling machine used in LANL. Note there is a discontinuity in the deformation when the pulling force is above 10,000lb. This discontinuity is associated with the maximum stress experienced by the joint, which is shown in Fig. 8.

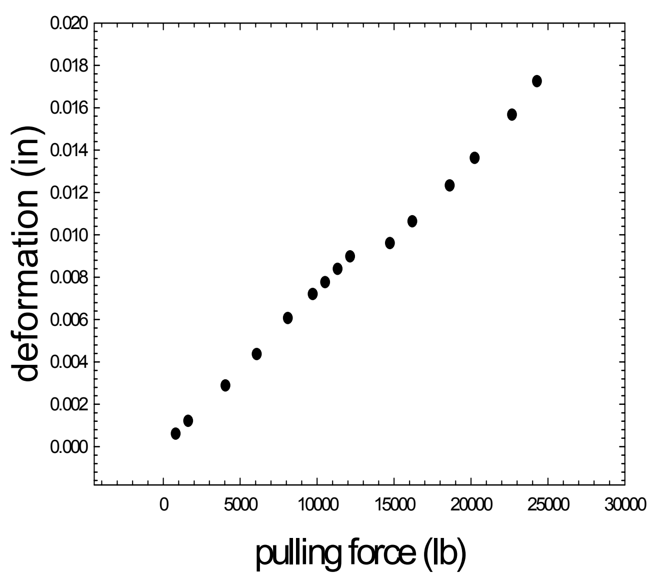

Figure 7. Maximum deformation varies linearly with pulling force.

In the system designing and optimization, it is important to know the maximum stress experienced by the system and its location. As shown in Fig. 8, FEA gives the value of maximum stress and its location. Moreover, the relationship between the applied pulling force on the upper joint and the resulting maximum stress is also shown in Fig. 8. Combining Fig. 7 and Fig. 8, it can be seen that when the maximum stress is above aluminum yield stress, there is discontinuity in the maximum deformation.

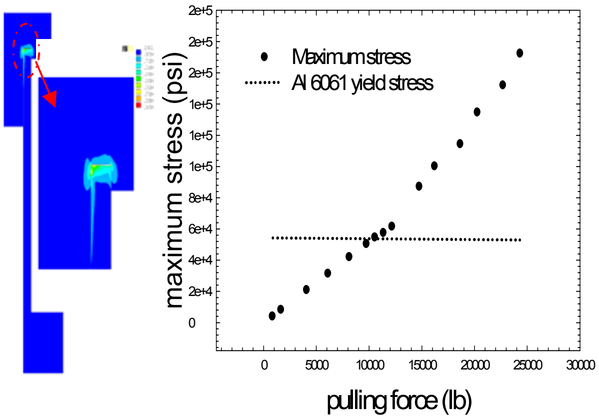

Figure 8. Maximum stress is a function of pulling force.

IV. CONCLUSION

The second-generation Atlas liner cassette joint accommodates unpredictable changes in inner power flow channel z-axis geometry by fabricating the liner and liner current joint electrodes as a single piece of aluminum. The effects of interference are investigated both experimentally and numerically. Finite element analysis in conjunction with experiments provides a way for a faster, cheaper, and better design and optimization.

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