Journal of Achievements in Materials and Manufacturing Engineering

VOLUME 25
ISSUE 1
November
2007

Stress analysis of shrink-fitted pin-pin hole connections via Finite Element Method

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Received 16.04.2007; published in revised form 01.11.2007

Analysis and modelling

ABSTRACT

Purpose: FEA analyses are frequently faced with modeling situations where field surface and changing contact cannot be assumed ignored.

Design/methodology/approach: The effect of stress in machine elements due to friction between working machine parts has to be considered for analyzing the machine component with ANSYS software package. The interaction between the hole surface and pin was modeled with contact elements. In this study, examination of stress in pin-pin hole connections was carried out by using ANSYS program.

Findings: The connection in pin-pin hole plates occurs between surface of pin hole in plate and side surfaces of pin. Stresses in contact surface of selected machine elements were investigated. three different materials such as steel, aluminium and structure steel were analyzed under three different rates of cylindrical plate radius r and length of hexagonal pin 2h (r/h = 2.5, 5 and 7.5). Stress analysis was carried out in x, y and z axises.

Research limitations/implications: Among the stress forms, in general, the maximum stress for all the three types of materials examined here was found to be occurring as the von Mises stress.

Originality/value: The comparison of the maximum normal stress, maximum shear stress and von Misses stress were determined.

Keywords: Numerical techniques; Shrink fitting process; Contact stresses; Finite Element Method (FEM)

1. Introduction

In order to attain the best possible results in engineering problems numerical methods are widely employed [1]. Advances in the computing technology with proficient soft packages lead to digital methods to be favourable [2]. Because of owing a wide application area, ease of use and efficient modelling finite element method, among other numerical methods, is conducted on the stress analysis through which the outcome are well correlated to the real results [3].

The package that implements the finite elements method in engineering problems is ANSYS. The fundamental principle of the finite elements method is to extract local equations from the parameters (such as force, moment and boundary conditions) of individual elements of the system and combining all the local equations in a general linear equation that covering all characteristics of the whole system [3].

In most applications the components/modules involving a process are continuously getting in touch with other components/modules during processing. The friction arose from this touch effects the surface of the material and the stress within the neighbouring regions [4]. In order to attain much valuable stress results from both analytic and computer aided analysis that in line with the real results the contact surfaces need to be taken into account.

In this particular study, as an example, mechanical components such as pin and plate connectors were analyzed.

The study begins with identification of type and specifications of pins, plates and contact elements as well as method of replacement of contacts on to the surfaces. There after problem definition, modelling the problem, choice of boundary conditions (such as displacement and loading), solution of the problem and analysis of the results were involved. The maximum stress values were found to be occurring for von Misses stress in z direction.

2. Materials and methods

In this experiment, steel, construction steel and aluminium circular plates with radius r and thickness, d, and hexagonal pins with a distance between the centre and corner, h, and height, l, were analyzed. The elasticity, E, of the steel module was 210 GPa, aluminium module was 70 GPa, and construction steel module was 36 GPa, and the passion ratio for all materials was taken as υ = 0.3. The plates were with r=2 cm and d=1cm, and the pins with l=4.5 cm and h=0.4 cm.

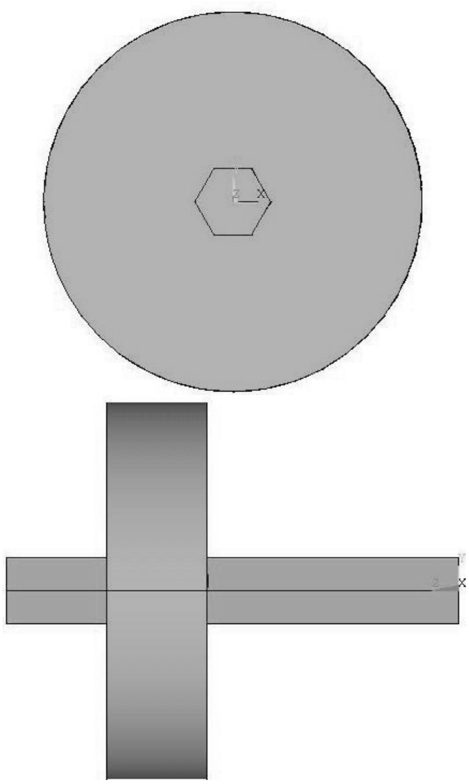

Fig. 1. Part aspect

The radius of plates was kept at a constant value and the h was altered for r/h ratios 2.5, 5, and 7.5. The gliding range of hexagonal pin inside the plate was 1.7 cm in z direction.

