Comprehensive Analysis of Interference Fit and its Attributes

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Abstract - **This paper examines about the stress and strain results for standard interference values to overcome the difficulties in the selection of suitable interference values for shaft part and to reduce the welding application by interference fit method. Work is carried out analytically and experimentally in both soft and hardened type materials. The interference values and dimensions are correlated using mini-tab software. FEA simulation is carried out using ANSYS17.2 software. After completion of modeling and analytical work,the obtained stress and strain results were analyzed with respect to dimensions of the shaft and hole parts and interference values. Experimental work is carried with various material, machining, assembly processes to get the fitment. Obtained fit is viewed with scanning electron microscope to get the fusion area in mating location.**

Keywords: Fits, Interference Fit, FEA Analysis, Stress and Strain.

I. INTRODUCTION

In engineering terms, the "fit" is the clearance between two mating parts, and the size of this clearance determines whether the parts can move independently from each other, or are temporarily or even permanently joined. Fits are of three types which are Clearance Fit, Transition Fit, and Interference Fit. **Clearance Fit:** The hole is larger than the shaft, enabling the two parts to slide or rotate when assembled. **Transition Fit:** The hole is fractionally smaller than the shaft and mild force is required to assemble / disassemble**. Interference Fit:** The hole is smaller than the shaft and high force or heat is required to assemble / disassemble. From the above fits, interference fit is chosen for analytical and experimental work.

An **interference fit** is also known as a press fit or friction fit is a fastening between two parts which is achieved by friction after the parts are pushed together, rather than by any other means of fastening. These fits, though applicable to shaft and hole assembly, are more often used for bearing-shaft assembly or bearing-housing assembly. The tightness of fit is controlled by amount of interference; the allowance. Formulas exist to compute allowance, which will provide various strength of fits such as loose fit, light interference fit and interference fit.

Press fit is achieved with pressure that can press the parts together with very large amount of force. The pressure is generally hydraulic operated. The amount of force applied in hydraulic presses may be anything from a few pounds for the tiniest parts to hundreds of tons for the largest parts. Often the shaft and holes are chamfered. The chamfer forms a guide for the pressing movement, helping to distribute the force evenly around the circumference of the hole, to allow the compression to occur gradually instead of all at once, thus helping the pressing operation to be smoother.

II. LITERATURE REVIEW

Rahman Seifi and Kaveh Abbasi(2015)[1]. Reliable finite element modeling has a great degree of importance for studies related to mechanical design in industry. Interference shaft \bush joints are under static as well as dynamic loads Strength of assemblies depends on amount of interference, material properties, physical dimension, friction co-efficient of contact surface,mating members etc. Paper is examined using ANSYS software. Friction co-efficient in contact surface is calculated.

Chao Zeng et al(2016)[2]. This study shows the crack opening stress should not be a function of stress ratio with crack length. Fatigue property is related to induced residual stress. The result shows that, with the presence of fatigue cracks, the initial stress-strain state in the structure would change, especially near the crack tip, where great compressive stress can be found.

Stefan Kleditzsch et al (2014)[3]. This study shows the knurled fit which been established in industrial applications because of their potential utility. Paper gives numerical investigation of joining process of knurled interference fit and its influence on the load characteristics of material. (1)For knurled interference fits joined by forming, *QH* influences the expansion of the hub and the process forces. (2) For knurled interference fits joined by cutting, the influence of *QH* on the expansion and the joining forces is negligible.

Barmanov I.S and Ortikov M.N (2016)[4]. To study the influence of interference on the rolling element of a ball bearing for radial and axial displacement of the bearing rings. To quantify the change in dynamic characteristics and durability of the bearing when there is change in amount of interference on the balls.

Nelli Aleksandrova (2015)[5]. This paper examines about the analytical research on strain analysis of dossuble shear reverted or bolted joints. The importance in this study was validation of stress solution, i.e the complete stress - strain field must be continuous. While modeling fastener-hole applications within the elastic-perfectly-plastic material, two different failure mechanisms should be considered, namely, decohesive carrying capacity and limit load carrying capacity.

T.N. Chakherlou and B. Abazadeh(2012)[6]. In this paper the fatigue behavior of double shear lap joints treated by different combinations of interference fit and bolt clamping have been investigated both experimentally and numerically. The fatigue test results showed that a better fatigue life improvement was achieved by employing the combination of a smaller interference fit size and bigger clamping force. The fracture section of different types of the specimens showed that the fatigue crack initiation location depends on the applied cyclic load range.

