Modelling & Analysis of Single Ferrule Compression Tube Fitting

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Abstract - A single ferrule compression tube fitting fails due to various parameters which affect the ferrule tube fitting performance. To improve the performance of ferrule tube fitting, a new ferrule is manufactured with revised configuration. There is no standards available for ferrule, so it is manufactured with the help of available standard of other assembly component. The ferrule tube fitting is used in high performance applications so, it has to be manufactured precisely. In present work, 316SS material with the following dimensions is used for analysing: Outer diameter of tube 1 inch and wall thickness 0.066 inch. Modelling and finite element analysis of ferrule is carried out with the help of SOLIDWORKS 2014 and ANSYS WORKBENCH 14.5.

Keywords: Ferrule, Compression fitting, FEM, Swaging

I. INTRODUCTION

Ferrules are an incredibly versatile and diverse component that is common throughout manufacturing items in fittings. Ferrule tube fitting is used for high pressure application and manufactured for nuclear, chemical, oil & gas, hydraulic industries etc. The single ferrule design with the spring-like action of the ferrule during make-up compensates for the variation in tubing materials, hardness and thickness of the tube wall to provide leak-tight connections. Tube fittings assembly consist of three precision-machined components: body, ferrule and nut. While swaging it becomes four part fitting assembly with the addition of tube. Single ferrule is integrated by double ferrule. The single ferrule compression fittings offers the same effectiveness as double ferrule compression fitting but, the added benefits of simplicity and ease of use reduces the manufacturing cost and number of components; thereby easy to handle.

A. Ferrule functionality

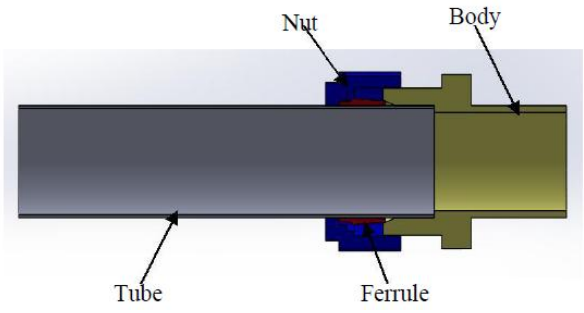

Fig.1 Fitting assembly

The Body has a threaded outer surface and an conical mouth with an angle of 20° where the ferrule rests. The inner diameter of body is slightly more than outer surface of tube so, it gives a smooth fit. The Body has a shoulder on inner surface were the tube rests which gives limition to the depth of insert. The nut is engaged with the body; torque is applied to the nut while assembling, the ferrule rests on the conical mouth of body and is compressed on the tube which makes a swaging process.

II. LITERATURE

James L. Smith, is the inventor of the device which is provided for sealing an inner tube and an outer tube without causing any deformation into them. This device consists of two ferrules which mates to form a vacuum tight seal between the inner and outer tube.[2]

H. Max Loy, Jr., has invented the assembly which consists of a male member connected to a ferrule and interlocks with the nut and freely rotates within the same. The number of parts handled is greatly reduced due to the interlock. This eliminates the need for ferrule and nut to be of the same material and also reduces the possibility of flow restriction or tubing deformation associated with the rotation of the ferrule.[3]

Yves Gamache, has invented a tube fitting component which has a body including a cavity for receiving the tube end and the ferrule. The cavity is defined by an inner lateral wall which opens on an extremity of the body. There is a pilot receiving section inside the cavity along with a channel connecting the cavity to another portion of the body. Pilot is the name given to the tube end which extends beyond the ferrule. A radial annular flange is located at the interface of the pilot receiving section along with the channel. The flange has a sealing lip protruding towards the cavity, this advantageously reduces dead volumes within the fitting components.[4]

Changxiang Xu, researched a tube fitting with either single or double ferrule swage design common in one system. It provides tube swage connection design with two coordinate tube-swaging motions which are separated and in succession, not interfered with and different from each other; the smooth-swaging motion realizes the sealing connection and the depression-swaging motion realizes the fastening connection.[5]

III. THEORY & APPROACH

A. Design consideration

i. Application

With the help of working pressure the tube fitting, dimensions of tube O.D. & wall thickness is selected. As per standard, pitch of the thread is selected which gives the required torque in swaging operation.[1]

ii. Material

As per the application and working environment the material is selected. The different types of materials used are Brass, Stainless steel (Type 316), Aluminium, Steel, Monel, Inconel etc. Most commonly used material is Stainless steel Gr. 316 which is suited for high pressure application & provides resistance to corrosion.[1]

iii. Standard

Tubes are selected as per ASTM A276 standard. The standard specifies the material, hardness and wall thickness.

B. Simulation Approach

The fitting assembly is modeled as per standard. According to the dimension of fitting assembly the performance is varied which is why some dimensions are non-standardized and can be selected as per the mating component sizes.

i. 3D model

The solid modeling and assembly is done in SOLIDWORKS 2014. The model of the fitting assembly: Tube O.D. = 25.4mm, Wall thickness = 0.066inch & length of ferrule = 12.6mm.

