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Design, Manufacturing and Analysis of Crimping Machine Tool for a Hose Pipe in Cooling Assembly

Mr. Abhishek I. Thorat
Post Graduate Student, Mechanical Engineering Department,
Pimpri Chinchwad College of Engineering
Pune, India
thoratabhishek25@gmail.com

Mr. N. Vivekanandan
Assistant Professor, Mechanical Engineering Department
Pimpri Chinchwad College of Engineering
Pune, India
n.vivekanandan@pccoepune.org

***Abstract* — This paper deals with design, manufacturing and analysis of crimping machine tool. Crimping is used for joining metal and non-metals. The crimping depends on the proper working of crimping machine. Thus the proper design is necessary to increase the performance and productivity of the machine. The crimping is used in an automobile hydraulic system such as refrigeration system and braking system. The main aim is to design and analyze the crimping machine tool for the different outside diameter of ferrules. The single set of die is used for crimping various diameters of ferrules. The numerical analysis of impression of the die on ferrule is done. The pullout test is carried on universal tensile testing machine for hose pipe crimp joint.**

Keywords—Crimping, hose pipe, ferrule, universal tensile testing machine.

I. INTRODUCTION

The crimping is joining of two materials by deforming one material on other. Crimping is used to crimp hydraulic hose pipes of various diameters. In order to increase the crimping machine productivity and performance the proper design is very essential. The crimping machines performance depends upon the behavior of its operation. The main aim is to design of crimping machine working condition. We can crimp different diameter size of ferrules using crimping machine. Crimping is mechanical assembly operations, which do not require additional joining elements. The main advantage of these processes is that they do not require any pre-processing or post-processing since there is no heat distortion involved.

The crimping quality is critical to the final performance of the assembly, which can be evaluated using pullout test. The failed casing rarely occurs in pullout testing and even if it occurs, it is near the crimp. The crimping machine can achieve more accuracy and reduce time consuming for joining process. The crimping machine can crimp various diameter of ferrule using single die.

Z. Pavlouskova, et al. has studied the various causes of failure of ferrule of hydraulic hose pipe crimped fittings. They have carried out the examination of damaged crimped ferrules, undamaged crimped ferrules and ferrules before crimping. The causes of failure were determined using fractographic analysis, metallographic analysis and chemical microanalysis. Investigation for this analysis, scanning and optical electron microscopes and hardness measurements were used. Based on micro-structural observation, it showed that cracking of shells occurred mainly due to deviations in the manufacturing process. To prevent such kind of failure modifications to the technology were suggested [1].

Katia Mocellin, et al. has focused on the modeling of electrical contact crimping process. To avoid expensive repairing of components and dangerous configurations, the crimping has to be mastered precisely. To impose the electrical continuity and mechanical contact, components are deformed highly. The cases studied in this work have very small components. The development of new crimping configuration is considered and the methodology is validated [2].

D. Duriatti, et al. has research to find optimal crimping conditions involved in the assembly of composite insulators. A configurable nonlinear numerical model has been designed to study the parameters. The clearance and friction coefficient between rod and end-fitting along with hardness were studied. It showed that roughness was most sensible parameter in crimping process. If the hardness is high end-fitting will deform less. The better results in terms of mechanical performance of composite insulators were obtained by combining the effect of these parameters [3].

Manas Shirgaokar, et al. has evaluated and optimized the mechanical crimping operation for specific application with the help of the finite-element method. The effect of various variables such as geometry, alignment and friction at the crimper-tube interface were studied. It was possible to optimize the process so that effect of spring-back could be reduced, assembly quality could be improved and as indicated pullout force could be improved [4].

Manas Shirgaokar, et al has determined the optimum process and geometrical parameters for crimping enhanced the performance of the assembly. Under various conditions finite element simulations were used to evaluate the crimping operation. As a case study a double grooved rod with tubular casing was evaluated for the crimping process. The misalignment between casing and rod, the manufacturing tolerance of final crimping assembly in terms of pullout force is determined[5].