III. ANALYTICAL WORK

A) *ANALYTICAL APPROACH*:

Analytical work is performed on ANSYS WORKBENCH 17.2. In ANSYS workbench 17.2, the analysis of the hole – shaft assembly is done to evaluate the hole and shaft parts displacement, stresses acting on those parts and strain values.

B) *PROCEDURES UNDER STATIC STRUCTURAL:*

- Engineering Data
- Geometry
- Model
- Setup
- Solution
- Result

TABLE I: Material Properties Used For Analysis

Material	Structural Steel
Property	Value
Density	7850 kg/m^3
Young's Modulus	200 GPa
Poisson's Ratio	0.3
Bulk Modulus	166 GPa
Shear Modulus	76 GPa
Tensile Yield Strength	200 Mpa
Tangent Modulus	2000 Mpa

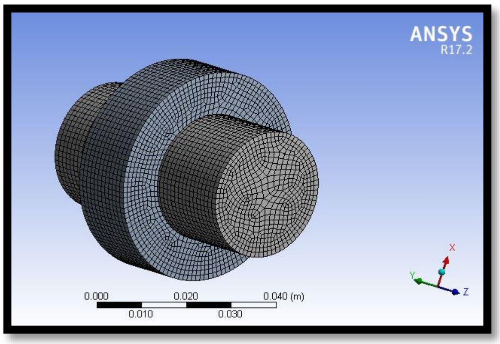

FIG 1: Meshed Model of Hole – Shaft Assembly

C) *STRESS ANALYSIS OF MODEL:*

The equivalent force acting on the shaft part is given to FEA model. The value for the force is taken by referring various journals and sources.

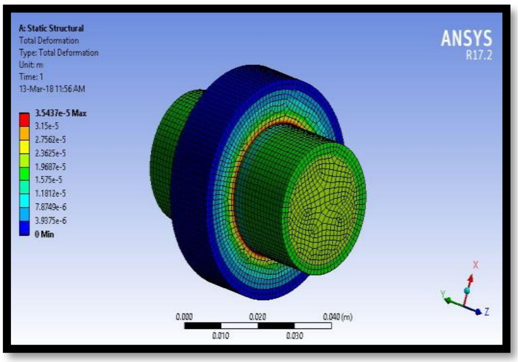

FIG 2: Deformation on FEA Model

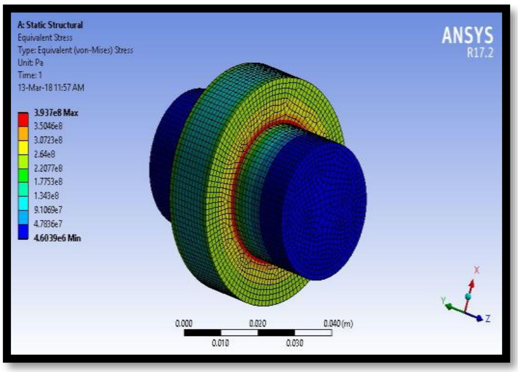

FIG 3: Equivalent Stress on Hole-Shaft Assembly

TABLE II: Results of Stress and Deformation

Categories	Maximum	Minimum
STRESS	394 MN/mm^2	4.61 MN/mm^2
DEFORMATION	3.544×10^-5 m	0 m

IV. EXPERIMENTAL WORK

S.NO	MATERIALS USED	MATERIAL TYPE
1	Mild Steel	Soft Material
2	High Carbon High Chromium Steel (D3)	Hardened Material

A) DESIGN ATTRIBUTES:

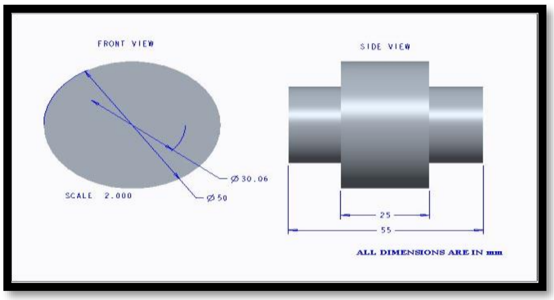

FIG 4: Design of Hole – Shaft Assembly

B) LATHE WORK:

FIG 5: Lathe Machine

C) HEAT TREATMENT:

HARDNESS (HRC) – HCHCr STEEL	
BEFORE HEAT TREATMENT	AFTER HEAT TREATMENT
24	52

FIG 6: (A) Before Heat Treatment

FIG 6 (B) After Heat Treatment

D) CYLINDRICAL GRINDING

FIG 7: Cylindrical Grinding Machine

FIG 8: (A) Before Grinding

FIG 8: (B) After Grinding

E) HYDRAULIC PRESS

FIG 9: Hydraulic Press Work

F) WIRE-CUT ELECTRO DISCHARGE MACHINING

Wire Cut -Electrical Discharge Machining is a process of metal machining in which a tool discharges thousands of sparks to a metal work-piece. Material is removed from the work-piece by a series of rapidly recurring current discharges between two electrodes, separated by a dielectric liquid and subject to an electric voltage.

