

## *11-MA`RUZA.*

# ***Markazdan qochma tebrangichli mashina agregati***

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## ▶ Adabiyotlar:

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## ▶ *11.1. Markazdan qochma vibratorli mashina agregatining ishlashi haqida*

- ▶ Yurituvchida ishchi mashina valiga aylanma harakatni uzatuvchi tishli mexanizm dinamikasini ko'rilganda yurituvchi rotorining burchak tezligini o'zgarimas deb qabul qilish mumkin edi. Bu tasdiq shunday holarda haqli ediki, qachonki yurituvchi amalda cheklanmagan quvvatga ega bo'lgandagina, shuning uchun mexanizm bo'g'inlariga ta'sir qiluvchi kuchlarni o'zgarishi yurituvchi rotorining barqaror tezligiga ta'sir qilmas edi. Yurituvchining quvvati cheklanganda uning xarakteristikasi nazarga olinishi kerak. Ayniqsa, bu ta'sir rezonansga yaqin harakat rejimida yaqqol namoyon bo'lishi mumkin. Bunday rejimlar vibrator mexanizmga, ya'ni yo'naltirilgan tebranishni yaratuvchi qurilmalarga xarakterlidir.

- ▶ 11.1 – rasmda oddiy, markazdan qochma vibratorlarni sxemasi ko'rsatilgan. U  $m_2$  massali bo'g'in,  $c$  bikrlilik koeffitsiyenrli va  $m_1$  muvozanatlanmagan massali,  $J_d$  inersiya momently yurituvchi bilan aylantiriluvchi qayishqoq bog'lanishdan iborat. Massali bo'g'inni  $x$  o'qi yo'nalishda tebranishini inersiya kuchini  $x$  o'qi bo'ylab yo'nalgan garmonik qonunda o'zgaradigan tashkil qiluvchisi majbur qilgan *tebranish* deb ko'rish mumkin. Shunga mos markazdan qochma vibratorli mexanizm ***inersionli qo'zg'atuvchi tebranuvchi Sistema*** deyiladi.

## 11.2. Cheklangan quvvatli yurituvchili vibratorlari harakat tenglamasi

Harakat tenglamasini tuzishda  $m_1$  massaning harakati gorizontal tekislikda bo'ladi, "polzun-tayanch" juftligi  $F_t = \beta x$  ifoda bilan aniqlanadi deb qabul qilamiz. Mexanizmning kinetik energiyasi quyidagicha:

$$T = \frac{1}{2} (m_2 \dot{x}^2 + J_D \dot{\varphi}^2 + m_1 V_A^2)$$

bu yerda,

$$v_A^2 = \dot{x}^2 + r^2 \dot{\varphi}^2 - 2\dot{x}r\dot{\varphi} \sin \varphi$$

Yurituvchining xarakteristikasini quyidagicha berilgan deb hisoblaymiz:

$$M_{\mathcal{D}} = M_{\mathcal{D}}$$

Harakat tenglamasini Lagranjning ikkinchi darajali tenglamasidan (11.1 va 11.2) ifodalarni nazarga olib quyidagicha aniqlaymiz:

$$m\ddot{x} - m_1 r \ddot{\varphi} \sin \varphi - m_1 r \dot{\varphi}^2 \cos \varphi = -cx - \beta \dot{x}$$

