一　般

興一機低壓汽機末2級葉片之流場分析及壽限評估

完成報告

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政府機關參考
請勿轉載

摘要

由台電公司所提供之資料，興達低壓汽機使用近 30 年後，L-1 級葉根槽出現深長裂縫，由於裂縫出現在葉根槽，需要更換轉子，而更換轉子需要很長時間，因此台電公司提出暫代方案期使汽機能繼續安全運轉，目前暫代方案有（1）切除裂縫位置之動葉片及相對應角度之動葉片，以減低葉根槽卡溝受力及維持轉子平衡。（2）切除裂縫位置之整群動葉片及其相對應角度之整群動葉片，以減低葉根槽卡溝受力及維持轉子平衡。（3）切除 L-1 級動葉片，而 L-1 級靜葉片則以導流板替代，以減低葉根槽卡溝受力及維持轉子葉片之流場平衡。由於切除動葉片會對末 2 級葉片之流場產生相當大的影響，而這種汽機暫態流場對葉片高週次疲勞有相當重大影響，因此我們必須嚴謹處理本問題，本計畫規劃進行分析研究為：

一、完整低壓汽機末兩級葉片之穩態流場分析：

以穩態流場分析結果做為暫態流場分析結果之比對基礎，另外穩態流場分析結果亦可用於軸碟壽限分析之受力基礎。

二、完整低壓汽機末兩級葉片之暫態流場分析：

在做切除葉片之汽機暫態流場分析前有必要先分析完整汽機暫態流場以瞭解低壓汽機葉片受壓變化情形，完整汽機暫態流場分析結果將做為切除葉片之汽機暫態流場分析結果之比對基礎，以瞭解切除葉片之汽機暫態流場變化。

三、L-1 級葉片改用導流板之汽機暫態流場分析

軸碟之葉根槽既然因長時間運轉而出現深長裂縫，那麼切除整級動葉片必定可以減低裂縫繼續成長，不過切除整級動葉片除了會降低運轉效能外，也必須在靜葉環上加上導流板以使前、後面葉片不致因為壓力陡變而產生問題。

四、切除裂縫對應位置動葉片之末兩級汽機暫態流場分析

由於切除葉片不只會影響切除葉片旁的葉片受力，對切除葉片位置後面的葉片通常可能會有更大影響，因此本分析模型除了裂縫位置的動、

靜葉片外，裂縫位置後面一級的動、靜葉也必須列入模型中。

五、切除裂縫對應位置葉片群之末兩級汽機暫態流場分析

分析切除葉片群之興達低壓汽機末兩級所承受的壓力負荷變化情形。這個分析結果將與切除葉片及完整低壓汽機末兩級之暫態流場分析結果做比較，以瞭解切除葉片群之影響，並以此結果作為分析葉片壽限之變動負荷。

六、切除裂縫對應位置動葉片之葉片與葉根槽壽限分析

葉根槽深長裂縫會因切除動葉片而減低離心負荷，不過切除動葉片卻也可能增加旁邊葉片的動、靜態壓差負荷，對葉根槽裂縫是否會有進一步的安全疑慮，這需要審慎去做安全評估。

七、切除裂縫對應位置動葉片群之葉片與葉根槽壽限分析

利用三維幾何實體建構切除動葉片群之興達低壓汽機有限元素模型。分析整級動葉片受離心力等之穩態應力反應，依此應力分析葉片及葉根槽之低週次疲勞損傷。分析整級動葉片承受壓力變動之暫態應力反應，依此應力分析葉片及葉根槽之高週次疲勞損傷。分析葉片及葉根槽之高、低週次疲勞損傷及使用年限。

八、研擬運轉維護建議

綜合分析結果及運轉資料研擬運轉維護建議。完成整個計畫以建立興達汽機之運轉壓力及應力反應資料、汽機運轉時之壓力分布資料、汽機運轉時之壓力變動資料及汽機暫態流場分析技術。

分析結果使用導流板之興一機在滿載運轉時，L-0 動葉片會增加 15~16%之 Torque，但是不影響結構安全。在切除葉片方面；切除一群葉片會有一葉片增加 1.6 倍之 Torque，不過不影響結構應變，只是結構轉動平衡略受影響，運轉振動應該會略微變大。在切除單葉片方面，會有一葉片增加 1 倍之 Torque，不過影響結構應變的不是 Torque，而是產生兩片葉片一群的情形，此情形讓高應變區壽限降低及結構轉動平衡受影響而讓運轉振動略微變大。

ABSTRACTION

According to the information from TPC that the low pressure steam turbine has been used for about 30 years, there is long deep crack in the L-1A stage blade groove; due to this crack exist in blade groove, therefore have to replace the rotor, and replace rotor cost a lot of time. Therefore TPC propose a temporal method, so that turbine could continue to rotate safely. As follows (1) cut out the rotor blade in the crack position and the relative angle ones. (2) Cut out the group of rotor blade in the crack position and the relative angle ones. (3) Cut out the rotor blade of stage L-1, and replace the guide blade of stage L-1 with baffles, to reduce the force act at blade groove gouge and keep the flow field balance of rotor blade.

