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放宽静稳定电传客机纵向短周期品质评定方法

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Handling Qualities Assessment of Short Period Mode for Fly-by-Wire Passenger Airliner with Relaxed Static Stability Design

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摘要 民用客机强调飞行的安全性和舒适性,由于设计与使用的特点,其短周期模式的自然频率、操纵灵敏度与带宽均较低,时间延迟较大,且一般采用不同于军用运输机的控制律构型。提出以军用规范作为参照的电传客机飞行品质评定及适航审定方法,是现代民用客机飞行控制律设计的关键问题。为改善某放宽静稳定构型客机的短周期飞行品质,设计了迎角、 C^* 和过载构型飞行控制律。按咨询通告AC25-7A所给出的操纵品质等级评定方法(HQRM),采用等效系统评定法、高阶频域法和高阶时域法评定了闭环飞机的短周期飞行品质及适航符合性。结果表明,军用规范条款对时延和带宽的限制对于客机可适当放宽。对于迎角构型,等效系统参数准则、带宽准则和俯仰速率响应准则均适用;过载构型评定应采用等效系统参数准则、俯仰速率响应准则; C^* 属非常规响应构型,应采用带宽准则和俯仰速率响应准则评定。

关键词: 客机 放宽静稳定性 短周期模式 飞行控制系统 飞行控制律 操纵品质 控制律构型

Abstract: The handling qualities design of a fly-by-wire passenger airliner places great emphasis on safety and comfort. Lower short period frequency, control sensitivity, bandwidth and higher time delay are expected on airliners due to its design and operating characteristics. Moreover, the control law designs differ from military airlift aircraft. Developing a handling qualities and airworthiness assessment method, which take military standards as reference, is crucial to the flight control law design for a passenger aircraft. In this paper a flight control law with C^* mode, load factor mode and angle of attack mode are developed to improve the short period handling qualities of a relaxed static stability passenger jet. Handling qualities and airworthiness assessment, based on handling qualities rating method (HQRM) from advisory curriculum AC25-7A, is used to examine the short period handling qualities of the augmented airplane. Low order equivalent systems method, bandwidth criterion and pitch rate response criterion are used in the assessment. Results indicate that time delay and band width restrictions from military specifications should be relaxed when applied to passenger aircraft. For conventional response type such as the angle of attack mode, all three criteria are applicable. Low order equivalent systems and pitch rate criteria are suitable for load factor mode. C^* mode features an unconventional response type, thus only bandwidth and pitch rate response criteria are applicable.

Keywords: passenger aircraft relaxed static stability short period mode flight control system flight control law handling qualities control mode

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