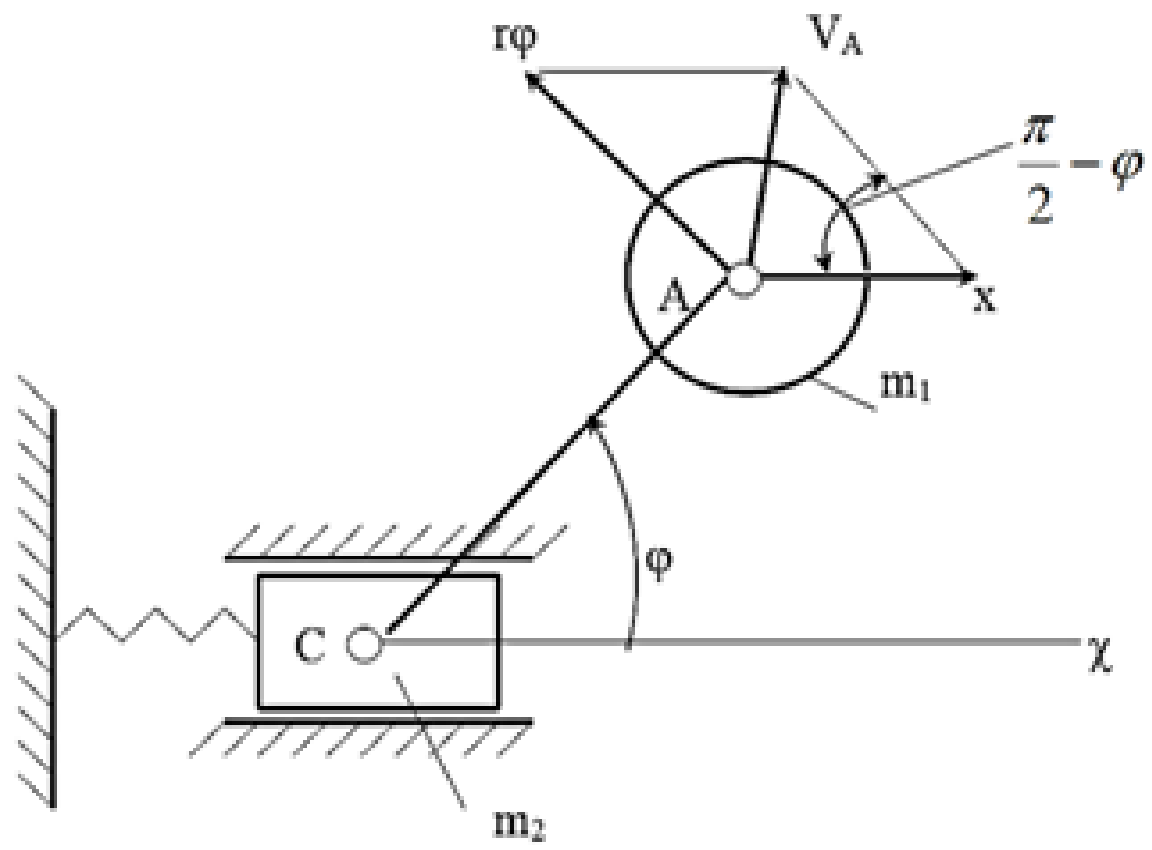
$$J\ddot{\varphi} - m_1 r \ddot{x} \sin \varphi = \tilde{M}_{\mathcal{D}}(\dot{\varphi}) \quad (11.3)$$

$m = m_1 + m_2$ ,  $J = J_0$  belgilarini kiritamiz. Harakat tenglamani Lagranjning ikkinchi darajali tenglamasidan (11.1 va 11.2) ni nazarga olib quyidagicha aniqlaymiz:

$$T = \frac{1}{2} m \dot{x}^2 + \frac{1}{2} J \dot{\varphi}^2 - m_1 \dot{x} r \dot{\varphi} \sin \varphi \quad (11.1)$$

Mexanizmning potentsial energiyasi:

$$\Pi = cx^2. \quad (11.2)$$



**11.1 – rasm. Markazdan qochma vibratori hisoblash sxemasi**

- ▶ Harakat tenglamasini sekin o'zgaruvchi paramaetrlar metodi bo'yicha standart shaklga keltiriladi. (11.3) dan kelib chiqib  $a$ ,  $b$  koeffitsiyentlarning kichik qiymatida va asta sekin o'zgaruvchi  $L$  da  $x$  siljish garmonik qonunda o'zgaradi,  $\varphi$  tezlanish esa kichik qiymatga ega deb taxminan hisoblash mumkin.
- ▶ Bunda  $x$  o'zgaruvchanni izlanadigan yechimini quyidagicha shaklda izlaymiz:

