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Design proposal of high temperature Coupling Redundant Latch Length

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Abstract— **The prime function of a machined coupling is to hold the connecting ducts together along with no leakage at the operating conditions. However, when the pressures are raised to proof pressure levels as defined per SAE AS1895 Rev D, which is 1.5 - 2 times of the operating pressure, very limited volume of leakage is permissible. When a case of burst pressure arises which is 3 times of operating pressure, per the SAE AS1895 standard defines that the coupling should withhold the two ducts with partial failure. The redundant link serves this purpose. The length of redundant link slot controls the leakage in case of an eyebolt or nut failure. The study proposes an optimum length of the redundant link slot inorder to have reduced leakage withholding structural integrity of the redundant link.**

Index Terms— **high temperature; coupling; redundant latch.**

I. Introduction

V-Retainer Couplings provide an economical and proven method for joining ducts, tubes, filters and other closure used in high-temperature and/or high-pressure pneumatic mechanical applications. They provide substantial savings in congregation and maintenance related costs—especially when the connection requires frequent assembly and disassembly. Comparing the V-Retainer Coupling with costly to manufacture and difficult to assemble bolted flanges and welded joints, are with only one or two bolts to fasten and can be easily assembled even when very limited access is an concern, or when a undersized envelope is specified. It has been observed that in case of eyebolt or nut failure when the redundant link connects the two retainer, the leakage is very excessive and the force generated would be adequate to shear the pin rivet.

The study aims at optimizing the coupling component geometry control inputs of the Redundant Latch System and their impact joint leakage. With analytical calculations, the optimum length of redundant latch to avoid joint rupture is determined.

The redundant latch has the following functions:

1. Maintain joint integrity in the event of a bolt or nut failure.
2. Minimize flange gap leakage rate of 36 SCFM in the event of a bolt or nut failure.
3. Aids in the installation procedure securing the retainers around the flange pair.

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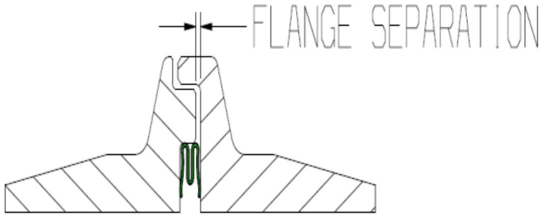


Figure 1: Flange separation in a rigid joint

II. Product Design

The function of a coupling in a rigid joint is to draw a pair of flanged ducts together. This is achieved by a wedging effect of the v-channel of the coupling on the face of the flanges. As the Eyebolt is tightened it results in a tangential (hoop) load on the coupling retainers to create an inward radial force. This inward radial force acting on the ramp angle of the flanges results in an axial clamping force. The coupling assembled with the Eyebolt on one side with either a similar bolt or a mass of connecting links on the other side. The redundant link is a redundant load path that is intended to keep the retainer on the flanges in the event of Eyebolt failure.[1]

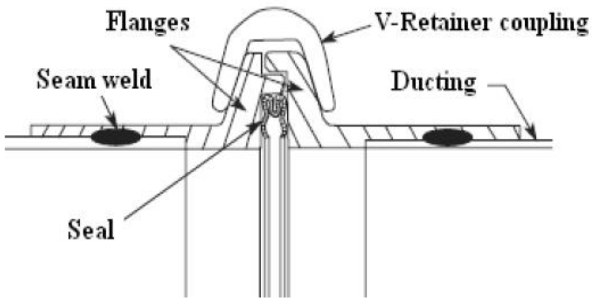


Figure 2 : Cross section of a Rigid Joint assembly

The flanges (coupling contact surface or conical feature) convert the radial forces resulting from the coupling hoop load into axial forces, which draw the flanged ducts together. The 20º angle of the flange V-face is an industry accepted standard and aims to maximize the axial preload on the duct within the range of economical machining tolerances. All the system loads will be transferred by the connecting ducts through the flanges on to the coupling. The coupling generally consists majorly of a pair of the V-channel grooved retainers, connecting links, a rivet pin, an eyebolt, a redundant link and a saddle washer. The load transfer path can be described as the circumferential load from the flanges is transferred to the coupling retainers which inturn exert radial force. The load is transfer via the rivet to connecting links and then back to the rivet and then coupling on the connecting link end. On the other side the load moves via the pin rivet to the eyebolt and is counter balanced by the threaded nut torqued on the eyebolt.

