Static and Dynamic Analysis of Clutch Plate With Crack

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Abstract
The objective of this thesis is to investigate how a crack propagates and grows in a clutch. The finite element program ANSYS is used to simulate crack growth and to compute the stresses and the stress-intensity factor. A Geometric model of clutch was designed in 3D by using software Pro/Engineer. Later the geometric model of the clutch converted into FEM model and get analysed by using ANSYS software to predict the analysis results. The Von Misses stress near the crack tip was compared against the yield strength of the material. The materials of clutch considered are Aluminium alloys 7475, 6061 and composite materials S2 Glass and Kevlar. Mathematical correlations are calculated determine stress intensity factor, crack extension force, crack opening displacement.

Keywords
Design, FE Analysis, Clutch, ANSYS, S2 Glass

I. Introduction
In homogeneous material systems, damage almost always involves cracks. From dynamics and fracture mechanics, it is well known that accelerated crack nucleation and micro-crack formation in components can occur due to various reasons, such as transient load swings, higher than expected intermittent loads, or defective component materials. Normal wear causes configuration changes that contribute to dynamic loading conditions that can cause micro-crack formation at material grain boundaries in stress concentrated regions (acute changes in material geometry). Structural systems may be composed of homogeneous or heterogeneous materials such as composites, plastics, ceramics, fabrics and metal-alloys. Heterogeneous structures have complicated dynamics of their own in addition to numerous types of damage and failure modes (crack growth, delaminations, fiber breakage, matrix cracking, component failures), which interact in complicated ways that vary tremendously for different initial states, levels of damage accumulation and loading history, making it very difficult to forecast their remaining useful life in operation. Though there have been abundant, relatively successful efforts to model and predict specific types of failure in complex material and structural systems, this work is directed towards the investigation of a more universal approach ‘time-domain’ technique can accommodate the diversity of failure modes exhibited by structures. This work is mainly concerned about time domain plots for various types of damages in composite as well as homogeneous materials.

II. Clutch
A clutch is a mechanical device that provides for the transmission of power (and therefore usually motion) from one component (the driving member) to another (the driven member) when engaged, but can be disengaged.

Fig. 1: Typical Problem in Clutch Assembly

Fig. 2: Clutch Plate

III. Design of Clutch
The materials of clutch considered are Aluminium alloys 7475, 6061 and composite materials S2 Glass and Kevlar. By using the PRO/E software the clutch was designed as shown in fig. 3.

Fig. 3: Design of Single Plate Clutch
IV. Finite Element Analysis Results of Clutch With Crack

Structural analysis was done on the clutch for different materials, the structural analysis results were given in the following figs and tables.

A. Dynamic Analysis

Table 1: Comparison of Static Stress Values Without Crack and With Crack

<table>
<thead>
<tr>
<th>Material</th>
<th>Theoretical</th>
<th>Without Crack</th>
<th>With Crack</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALUMINUM 7475</td>
<td>46.961</td>
<td>0.345338</td>
<td>0.355466</td>
</tr>
<tr>
<td>ALUMINIUM 6061</td>
<td>11.263</td>
<td>0.307968</td>
<td>0.355561</td>
</tr>
<tr>
<td>S2 GLASS</td>
<td>444.184</td>
<td>1.932</td>
<td>18.12</td>
</tr>
<tr>
<td>KEVLAR</td>
<td>328.819</td>
<td>0.300531</td>
<td>51.897</td>
</tr>
</tbody>
</table>

B. Graphical Representation of Stress Values of Dynamic Analysis – Without Crack and With Crack

On x-axis- time in sec
On y-axis – Stress in MPa
V. Conclusion

In this thesis, a clutch plate is analyzed for crack propagation for different materials Aluminium alloy 6061, Aluminium alloy 7475, Composite materials S2 Glass and Kevlar. Theoretical calculations are done to determine stress intensity factor, crack extension force, crack opening displacement.

Static and Dynamic analyses are done in finite element analysis software Ansys. The analysis is done on the clutch before crack and propagated crack after load steps.

By observing the analysis results, the stress values are more for composite materials and when the crack is started the composite materials, stress values increases more than the condition of no crack so the composite materials fails faster once the crack propagates.

So we can conclude that if the crack propagates in the composite materials, they tend to fail faster than aluminium alloys thereby reducing their life. So care should be taken for composite materials not to get the crack.

References