Green' s Function Solution for Lateral Vibration of Axially Compressed Rotating Composite Drill Strings - Postprint

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Abstract

Compressed rotating drill strings are susceptible to lateral vibrations, which can lead to severe accidents such as drill string failure and borehole enlargement. This study investigates the lateral vibration response of compressed rotating composite drill string systems using the Green' s function method, obtaining an analytical solution for the system' s bidirectional coupling vibration response. Taking the entire drill string as the object, a bidirectional coupling dynamic equation for the drill string is established based on Hamilton' s principle, accounting for the effects of spin angular velocity and weight on bit. By employing the Green' s function method, the equation is subjected to separation of variables, Laplace transform, and inverse Laplace transform to derive the Green' s function solution for the bidirectional coupling vibration of compressed spinning composite drill strings. In the numerical analysis section, the reliability of the proposed method is first verified, and subsequently, utilizing the system' s Green' s function solution, the influences of parameters such as fiber ply angle, rotational angular velocity, weight on bit, and drilling fluid flow rate on the lateral vibration of compressed rotating composite drill string systems are analyzed. The research demonstrates that the Green' s function response of the drill string system increases with fiber ply angle, and within a certain range, also increases with rotational speed. Under the combined effects of spin angular velocity, drilling fluid flow rate, and fiber ply angle, resonance bands can be generated in the lateral coupling vibration of the drill string system. Based on the locations where these resonance bands occur, dangerous value intervals for composite materials and rotational angular velocity that may cause structural instability and failure due to large-amplitude vibrations can be identified, thereby enabling effective avoidance of structural instability and failure by steering clear of these hazardous ranges.

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