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Design and Analysis of Hose Clamp

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Abstract

A hose is attached to and sealed off of a fitting such a barb or nipple using a hose clamp, hose clip, or hose lock. This study examines the relationship between experimental results and theoretical models to analyse the bending stress in hose clamps. in the experiment, stiff cylinder was encircled by flat section band clamps, and strain and related displacement were measured. To steadily increase torque till failure, the clamp nut was tightened. The theoretical torque value and the torque obtained from FEM analysis are compared and further analyzed to prepare the hose clamp.

Keywords: *Bending stress, section band clamp, rigid cylinder.*

1.0 Introduction

Hose clamps are frequently used to join parts such tubes, hose, duct, pipes, rigid flanges, and other machinery. Outside of the aviation sector, turbochargers were one of the first products to incorporate hose clamps in high-quality manufacturing. The band becomes more taut when the clamp nut is tightened. When the band is wedged onto the flanges, an axial load is created that can seal the joint and enable it to withstand applied rotational and bending loads. Despite their wide use in industry, there is tiny, or no guidance given regarding the relationship between the torque applied to the clamp nut and the resulting stress distribution in the band. Most manufacturers based their designs on empirical equations [1]. The limitations in such equations is associated with obtaining accurate experimental data over a wide range of design variables. Lin and Cole also identified the stiffness of the clamp as a key variable in their dynamic analysis and stated that stiffness values presented by the manufacturers were inaccurate. The difficulty of using clamps of this type were recognized. Installed clamps are sequentially loaded and tapped around the circumference to assist creating a consistent internal circumferential force. It is also suggested to monitor this force using a variety of strain gauges. In order to avoid this complicated and time-consuming procedure [2]. A clamp mechanism that uses an abnormally rigid band that is efficiently shrunk onto the interface flanges is proposed. Complexity of band behaviour and the poor knowledge about such joints is the basis of their installation procedure. Within this field have recently proposed a theoretical model that recognizes the variation of circumferential the force around such joints [3]. According to this model, the clamp will be made up of a distinct band and a few small, identifiable parts. As a result, this model and the recently proven at band model are highly similar. The Takeuchi-Onoda model incorporates the coefficient of friction to account for the impact of the section angle's magnitude. This parameter therefore must be determined by tests on clamps of the type to be used and is not transferable to other clamps. By applying the necessary radial pressure to the flexible joint component, the flat section band clamp serves to create a seal between the components. The tightening of the clamp's nut results in the application of

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radial force on the components due to increase in tension in the band. The resulting fictional force between the band and the components provides necessary clamping action. However, if the tension band is excessive it results in failure of the band. There is no code of practice or standard available for the design of flat band clamps and because of the competitive market manufacturers tend to keep the information confidential. The majority of manufacture base their design on experience. There is no published work that will provide the knowledge for rational design of band clamps.

2.0 Methodology

We begin by getting the engine manufacturer's design specifications, then build the component using CAD software and do CAE analysis utilising hyperworks tools. If there is mismatch between the design requirement and results then make modification as per condition, then manufacture a final product. Then, in order to ensure its sustainability, we conduct a fatigue life cycle study utilising CAE software.

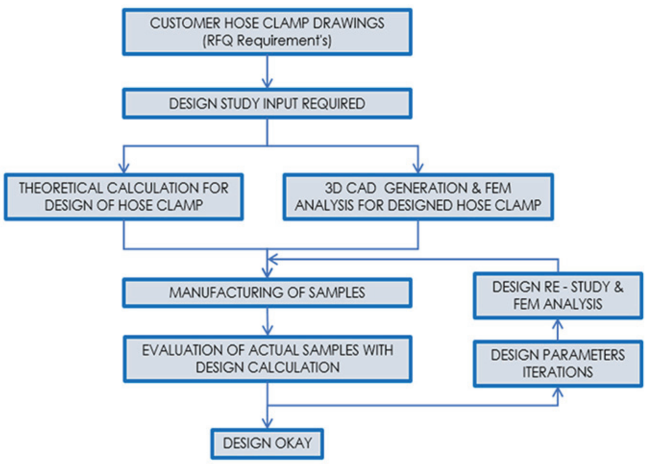

Figure 1: Methodology

3.0 Design Calculation

The force (F) is applied on both clamps to increase the OD from radius ($R1$) to radius ($R2$) final stage. Due to applied in the force the center at yellow portion will act as the neutral axis where the moment (M) is generated.