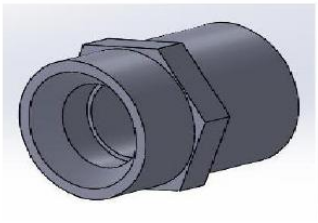

Fig.2 (a) Connector

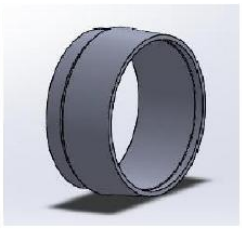

Fig.2 (b) Ferrule

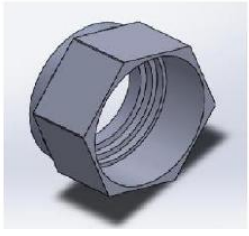

Fig.2 (c) Nut

Fig.2 (d) Tube

ii. Material model

The fitting components are manufactured using same material 316SS. In this tube fitting we have considered that the tube is made of regular SS316 material grade and thus has the least hardness as per standard and the elastic modulus selected is 100GPa, after the tube comes the body and nut which have a fairly increased hardness then the tube thus, its elastic modulus is selected as 200GPa and finally the main component i.e. ferrule must have even greater hardness then the rest of the fitting to withstand load and deliverance for which its elastic modulus is kept at 220GPa respectively.

The other properties are same for all components i.e. poissons ratio is 0.3, yield strength is 205MPa, tensile strength is 515MPa, friction coefficient is 0.557. The plasticity is assigned to the material using stress-Strain Curve.

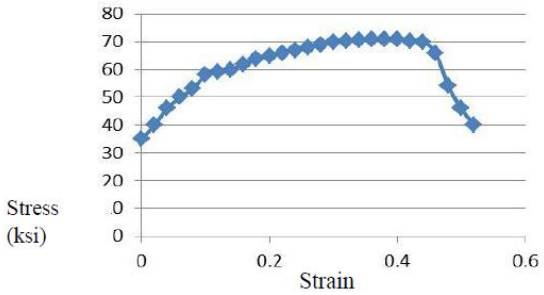

Fig.3 Stress-strain Curve for SS-316

iii. Mesh generated on the model

Mesh generation was performed in Static structural with fine element size. The nodes are 43763 and the elements are 13541 on the fitting assembly.

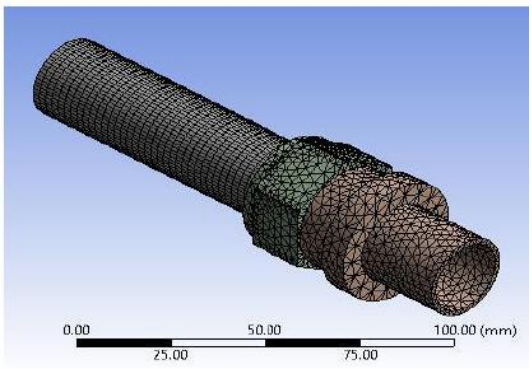

Fig.4 Mesh generation model

v. Connections

Contacts between the surfaces are carried out by connections. The different types of contact regions are - No separation, Bonded, Frictional, Frictionless, Rough and Forced Frictional Sliding.

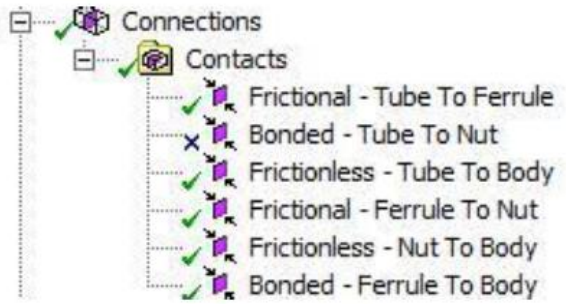

Fig.5 Contacts surface

iv. Boundary condition

In the swaging operation, torque is applied on the nut gives the the linear transformation on the ferrule. To complete the tighting of the nut for getting the perfect sealing the nut should rotate to one quarter turn. So, the displacement of the nut is applied.

The other end of body is fixed as boundry condition.

Displacement = One and quarter turn x pitch

= 1.25 x 1.27

= 1.58mm

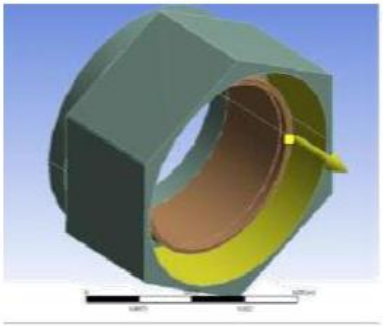

Fig.6 Displacement

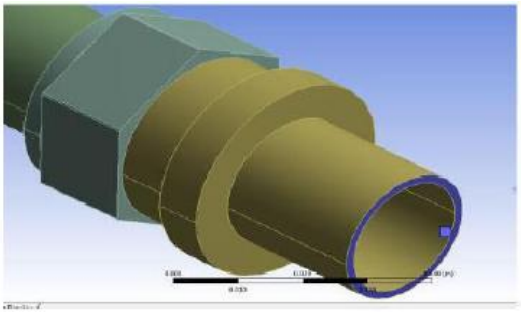

Fig.7 Fixed Support

C. Result & discussion

Stage I

The ferrule has to compress the tube for proper swaging process. But the ferrule bites the tube and maximum stress is observed on the ferrule.

