Integral Tuned Mass Absorber for Turbine Blades

NASA’s Marshall Space Flight Center has developed a novel turbine blade design and manufacturing approach that provides a significant reduction in turbine blade resonant vibration. In particular this innovation addresses the unique resonance vibration challenges of conventionally machined turbine bladed-discs, or blisks. The design approach includes an internal blade tuned mass absorber structure that can be placed at optimal location where deflection is greatest. Additive manufacturing is used to make this unique structure. Prototypes have demonstrated a 50% reduction in resonant vibration. Importantly, the innovation also enables improved predictive modelling of the resonant behavior of new blisk designs because the tuned-mass absorber acts as a linear system. In contrast, modelling of conventional blade dampers is extremely complex and therefore requires an expensive iterative test program dedicated to validation of the damper design.

BENEFITS

- Effective: Prototype designs and tests have demonstrated 50% reduction in vibration.
- Inexpensive: Use of additive manufacturing enables Tuned Mass Absorber to be fabricated simultaneously with blade at no extra cost.
- Response reduction can be implemented into up-front design: Linear design allows accurate prediction of blade response without costly test program.
- Applicable to Multiple Modes: each tuned-mass-absorber targets two modes, and multiple absorbers can be used in each blade.
- Reliable: Design will not lock-up or potentially introduce foreign-object-debris like conventional blade dampers.
THE TECHNOLOGY

Additive manufacturing methods (e.g. Laser Metal Sintering) are used to integrally fabricate a tuned-mass vibration absorber inside a turbine blade. The design approach uses an internal column manufactured as part of the blade that is optimized such that the dynamics of the blade damper system are rearranged and reduced according to the well-known science of tuned mass-absorption (TMA). The TMA concept has been implemented successfully in applications ranging from skyscrapers to liquid oxygen tanks for space vehicles. Indeed, this theory has been conceptually applied to bladed-disk vibration, but a practical design has not previously been reported.

The NASA innovation addresses another important challenge for turbine blade vibration damper designs. All existing blade damper solutions are essentially incapable of being reliably predicted, so an expensive post-design test program must be performed to validate the expected response. Even then, the actual magnitude of the response reduction under actual hot fire conditions may never be known. The dynamic response of this tuned-mass-absorber design is both substantial and can be analytically predicted with high confidence, and thus the response can be incorporated fully into the up-front design process.

APPLICATIONS

The technology has several potential applications:

- Rocket engine turbopumps
- Jet engines
- Land-based gas turbines for power generation
- APU’s and turbochargers
- All components in turbomachine flow-path (impellers, stators, vanes).

PUBLICATIONS

Patent Pending

Figure shows reduction in resonant response of a turbine blade with the NASA integral tuned mass absorber innovation.