II. ANALYTICAL DESIGN

A. Calculation of working stress

The crimping machine contains various mechanical elements correctly designed. It is important to decide the concerning load and of kinematic elements to be used, before planning of a machine.

Ferrule material used is steel EN8. The yield stress of EN8 is 465 N/mm^2. The factor of safety taken into consideration is 1.5.

Working stress (maximum) = Yield strength/FOS = 465/1.5 = 310 N/mm^2

B. Pressure calculation for hydraulic ferrule

The calculation of pressure is carried out according to the formula given below.

P = (20 x K x T x C) / (S x D)

Variables –

1. D = Outer diameter of ferrule

2. T = Ferrule thickness

3. P = Pressure

4. K= Yield strength

5. S=Safety factor, 1.5

6. C= Reduction factor for thinner ferrule walls, 0.9

Table 1 shows the pressure for load of different ferrule dimension.

TABLE 1

Sr. No.	Outer Diameter D_o (mm)	Inner Diameter D_i (mm)	Pressure in bar
1	12	10	190
2	14	12	205
3	15	13	220
4	16	14	230
5	18	16	255
6	20	17	280
7	22	20	300
8	25	22	302
9	28	25	305
10	30	26	310
11	35	32	345
12	38	34	385
13	42	39	390

C. Cad Modeling

The new proposed design consists of main four parts as shown in figure 1 below.

- Holder – The holder is fixed to the support plate. The hose pipe will be placed in center for the crimping process.

- Dies (Teeth) - There are eight numbers of teeth, which are placed at equidistant from each other. The teeth move radially inward and outward direction in holder, when force on handle is applied.

- Rotating part – The rotating part is mounted upon the holder. The rotating part rotates freely on the surface of the holder.

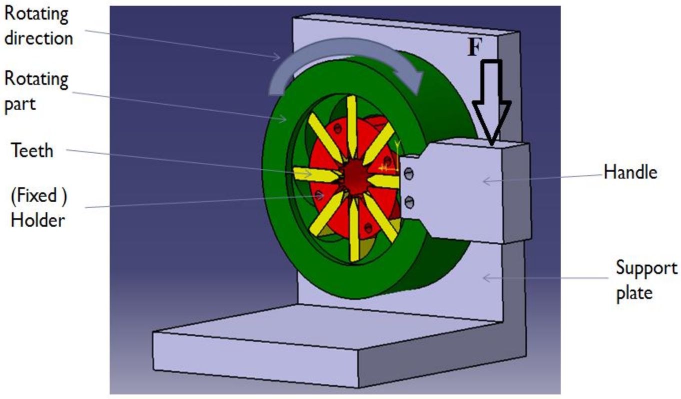

Figure 1: CAD Model crimping machine

The figure 2 shows the assembly of hose pipe and ferrule for the crimping operation. The equal pressure will act on all the teeth for proper crimping.

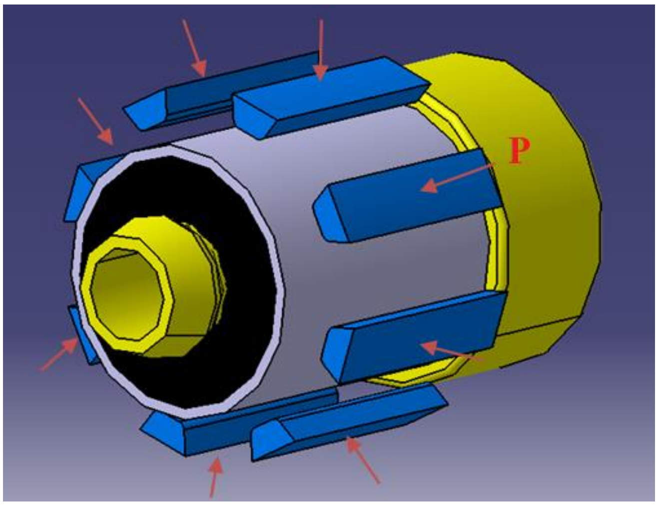

Figure 2: CAD Model of the complete hose crimp assembly

III. NUMERICAL ANALYSIS

The ferrule has the minimum thickness compared to hose. Thus numerical analysis is performed to check the stress distribution on ferrule. The analysis is done for the single impression of die. Since the dies (teeth) are placed at equidistant i.e. they are symmetrical. The dimension of die surface is (3*10 mm).