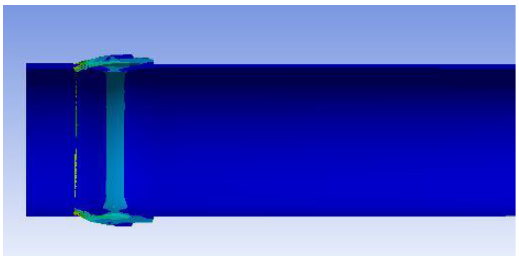

Fig.8 Ferrule bite the tube

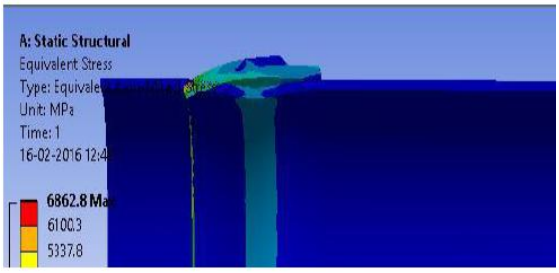

Fig.9 Maximun Von-Mises stress

Stage II

The ferrule is compressed on maximum area of tube with medium range of stress. By changing the configuration of ferrule and its elastic modulus property, the compression function is therefore satisfied.

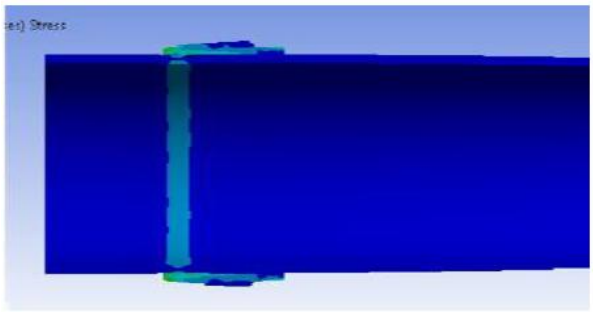

Fig. 10 Deformation of ferrule

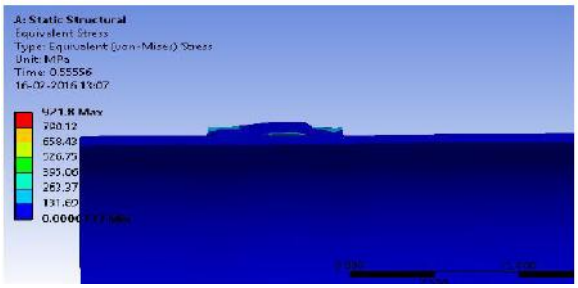

Fig.11 Von-Mises Stresses

IV. PROPOSED FUTURE PATH

By changing the configuration of ferrule the mechanical properties of the fitting can provide more relevant values then the present work. The present model fullfils the criteria of compression. But for the performance of fitting analyzing is carried out in CFD of ANSYS.

Geometric and Metallurgy parameters are more important parameters for the performance of fitting. Design of Experiment is carried out in ANSYS design exploration by changing the parameters to get the regression equation which helps to optizime the parameters..

For the performance criteria we need to carry out two different tests.i.e. Burst pressure test and Leak proof test. Thus testing can also be done CFD in ANSYS.

REFERENCES:

[1] Parker Hannifin Corporation-Catalogue 4230/4233

[2] United States Patent Number: [4,458,927]"Ferrules Seals" James L-smith, Lemont, 111, Jul 10,1984.

[3] United States Patent Number: [US 7,316,777 B2] "Compression fitting nut with interlocked ferrule" H. Max Loy, Jr., Houston, TX (US), Jan 8,2008.

[4] United States Patent Number:[US 8,573,653 B2] "Fitting Component, Ferrule And Nut" Yves Gamache, Adstock (CA), Nov. 5,2013.

[5] United State Patent No.: [US 2010/0102554 A1] "Tube Fitting with either Single or Double Ferrule swage design common to one system" Changxiang Xu, Apr. 29, 2010.

[6] R.K.Blandford, D.K.Morton, S.D.Snow, T.E.Rahl, "Tensile Stress-Strain Results for 304L and 316L Stainless Steel Plate at Temperature" 2007 ASME Pressure Vessels and Piping Division Conference.

[7] http://instrumentationtubing.blogspot.com/2012/12/130-tube fittings.html Types of tube fittings

[8] W.R. Shipway, "Forensic Investigation Of Compression Fitting Failures" Brunel University London, Sept 2011.

[9] Huei-Huang Lee,(June 1, 2012)"Finite Element Simulationwith Ansys Workbench 14" , Schroff Development Corporation, 10-37, 328-349, 415-452, 520-592.