The stress results were obtained using ANSYS package (acknowledge version 8.0) and were evaluated and compared according to components of three types of materials, r/h ratios and spatial directions. This cross-analysis may help in the selection of proper materials for particular purposes in engineering field.

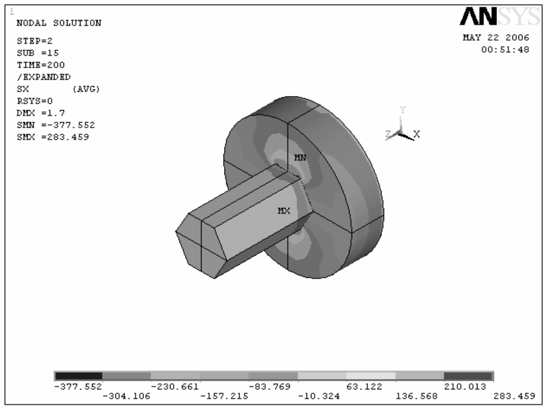

Fig. 2. Stress distribution in x-axes direction for r/h=2.5

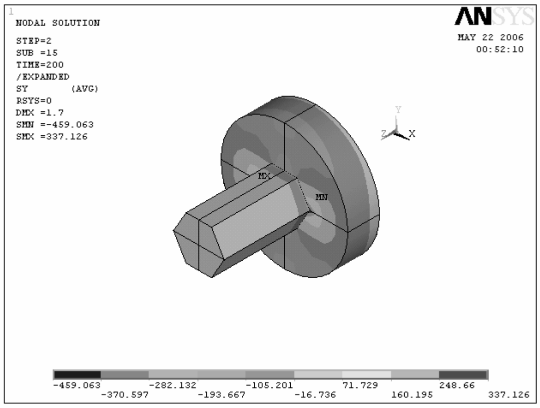

Fig. 3. Stress distribution in y-axes direction for r/h=2.5

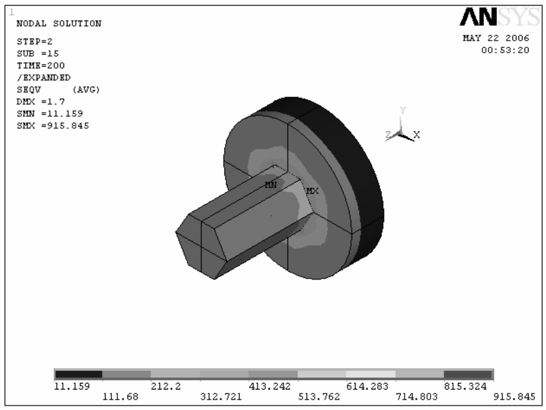

Fig. 4. Stress distribution in z-axes direction for r/h=2.5

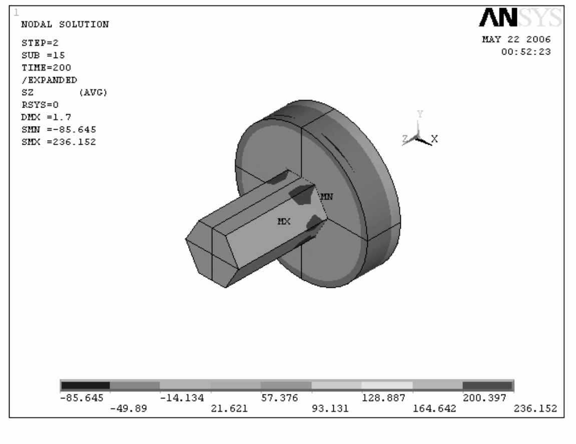

Fig. 5. von Misses stress distribution for r/h=2.5

3. Results

The stress analysis was achieved in x, y and z spatial directions on the mechanical components made from steel, construction steel and aluminum. From this analysis, as an example, the stress forms occurred within a component for *r/h*=2.5 are figured out through Figures 2 to 4. The directional press, pulling and the maximum stress values were respectively fond as: σ_{bx}= -377.552 MPa, σ_{px} = 283.459 MPa, and σ_{xmax} = 377.552 MPa; σ_{by} = -459.063 MPa, $\sigma_{çy}$ = 337.126 MPa, and σ_{ymax}= 459.063 MPa; σ_{bz} =-85.645 MPa, $\sigma_{çz}$ =236.152 MPa, and σ_{zmax}= 236.152 MPa.

Where, indices show the associated direction and the conducted press and pull, and the maximum value respectively.

Also the von Mises stress distributions were determined and the example for the same *r/h* ratio in which the maximum stress found as σ_{max} = 915.845 MPa is shown in Figure 5.

4. Discussion

The results showed that maximum stress, slip-stress come and von Mises stress coming about the three types of materials under test arise in x direction and xy plane and for r/h=7.5. The maximum and all other values of these stress forms for the here materials can be found in Table 1. Among the stress forms, in general, the maximum stress for all the three types of materials examined here was found to be occurring as the von Mises stress.

Referring to the Table 1, among tested materials the highest directional stress (x direction) occurs in steel at r/h=7.5 ratio as s_x=3839 MPa which is very high compared to the stress occurred in the other materials. Similarly the greatest planar slip-stress and von Mises stress were again found in steel at the same ratio as τ_{xy}=3795 MPa, and 8211 MPa, respectively. This is natural due to the fact that the maximum stress should occur in the material which had the highest elasticity module; it is steel.