$$\text{▶ } X = A \cos(\varphi + \xi), \quad (11.5)$$

- ▶ bu yerda,  $A$  va  $\xi$  – sekin o'zgaruvchi parametrlar quyidagi nisbaat bilan bog'langan

$$\dot{x} = -A \sin(\varphi + \xi) \quad (11.6)$$

$\dot{X}$  hosila (11.5) ifodani differensiallash orqali topilishi mumkin:

$$\dot{X} = \dot{A} \cos(\varphi + \xi) - (\tilde{\omega} + \dot{\xi}) A \sin(\varphi + \xi). \quad (11.7)$$

(11.6) va (11.7) o'ng qismlarini tenglashtirib quyidagi olamiz:

$$\dot{A} \cos(\varphi + \xi) - \dot{\xi} A \sin(\varphi + \xi) = (\tilde{\omega} - k) A \sin(\varphi + \xi). \quad (11.8)$$

(11.8) differensiallaymiz:

$$\ddot{X} = -\dot{A} k \sin(\varphi + \xi) - (\tilde{\omega} + \dot{\xi}) A k \cos(\varphi + \xi). \quad (11.9)$$

(11.4) harakat tenglamalr sistemasi (11.5), (11.6) va (11.9) ni nazarga olganda quyidagi ko'rinishda bo'ladi:

$$-\dot{A} k \sin(\varphi + \xi) - \dot{\xi} A k \cos(\varphi + \xi) + A k (k - \tilde{\omega}) \cos(\varphi + \xi) = a \tilde{\omega} \sin \varphi + a \tilde{\omega}^2 \cos \varphi + A k h \sin(\varphi + \xi) \quad (11.10)$$

$$\dot{\omega} = L(\tilde{\omega}) - b \left[ \dot{A} k \sin(\varphi + \xi) + (\dot{\omega} + \dot{\xi}) A k \cos(\varphi + \xi) \right] \sin \varphi. \quad (11.11)$$

Bu sistemani sekin o'zgaruvchi parametrlar metodida standart shaklga mustaqil o'zgaruvchansifatida  $\varphi$  burchagi va  $d\varphi = \tilde{\omega}dt$  nisbatidan foydalanib keltirish mumkin:

$$\frac{d\tilde{\omega}}{d\varphi} = \frac{1}{\tilde{\omega}} [L(\tilde{\omega}) - Abk\tilde{\omega} \cos(\varphi + \xi) \sin \varphi],$$

$$\frac{dA}{d\varphi} = -\frac{1}{k\omega} [a\tilde{\omega}^2 \cos \varphi + Akh \sin(\varphi + \xi)] \sin(\varphi + \xi), \quad (11.12)$$

$$\frac{d\xi}{d\varphi} = \frac{k - \tilde{\omega}}{\tilde{\omega}} - \frac{1}{Ak\tilde{\omega}} [a\omega^2 \cos \varphi + Akh \sin(\varphi + \xi)] \cos(\varphi + \xi).$$

### 11.3. Harakatning statsionar rejimini tadqiqoti

(11.12) tenglamalar sistemasini soddalashtirilishini davom ettirish mumkin, agar  $\varphi$  burchagini 0 dan  $2\pi$  gacha o'zgarish davrida  $\tilde{\omega}$ ,  $A$  va  $\xi$  kattaliklarni o'zgarishi kichik va ularni  $\varphi$  burilishi burchagiga nisbatan hosilasini ularni o'rtacha qiymatiga teng deb hisoblash mumkin bo'lganda quyidagicha bo'ladi:

$$\frac{d\tilde{\omega}}{d\varphi} = \frac{1}{2\pi\tilde{\omega}} \int_0^{2\pi} L(\tilde{\omega}) d\varphi - \frac{Abk}{2\pi} \int_0^{2\pi} \cos(\varphi + \xi) \sin \varphi d\varphi$$

