REDUCING VIBRATIONS OF ELECTRIC CENTRIFUGAL SUBMERSIBLE PUMP THROUGH INSTALLATION OF THE DYNAMIC DAMPER

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                                                                                                                                  m_2
                                                                                                u(0,t).
                                \begin{cases} u_{tt} + bu_{t} - a^{2}u_{xx} = 0, \\ m_{1}\ddot{x}_{1} = -\lambda[x_{1} - u(0, t)] - \mu[\dot{x}_{1} - \dot{u}(0, t)], \end{cases}
                                                                                                                                                                                      (1)
                                 m_2 \ddot{u}(0,t) = ESu_x(0,t) - Pe^{i\omega t} - \lambda [u(0,t) - x_1] - \mu [\dot{u}(0,t) - \dot{x}_1]
                                                                                                                                                                                      (2)
                                                                  u = Ae^{-kx + i\omega t} + Be^{kx + i\omega t},
                                                                                                                                                                                      (3)
A, B, k —
                                                                                                                                                                                 (3)
                                                  ,
(1)
                                                                                                                                                         k:
                                                                      a^2k^2 + \omega^2 - i\omega b = 0.
                                                                       k_{0,1} = \pm \sqrt{\frac{i\omega b - \omega^2}{a^2}}
                                                                      k_0 = re^{i\phi}, \ k_1 = re^{i(\phi+\pi)}.
                                                                                                                                                                                     (4)
                            r = \frac{1}{a} \sqrt[4]{\omega^2(\omega^2 + b^2)}, \quad \phi = \frac{\pi}{2} - \frac{1}{2} \operatorname{arctg} \frac{b}{\omega}, \qquad \phi \in \left[\frac{\pi}{4}, \frac{\pi}{2}\right].
      H = r\cos\phi = \frac{1}{\sqrt{2}a}\sqrt{\omega(\sqrt{\omega^2 + b^2} - \omega)}, \quad G = r\sin\phi = \frac{1}{\sqrt{2}a}\sqrt{\omega(\sqrt{\omega^2 + b^2} + \omega)},
                                                                                                                                                                                      (5)
                                                                                  G > 0.
                      H = 0
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 $k. \qquad \operatorname{Re}(k_0) = r\cos\phi \ge 0, \ \operatorname{Re}(k_1) = r\cos(\phi + \pi) \le 0.$ $k = k_0.$

$$k = r(\cos \varphi + i \sin \varphi) = H + iG. \tag{6}$$

(3) $B \neq 0$. $x \rightarrow \infty$ $\left| Ae^{-kx + i\omega t} \right| \rightarrow 0$,

 $\left|Be^{kx+i\omega t}\right| \to \infty.$ (3) $u \to \infty,$ (2). -B = 0.

--B=0. (3)

$$u = Ae^{-kx + i\omega t}. (7)$$

$$u(0,t) = Ae^{i\omega t}, \ u_x(0,t) = -Ake^{i\omega t}, \ \dot{u}(0,t) = i\omega Ae^{i\omega t}.$$
 (8)

3)

(1), $\begin{cases} m_1 \ddot{x}_1 + \mu \dot{x}_1 + \lambda x_1 = A(\lambda + i\omega\mu)e^{i\omega t}, \\ m_2 A\omega^2 e^{i\omega t} = ESAke^{i\omega t} + Pe^{i\omega t} + \lambda(Ae^{i\omega t} - x_1) + \mu(i\omega Ae^{i\omega t} - x_1). \end{cases}$ (9)

$$x_{1} = e^{-\frac{\mu}{2m_{1}}t} \left(C_{1}e^{\frac{\sqrt{\mu^{2}-4m_{1}\lambda}}{2m_{1}}t} + C_{2}e^{-\frac{\sqrt{\mu^{2}-4m_{1}\lambda}}{2m_{1}}t} \right) + \frac{\lambda + i\omega\mu}{\lambda + i\omega\mu - m_{1}\omega^{2}} Ae^{i\omega t}.$$

 $t \to \infty$.

$$x_{1} = \frac{\lambda + i\omega\mu}{\lambda + i\omega\mu - m_{1}\omega^{2}} A e^{i\omega t}.$$
 (10)

 $A[(m_2\omega^2 - ESk)(\lambda + i\omega\mu - m_1\omega^2) + m_1\omega^2(\lambda + i\omega\mu)] = P(\lambda + i\omega\mu - m_1\omega^2).$ (11)

$$A = \frac{P(\lambda + i\omega\mu - m_1\omega^2)}{(m_2\omega^2 - ESk)(\lambda + i\omega\mu - m_1\omega^2) + m_1\omega^2(\lambda + i\omega\mu)}.$$
 (12)

 $m_1 = 0$

$$A = \frac{P}{m_2 \omega^2 - ESk}.$$

 λ μ

(11) (10),

$$x_{1} = \frac{\lambda + i\omega\mu}{(m_{2}\omega^{2} - ESk)(\lambda + i\omega\mu - m_{1}\omega^{2}) + m_{1}\omega^{2}(\lambda + i\omega\mu)} Pe^{i\omega t}.$$
 (13)