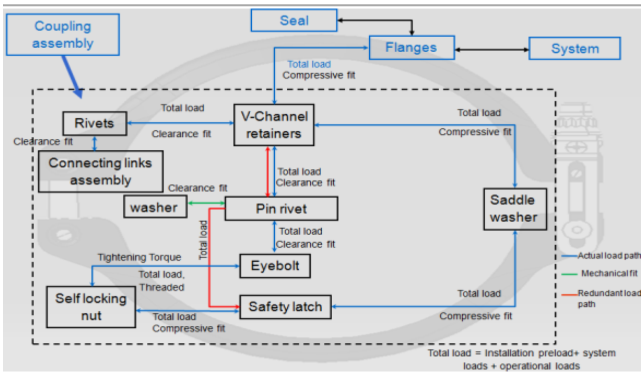


Figure 3 : Load transfer diagram in a coupling

The load transfer path can be represented by the above diagram. Consider the red highlighted load path which will be engaged on failure of the redundant link. The total load will be transferred via the pin rivet from the bottom retainer to the redundant link which rests on the saddle washer connecting the top retainer. Thus the redundant link holds the two ends of the retainers together in case of eyebolt or nut failure.

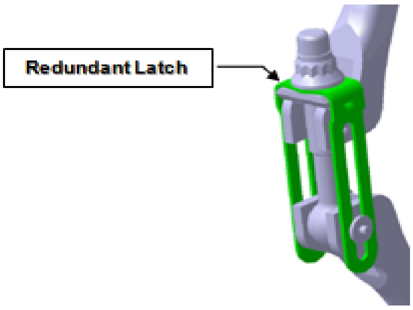


Figure 4 : Redundant latch in a coupling

$$F(h) = \frac{A_W}{2\tan\Phi} + \frac{F_s}{2\tan\Phi} + S_w + constant$$

$A_W = 70°$

Φ = *Apex width tolerance*

F_s = *Flange separation*

S_w = *Saddle washer*

constant = *takes up tolerance stackup of other geometry not considered*

III. Proposal for Reduced Length of the Latch Slot

When a Coupling is installed over max flange profile, the redundant link slot length plays a crucial role in installation and uninstallation of the coupling. With the dimensional constraints per SAE AS1895,the figure below dictates that the surplus length of the slot for installation and uninstallation of the redundant link over the retainer the slot length of the present design is .200 inches which can be further minimized by .100 inches.

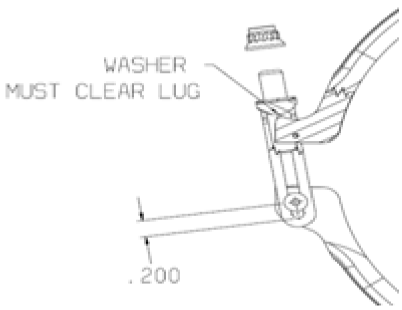


Figure 5 : Minimum latch length required for latching

Thus, the total length of the redundant link should be reduced from 1.960 to 1.860 keeping the slot travel the same.

$F_{st} = \tau * A$

F_{st} = *static force to shear (lbs)*

τ = *shear stress (psi)*

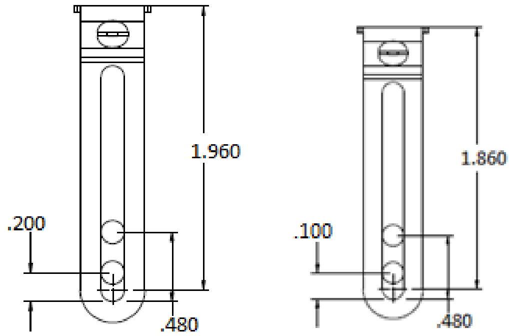
A = *cross sectional are* (in^2)

$F_{st} = \tau * A$

F_{st} = 980.6 *to* 1073 *lbs*

Rivet in double shear,

$\therefore F_{st}$ = 1961 *to* 2146 *lbs*



2.1 Impact Shear of Cross Pin Rivet

$$F_e = W\left(1 + \sqrt{1 + \frac{2h}{\delta_{st}}}\right)$$

h = *slot travel*

W = *theoretical weight of impact*

δ_{st} = *static deflection after impact*

F_e = *equivalent static force to produce deflection* δ

The static force to shear is set to the impact for shear

$F_{st} = F_e$

Thus with values per SAE AS1895 the present value of the redundant latch travel can be computed with a stackup.