In the analyzed three materials all forms of the stress were primarily depending on the r/h ratio. The maximum stress changes were obtained through the experiments, and with the reduction of r value the stress levels have increased. In other words the stress in the hole of the circular plates for those prismatic pins with the smallest width is found to be increasing.

Table 1.
Maximum normal stress, maximum shear stresses and von Misses stress values.

		Maximum normal stress (MPa)			Maximum Shear Sresses (MPa)			von Mises (MPa)
		σ_x	σ_y	σ_z	τ_{xy}	τ_{xz}	τ_{yz}	
Construction Steel	r/h=2.5	194.17	236.089	121.45	246.014	63.197	72.672	471.006
	r/h=5	463.869	485.748	308.337	440.000	134.382	144.600	883.141
	r/h=7.5	658.044	618.647	566.219	650.555	150.915	117.261	1408.00
Aluminium	r/h=2.5	377.552	459.063	236.152	478.361	122.883	141.306	915.845
	r/h =5	901.967	944.511	599.505	885.604	261.299	281.173	1717.00
	r/h=7.5	1280.00	1203.00	1101.00	1265.00	293.447	228.008	2737.00
Steel	r/h=2.5	1133.00	1377.00	700.46	1435.00	360.650	424.000	2748.00
	r/h=5	2706.00	2834.00	1799.00	2567.00	783.896	843.518	5152.00
	r/h=7.5	3839.00	3609.00	3303.00	3795.00	836.697	684.000	8211.00

The percentage change in the stress rates between r/h =2.5 and 5 ratios in the three materials in x, y and z directions were found as 140, 105 and 150, respectively. From this maximum stress change comes about z direction. The percentage change in the slip-stress rates at the same ratios in xy, xz and yz planes were respectively 80, 115 and 100, and therefore the maximum increase was in xz plane.

In a similar fashion the percentage change in the stress rates between r/h=5 and 7.5 ratios in the three materials in x, y and z directions were 42, 27 and 83, respectively, where the maximum stress change comes about z direction. The percentage change in the slip-stress rates in this case in xy, xz and yz planes were respectively 48, 12 and 19, with the maximum increase is being in xz plane.

The percentage changes in von Misses stress values between r/h =2.5 and 5 ratios was found to be 87, where as between r/h=5 and 7.5 was found to be 60.

Acknowledgements

The authors are grateful to FIGES A.S. in their support and providing ANSYS 8.0 package program.

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