, t -

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: A = 0.
                                       (11)
                                                                                                                                                                                                                                       \lambda + i\omega\mu - m_1\omega^2 = 0.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              (14)
                                                                                                                                                                                                                                                  \lambda = m_1 \omega^2, \quad \mu = 0.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               (15)
                                                                                                  (14) (13),
                                                                                                                                                                                                                                                          x_1 = \frac{P}{m_1 \omega^2} e^{i\omega t}.
                                                                              (15)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   (
                        A = P[(\lambda - m_1\omega^2)^2 + (\omega\mu)^2]^{1/2} \cdot \{[(m_2\omega^2 - ESH)(\lambda - m_1\omega^2) + ESG\omega\mu + \lambda m_1\omega^2]^2 + (\omega\mu)^2\} + (\omega\mu)^2\} + (\omega\mu)^2 + (\omega\mu)^2\} + (\omega\mu)^2 + (\omega\mu)^2 + (\omega\mu)^2\} + (\omega\mu)^2 + (\omega\mu)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               (16)
                                                                                                                               +[\omega\mu(m_1\omega^2+m_2\omega^2-ESH)-ESG(\lambda-m_1\omega^2)]^2\}^{-1/2}.
                                                                                                                                                                                                                                   (12)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             (6).
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 (15)
                                                                                                                                                                                                                                             (16).
A(\lambda, \mu),
                                             ES = 897 \cdot 10^6 \,\text{H}, = 10^4 \,, m_1 = 500 \,, m_2 = 1\,000 \,, = 5\,160 \,\cdot\,^{-1}, b = 3\,\text{c}^{-1}.
                                                                      \mu = 0.
                                                                                                     λ
                                                                                                                                                                                                                                                                                                                                                   8×10
                                                                                                                                                                                                                                                                                                                        K.
⊠
e×10
                                                                                                                                                                                                                                                                                                                                                                                                                                                                         n = 50, m_1 = 500
                                                                 . 2.
                                                                                                                                                                             \mu = 0.
                                                                                                                          λ
                                                                                                                                                                                                                                                                                                                                                  2×10
                                                                                                                                                                                                                                                                                                                                                                                                                           2×10<sup>5</sup> 4×10<sup>5</sup> 6×10<sup>5</sup> 8×10<sup>5</sup>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   μ, H·c·m<sup>-1</sup>
                                                                                                                                                                                                                                                                                                                                                                                                                                            . 3
                                                                                                                                                                                                                                                                                                                                      m_1 = 0.
                                                                                                                                                       \lambda = m_1 \omega^2 = 4,935 \cdot 10^7 \cdot ^{-1}.
                                                                                                                                                                                                                                                                                                                                                 2×10
                                                                                                                                                                                                                                                                                                                                                                                                                                                                   \mu = 0, n = 50
                                                                                                                                                                                                                                                                                                                               ¥ 1×10_
                                                                                         \lambda = m_1 \omega^2 = 4.935 \cdot 10^7 \cdot ^{-1}.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       m<sub>1</sub>=500
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            1×10<sup>8</sup> 1.5×10<sup>8</sup>
                                                                                                                                                                                                                                                                                                                                                                                                                                      5×10<sup>7</sup>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                λ, H·m<sup>-1</sup>
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(16)
                                                      \lambda \to \infty,
                                                                                      \mu \rightarrow \infty
                                                  \frac{1}{\sqrt{[(m_1+m_2)\omega^2-ESH]^2+(ESG)^2}}
                                                                                                           \lambda \mu
                 . 4
1.5·10<del>:4</del>
  1.10^{-4}
                                                                                                                  . 4.
                                                                                                                      \lambda \mu
 5·10<sup>-5</sup>
          1·10
1·5·10
2·10
               . 5
                                                                                                               44, 46 48
                                                                                                              \lambda = m_1 \omega^2,
          . 5
                                                                \mu = 0,
              \omega = 2\pi n.
                                                                                   8×10
       2×10
     1.5×10
                                         \mu = 0
       1×10
                                                                                   4×10
                                                                                   2×10
       5×10
                                       1×10<sup>8</sup> 1.5×10<sup>8</sup>
                                                                2×10<sup>8</sup>
                                                                                                    2 \times 10^5 4 \times 10^5 6 \times 10^5
                                                                                                                                  8×10<sup>5</sup>
                                                                                                                                            1×10<sup>6</sup>
                           5×10<sup>7</sup>
                                     λ, H·m<sup>-1</sup>
                                                                                                               μ, H·c·m<sup>-1</sup>
                             . 5.
                                                       -\mu=0; \quad -\lambda=m_1\omega^2
                                     \lambda \mu
                                                                                                                   (15),
                                                                                                            », 2011. – 244 .
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