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(54) ROTOR BLADE WITH OPTIMIZED TWIST DISTRIBUTION

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(57) **ABSTRACT**

A rotor blade has a local geometric twist angle $\theta=f(r/R)$, with R being the blade span and r being the distance along the blade span from the axis of rotation. The blade has an inner region between an $(r/R)_{inner}=0.20\pm0.04$ and a transition point at $(r/R)_{trams}=0.75\pm0.04$, wherein θ_{inner} at $(r/R)_{inner}$ has a positive value and is greater than or equal to θ_{trans} at $(r/R)_{trans}$. A blade tip region includes a first portion between $(r/R)_{trans}$ and $(r/R)_{min}>(r/R)_{trans}$, wherein θ continuously decreases from θ_{trans} to θ_{min} at $(r/R)_{min}$, and $\Delta\theta_{tip1}=|\theta_{min}-\theta_{trans}|>3°$, and a second portion between $(r/R)_{min}$ and the blade tip, wherein θ continuously increases from θ_{min} to θ_{tip} at the tip, and $\Delta\theta_{tip2}=|\theta_{tip}-\theta_{min}|$ is at least about 3° and no greater than about 20°. This geometry pushes the vortex trailed by the blade tip away from the blade and thus increases blade performance. In a preferred tiltrotor blade embodiment, $\Delta\theta_{inner}=|\theta_{inner}-\theta_{trans}|=32.5°\pm7.5°$, θ continuously decreases from $(r/R)_{inner}$ to $(r/R)_{trans}$, $(r/R)_{min}=0.91\pm0.04$, $\Delta\theta_{tip1}=7.5°\pm2.5°$, and $\Delta\theta_{tip2}=10°\pm6°$. In a preferred helicopter blade embodiment, $\Delta\theta_{inner}=|\theta_{inner}-\theta_{trans}|=20°\pm5°$, θ continuously decreases from $(r/R)_{inner}$ to $(r/R)_{trans}$, $(r/R)_{min}=0.94\pm0.04$, $\Delta\theta_{tip1}=5°\pm2°$, and $\Delta\theta_{tip2}$ is from about 3° to about 10°. Another embodiment of the invention uses adjustable flaps to control $\theta=f(r/R)$ in an inboard region of a helicopter blade to optimize performance in hover and forward flight regimes.

19 Claims, 15 Drawing Sheets