The applied load and the strain energy is predominantly due to bending of the band. From the figure resolving the horizontally and vertically force the equilibrium condition is given below:

N= **Fh** cosØ + **Fv** sinØ

V= - **Fh** sinØ + **Fv** cosØ

The bending moment M, at any cross-section w.r.t. neutral axis of the band is given by:

M = [**Fh** (cosØ–cosʒ) + **Fv** (sinØ+sinʒ)]

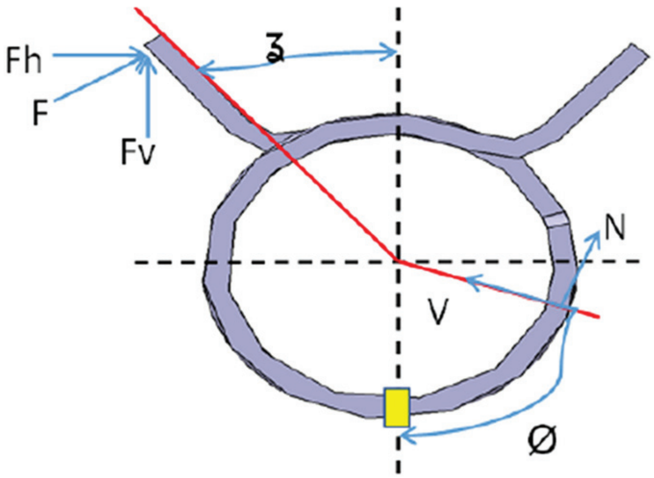

Figure 2: Design of hose clamp

The clamping force in the initial stage F, and the displacement in the band is given by Castiglione's theorem. Since the strain energy due to shear and axial load is small compared to the bending moment hence neglect the axial and shear load. The displacement horizontal and vertical is given by:

δh=(**Fh*R23**/EI)*[β(1/2+cos2β)(3/4*sin2β)]

δv=(**Fh*R23**/EI)*[(3/4cos2β)cos2β+0.25+(β/2*sin2β)]

Stress distribution in the band can be calculated using the simple straight beam bending theory. Since usually the ratio of radius to depth of the band is large. The straight beam theory is applied to calculate the bending stress.

Bending stress(**σB**)=(Et/2***R22**)[(δh(cos2β+cosØ)/(δ(1/2 + cos2β)(3/4*sin2δ)]

4.0 CAD Model

The 3D model will be generated by using CATIA V5 software, at the beginning an axis is choosen and using the commands available on the platform a model is created through CATIA workbench and necessary operations are performed on the designed part as per the requirements.

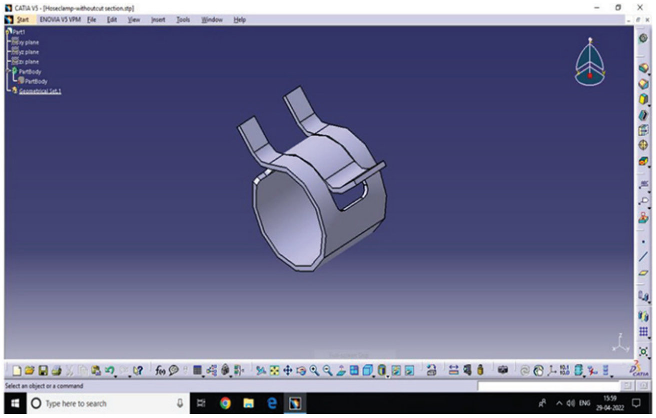

Figure 3: CAD Model

5.0 FEM Analysis

For stress analysis, meshing operation was performed through Hypermesh software and the resulting model was imported to ABACUS CAE for the generation of stress analysis. The resulting stress in the hose clamp is as shown in the Figure 4.

Elements which observe high stress are observed in red and intermediate elements are ranging in shades of green and blue being the elements experiencing comparatively minimum stress.

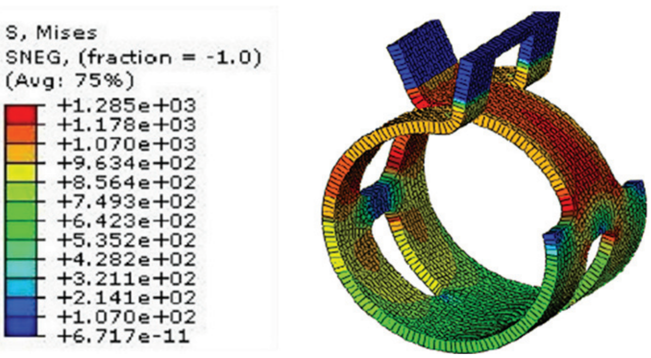

Figure 4: Stress analysis of hose clamp

6.0 Result and Discussion

During design study, we have found out various design parameters like axial load, shear load, bending moment, horizontal displacement, vertical displacement, bending stress and stress induced and at different loading and boundary conditions.

We were able to compare both theoretical and FEM results and the resultant values are mentioned below.

Analytical method: We used the bending stress design formula, and the result obtained was 1216.7 Mpa.

Numerical (FE Method): We have designed the hose clamp as per the customers drawing parameters and the resultant stress through analysis was observed to be 1285 Mpa.

7.0 Conclusion

We have calculated all the design parameters required for the CAD modelling using the input parameters. Then, we create a FEA model of the hose clamp according to the work or design layout. Later in the FEA analysis stage, we create a meshed model of the shoes clamp for further analysis stage

After successful completion of all the procedures for design of hose clamp, we got to know that the resultant bending stress in the calculation and after FE analysis are almost similar in resultant values considering the same methodology and experimental procedures used for calculation as well as for designing of model.

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