$$\frac{dA}{d\varphi} = \frac{a\tilde{\omega}}{2\pi k} \int_0^{2\pi} \cos \varphi \sin(\varphi + \xi) d\varphi - \frac{Ah}{2\pi\tilde{\omega}} \int_0^{2\pi} \sin^2(\varphi + \xi) \sin d\xi$$

$$\frac{d\xi}{d\varphi} = \frac{1}{2\pi\tilde{\omega}} \int_0^{2\pi} (k - \omega) d\varphi - \frac{a\tilde{\omega}}{2\pi Ak} \int_0^{2\pi} \cos \varphi \cos(\varphi + \xi) d\varphi - \frac{h}{\tilde{\omega}} \int_0^{2\pi} \sin(\varphi + \xi) \cos(\varphi + \xi) d\varphi$$

$\tilde{\omega}$ ,  $A$  и  $\xi$  kattaliklarini o'rtalash jarayoni bajarilishida o'zgarmas deb qabul qilamiz:

$$\int_0^{2\pi} \cos \varphi \sin \varphi d\varphi = 0, \quad \frac{1}{2\pi} \int_0^{2\pi} \sin^2 \varphi d\varphi = \frac{1}{2\pi} \int_0^{2\pi} \cos^2 \varphi d\varphi = \frac{1}{2},$$

integrallasdan so'ng quyidagini olamiz:

$$\frac{d\tilde{\omega}}{d\varphi} = \frac{1}{\tilde{\omega}} \left[ L(\tilde{\omega}) + \frac{b}{2} Ak \tilde{\omega} \sin \xi \right],$$

$$\frac{dA}{d\varphi} = -\frac{a\tilde{\omega}}{2k} \sin \xi - \frac{Ah}{2\tilde{\omega}},$$

(11.13)

$$\frac{d\xi}{d\varphi} = \frac{1}{\tilde{\omega}} \left( k - \tilde{\omega} - \frac{a\tilde{\omega}^2}{2Ak} \cos \xi \right).$$

Statsionar rejimni naoyon bo'lish sharti:

$$d\tilde{\omega} / d\varphi = 0, dA / d\varphi = 0, d\xi / d\varphi = 0$$

Bunday sharoitda statsionar harakat rejimini tenglamasi quyidagi ko'rinishda bo'ladi:

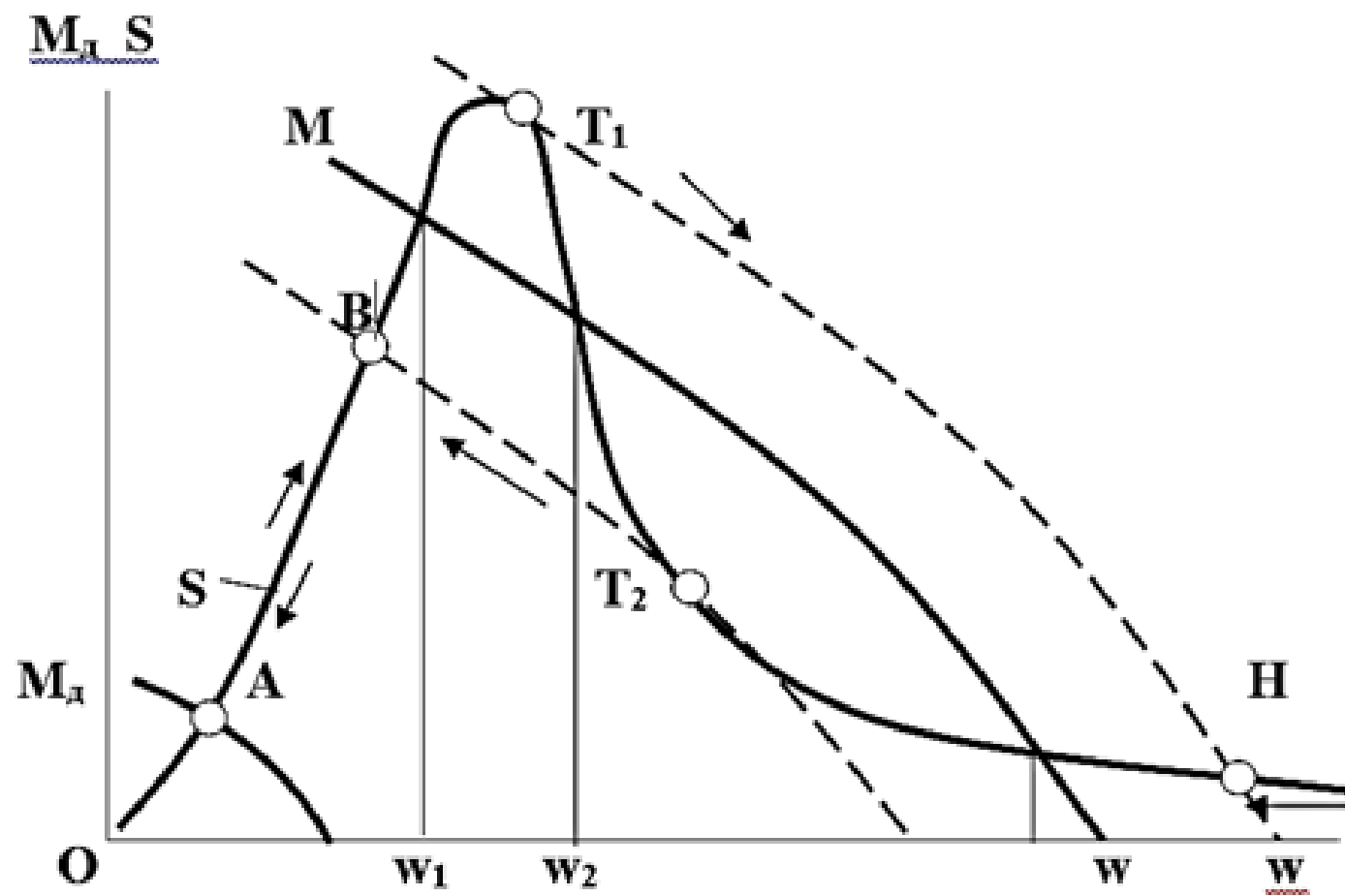
$$L(\tilde{\omega}) + \frac{b}{2} Ak \dot{\omega} \sin \xi = 0,$$

$$hA + \frac{a\tilde{\omega}^2}{k} \sin \xi = 0, \quad (11.14)$$

$$k - \tilde{\omega} - \frac{a\tilde{\omega}^2}{2Ak} \cos \xi = 0$$

## ▶ 11.4. Rezonansdan o'tish rejimi

- ▶ (11.11) tenglama yuirtuvchini statsionar rejimida burchak tezligini aniqlovchi bitta yoki bir nechta ildizlarga ega bo'lishi mumkin.
- ▶ 11.2 – rasmda  $S(\omega)$  kattaligini (11.18) formula bo'yicha mexanizmni doimiy parametrlarini  $\beta$ ,  $m_1$ ,  $m$ ,  $k^2$ ,  $r^2$  ba'zi kombinatsiyasi uchun o'zgarish grafigi keltirilgan.



11.2 – rasm.

## ***11.5. O'z- o'zini tekshirish savollari***

1. Markazdan qochma vibrator qanday ishlaydi?
2. Vibtarorli mashina agregatini harakat tenglamasini tuzish tartibini tushuntiring.
3. Vibratorning tebranish massasi yechimi qanday amalga oshiriladi?
4. Statsionar rejimda tebranish amplitudasi va chastotasi qanday bajariladi?
5. Rezonansdan o'tish sharti qanday xarakterlanadi?