Geometry	Nom DIM	U_{SL}	L_{SL}
Apex Width Tol	0.0025	0.0025	0.000
Flange Separation	0.0085	0.017	0
Saddle Washer	0.225	0.215	0.235
Constant	0.262	N/A	N/A

Redundant latch Travel	**0.481**

Constant included to account for noise factors in the coupling design

IV. Validation of the Proposed Length of Latch

Using F_e from the previous calculation δ_{st} was determined. The froce was an input condition for ANSYS simulation. Assumptions:

- All deformation in redundant latch system is due to deformation of the cross pin rivet which leads to shear.
- Force is applied to redundant latch at the same time in downward direction
- Room temperature Material properties
- Cross sectional area at A is at minimum

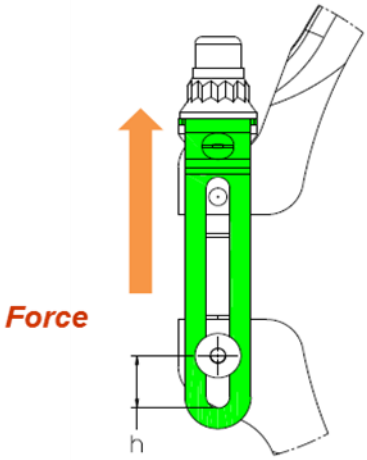


Figure 6 : Force generated in the latch when the coupling is loaded

Thus as above figure shows that the latch will be induced to pull from the above direction and will inturn induce a reaction force in downward direction. Thus applied a reaction force in the downward direction for studying stress plot.

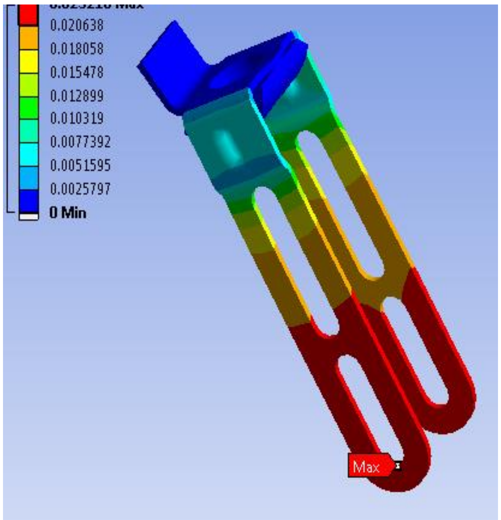


Figure 7 : Stress plot in the latch when the coupling is loaded

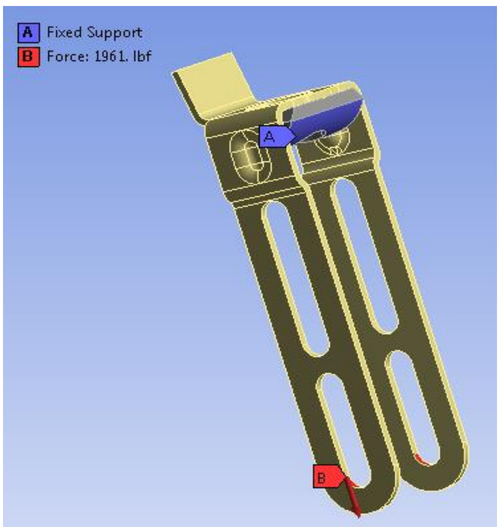


Figure 8 : Force generated in the latch when stresses are applied to the latch

$Total\ latch\ deformation,$

$\delta_{st} = .023\ inches$

$$W = \frac{F_{st}}{\sqrt{\frac{\delta_{st} + 2 * h}{\delta_{st}}} + 1}$$

Where,

$h = slot\ travel$

$W = theoretical\ weight\ of\ impact$

$\delta_{st} = static\ deformation\ after\ impact$

$F_{st} = equivalent\ static\ force\ to\ produce\ deflection\ \delta$

$W = theoretical\ weight\ of\ impact$

$Solving\ impact\ equation\ for\ h$

$$h = \frac{2F * \delta_{st}(W - .5(F))}{W^2}$$

$\therefore h = .481\ inches$

Considering the variation in the dimension and the manufacturing process to be 3 sigma, the standard deviations are per the SAE AS1895 specification.

V. Conclusion

This study is very effective in managing the risks and technical aspect of the latch design. The outcome of the analysis closely resembles the production data per the standards. The project provided a limiting factor to shoot for in production couplings 6.0 inches and above. The study proves that if we change the length of redundant latch from 1.960 to 1.860 keeping the slot length constant to .200 the problem of removal of latch gets resolved.

With the study carried out, the further recommended actions for study are to re-run the analysis with more variables and simulate the flange separation variation using varying length of redundant latch. This exercise will explore chances of optimization of weight and further design which is very beneficial for aerospace industry.

References

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