坐姿人體於垂向振動環境下生物力學模型研究及乘適性能評估

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摘 要

人體是一個非常複雜的動態系統，且在坐姿環境下受到低頻全身振動的反應非常靈敏，因此坐姿人體動態反應在過去幾十年來已是相當重要的研究課題。雖然在過去曾針對特定測試環境所獲得的實驗數據以建立許多生物力學模型，但對此類數學模型的整體性研究並未受到相等的重視，所以本論文將針對坐姿人體承受垂向振動的質量參數(Lumped-parameter)模型作一透徹的研究，所有模型均經過有系統的分析，並由文獻中針對不同的實驗研究經過綜合分析的量測數據驗證，藉由這些解析的研究與實驗驗證可獲得由Wan與Schimmels所建構之四自由度模型最接近實驗數據；此外，針對較特殊的案例如女性孕婦模型分析時因需較多之質量塊，則建議使用修改自Muksian及Nash的非線性模型，此一模型並將與－全車模型(Full-car model)整合以評估坐姿的正常人體與孕婦在車輛行駛狀況下的生物動態反應。而為了更近一步了解坐姿人體承受垂向振動之動態反應的內涵，人體的數學模型至少須是矢狀平面(Sagittal plane)的二度空間模型，因此具適當複雜性的多體(Multibody)模型亦在本研究中有相當深入的探討，本論文針對文獻中兩個汽車乘坐姿態的代表性多體模型作詳細的研究，並在相同條件下與不同的實驗數據驗證，經解析的研究與實驗驗證後，本研究提出之14個自由度模型最能與實驗數據吻合，因此建議可將之應用於研究坐姿人體在不同的車輛乘坐姿態中承受垂向振動的動態反應。本論文最後針對應用在越野路面之雙A臂式乘載系統提出建構四分之－車(Quarter-car)模型的程序，此－程序首先利用ADAMS多體動力學分析軟體建立模型，並用以決定質量參數模型所需之等效彈簧率(Wheel rate)與阻尼率(Damping rate)，兩種模型同時與實驗數據驗證，最後並依此提出建立全車模型的程序，並建議可使用於評估坐姿人體乘適性能評估。綜合本論文之研究可歸納下列幾點貢獻： 1. 完成人體質量參數模型的完整且透徹之研究，並建議二模型以提供坐姿人體於垂向振動環境下之動態反應分析。 2. 建立孕婦質量參數模型及車輛?{人體系統模型，並提出孕婦與正常人體於車輛行駛於隨機路面狀況下乘適性能評估流程。 3. 建立坐姿人體在不同的車輛乘坐姿態之多體模型並提供相關模擬程序。 4. 提出－有經濟效益之四分之－車模型的建構方法，以及全車模型建構流程，可用以評估承載系統及車輛的乘適性能。 本論文所研究之專題對車輛承載系統動力學及坐姿人體承受垂向振動之生物動態反應已有相當深入的探討，並相信本論文之研究在承載系統設計、座椅設計及全車乘適性能評估等相關領域，可提供車輛工程師相當好的設計參考。

關鍵詞 : 全身振動 ; 質量參數模型 ; 多體模型 ; 四分之－車模型 ; 半車模型 ; 全車模型

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