Due to cut out the rotor blade will change the flow field of the last 2 stage blade, and transient flow will change the high cycle fatigue rapidly for this kind of steam turbine, hence we must deal this kind of problem seriously, this project will study analysis the following items:

1. The steady state flow field analysis of the original low pressure steam turbine last two stage blade

   Base on the steady state flow field analysis results as the comparison basis of transient flow field analysis results, besides the steady state flow field analysis results also could use as the force basis of axial disk life analysis.
2. The transient flow field analysis of the original low pressure steam turbine last two stage blade

   Before analysis the transient flow field of the blade cut out steam turbine, we have to analysis the transient flow field of the original low pressure steam turbine in order to study steam turbine blade change by force acting. The transient flow field analysis results of the original low pressure steam turbine could use as the comparison basis for the transient flow field analysis results of the rotor blade cut out in the crack position and the relative angle ones. And study the transient flow field change of the steam turbine when cutting out the blade.
3. The transient flow field analysis of the one which replace the guide blade of stage L-1 with Baffles

   The axial disk exist long deep crack owing to long time operation, then cut out the whole group of blade will reduce the crack propagation, but cutting out the whole group of blades will reduce the operating efficiency, also have to add baffles in the guide blade ring, in order to reduce the problem for the fore and rear blade when the pressure suddenly change.
4. The transient flow field analysis of the last two stage which cut out the rotor blade in the

crack position and the relative angle ones.

Cut out blade not only influence the force act on the blade beside, also influence more on the one behind, therefore the analysis model should include the rotor blade and guide blade in the crack position, also should include the next stage rotor blade and guide blade

5. The transient flow field analysis of the last two stages which cut out the rotor blade group in the crack position and the relative angle ones.

   Analysis the last two stages loading variation for the cut out blade group of Shin-Dar low pressure steam turbine. The analysis result will use to compare with the transient flow field analysis of the blade cut out one and the original low pressure steam turbine last two stage, in order to study the influence when cut out blade group, also use this result as blade life during dynamic loading.

6. The life analysis of the last two stage which cut out the rotor blade and groove in the crack position and the relative angle ones.

   By cutting out the long deep crack in the blade root groove, will reduce the centrifugal load, but cut out the rotor blade will increase dynamic and steady state loading of the blade aside.

   We have to carefully handling this kind of problem.

7. The life analysis of the last two stage which cut out the rotor blade group and groove in the crack position and the relative angle ones.

   By using the 3D solid model to create the finite element model for Shin-Dar low pressure steam turbine with rotor blade cut out. Analysis steady state stress response of single stage of rotor blade owing to centrifugal and so on force. And use this result to analysis the low cycle fatigue damage for blade and blade root groove. Analysis transient stress response of single stage of rotor blade owing pressure vary. And use this result to analysis the high cycle fatigue damage for blade and blade root groove. Analysis the low cycle and high cycle fatigue damage for blade and blade root groove, and life duration.

8. Study and plan the operation and maintenance suggestion

   Summarize the analysis result and operation data, to elaborate the operation and maintenance suggestion. Accomplish the whole plan, so as to create Shin-Dar low pressure steam turbine operation pressure and stress response data, pressure distribution and pressure change during operation, and steam turbine transient flow field analysis technique.

Analysis results show that by using baffles, during full load operation, the L-0 rotor blade will increase 15~16% Torque, but the structure is still safe. By cutting one group blade, the Torque for

one blade largest increase 1.6 times, and no effect for the structure strain, but little effect for the structure rotate balance, and the vibration for the operation will be higher. By cutting one blade, the Torque for one blade largest increase 1.0 times, and no effect for the structure strain, but it will display 2 blades group and will reduce the life of original high strain area. And it also little effect for the structure rotate balance and the vibration for the operation will be higher.

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第1章 緒論

興達低壓汽機使用近 30 年後，L-1 級葉根槽出現深長裂縫，由於裂縫出現在葉根槽，需要更換轉子，而更換轉子需要很長時間，因此台電公司提出暫代方案期使汽機能繼續安全運轉，目前暫代方案有（1）切除裂縫位置之動葉片及相對應角度之動葉片，以減低葉根槽卡溝受力及維持轉子平衡。（2）切除裂縫位置之整群動葉片及其相對應角度之整群動葉片，以減低葉根槽卡溝受力及維持轉子平衡。（3）切除 L-1 級動葉片，而 L-1 級靜葉片則以導流板替代，以減低葉根槽卡溝受力及維持轉子葉片之流場平衡。由於切除動葉片會對末 2 級葉片之流場產生相當大的影響，而這種汽機暫態流場對葉片高週次疲勞有相當重大影響，因此我們必須嚴謹處理本問題，本計畫規劃進行分析研究為：。

（一） 完整低壓汽機末兩級葉片之穩態流場分析。
（二） 完整低壓汽機末兩級葉片之暫態流場分析。
（三） L-1 級葉片改用導流板之末兩級汽機暫態流場分析。
（四） 切除裂縫對應位置動葉片之末兩級汽機暫態流場分析。
（五） 切除裂縫對應位置葉片群之末兩級汽機暫態流場分析。
（六） 切除裂縫對應位置動葉片之葉片與葉根槽壽限分析。
（七） 切除裂縫對應位置動葉片群之葉片與葉根槽壽限分析。
（八） 研擬運轉維護建議。