FIG 10: (A) WC – EDM Machine

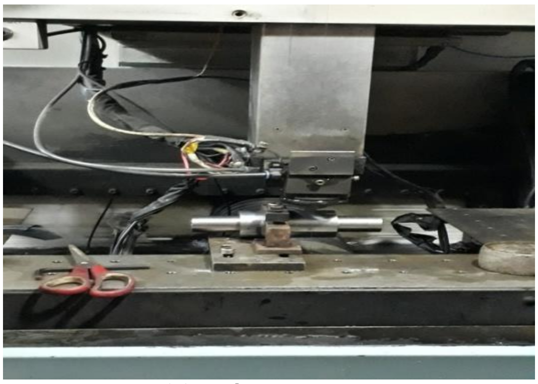

FIG 10: (B) Machining Process

WC-EDM WORK SAMPLES

FIG 11: (A) Mild Steel Piece

FIG 11 (B) HCHCr Steel Piece

G) SCANNING ELECTRON MICROSCOPE SEM:

Scanning electron microscope is a type of electron microscope that produces images of a sample by scanning the surface with a focused beam of electrons. The electrons interact with atoms in the sample, producing various signals that contain information about the sample's surface topography and composition. The electron beam is scanned in a raster scan pattern and beam's position is combined with the detected signal to produce an image. SEM can achieve resolution better than 1 nanometer.

SEM IMAGES:

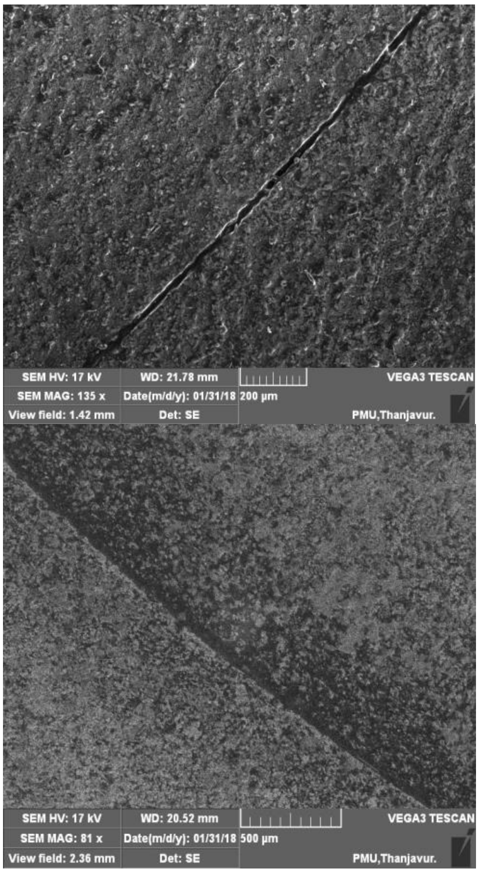

FIG 12: Mild Steel Sample & (B) HCHCr Steel

V. CONCLUSION

In general interference fit is the overlapping of shaft and hole mating parts. On reviewing various literature papers, it is found that standard interference values, fretting fatigue and cracking points on various materials are not discussed. To make realistic standard interference values are chosen from westermann tables in IS FITS with IS:919-1963 and IS:2709-1964 which is basically hole system. Selected interference values are 33, 59, 73 micro-meter. Interference values, diameter and length of hole parts are correlated in mini-tab software. Soft mild steel and hardened high carbon high chromium steels are chosen for analysis. Obtained correlation values are modeled and analyzed with CREO software and ANSYS software. ANSYS results provides the stress, strain and deformation values with respect to applied interference values and dimensions of hole part. To get a realistic view experimental approach is carried out with soft and hardened materials. Shaft and hole parts are manufactured in following processes, they are machining process, material process, assembly process. Complete fit is taken for microscopic analysis process in scanning electron microscope. Fusion area in mating location is analyzed in scanning electron microscope. Thus to carry out smooth interference fit operation in industrial applications soft material work-pieces are mostly preferred in interference range 33 to 60 micrometer. From experiments in hardened work-pieces for interference value above 60 micrometer crack will occur.

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