The total pressure will divided equally to all dies as they are symmetrical. The pressure is given from the upper surface of the ferrule and the below surface of ferrule is constrained. The maximum stress is calculated by simple structural analysis.

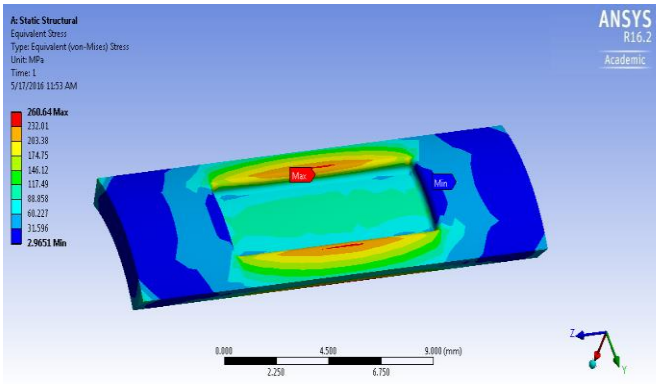

Figure 3: Maximum stress (Equivalent Von-Mises stress)

The maximum working stress calculated for ferrule is 310 MPa. The maximum stress generated is 260.64 MPa as shown in figure 3. Thus the maximum stress is below the working stress for the ferrule.

IV. EXPERIMENTAL ANALYSIS

The tensile strength of hose pipe crimp joint is experimentally analyzed. The experimental analysis is done on universal tensile testing machine. As per the application of hose pipe, it has certain requirement of minimum pullout load. The minimum pullout load of crimp joint is been achieved or not is checked on universal tensile testing machine.

- Specification of universal tensile testing machine –
  1. Type = Vertical
  2. Load capacity = 3000 kg
  3. Test speed = 0.01 – 500 mm/min
  4. Operational condition = Room temperature
  5. Digital display
  6. Strain measurement accuracy = 0.5 µm

The crimped hose pipe is placed in the universal tensile testing machine between the grips. An increasing load is applied gradually on hose pipe, when the machine is started. The load and extension of the hose pipe is recorded throughout the test and the result is shown on digital display. The load is applied on hose pipe till it is broken. The breaking point of hose pipe gives the pullout load, which is displayed on digital screen. The pullout load is then compared to the minimum requirement of working condition of hose pipe. The pullout test machine is shown in figure 4.

Figure 4: Pullout test machine

V. RESULT

The table 2 shows the pullout test results of different diameter size of crimped hose pipe. The experimental pullout load is compared to minimum pullout load requirement.

TABLE 2

PULLOUT TEST RESULT

Sr. No.	Outer Diameter D_o (mm)	Minimum Pullout Load Required (Kg)	Experimental Pullout Load (Kg)	FOS
1	12	40	110	2.75
2	14	45	133.2	2.96
3	15	50	152	3.04
4	16	60	166.8	2.78
5	18	70	224	3.3

The result show the minimum pullout load is achieved as per the requirement. The minimum factor of safety achieved is 2.75 for crimped hose pipe. This helps to valid the crimping of hose pipe.

VI. CONCLUSION

The main objective of project that is crimping of various diameter size of hose pipe is achieved. The crimping of various hose pipe is done using single set of dies. Thus the new machine designed is easy, fast and cost effective for crimping operation of hose pipe. The crimping joint of hose pipe is validated using pullout test.

The analysis is carried out for the crimp part ferrule to check the stress generated. The numerical analysis shows the maximum stress generated is below the working stress. The experimental analysis is carried on universal tensile testing machine. The universal tensile testing machine gives the value of maximum pullout load of crimp hose pipe. According to experimental analysis, the pullout test of hose pipe shows the factor of safety 2.75. Thus the numerical analysis and experimental analysis shows that the crimping operation is successful using new crimping machine.

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