Balancing rotors in one plane with multi-point vibration measurements

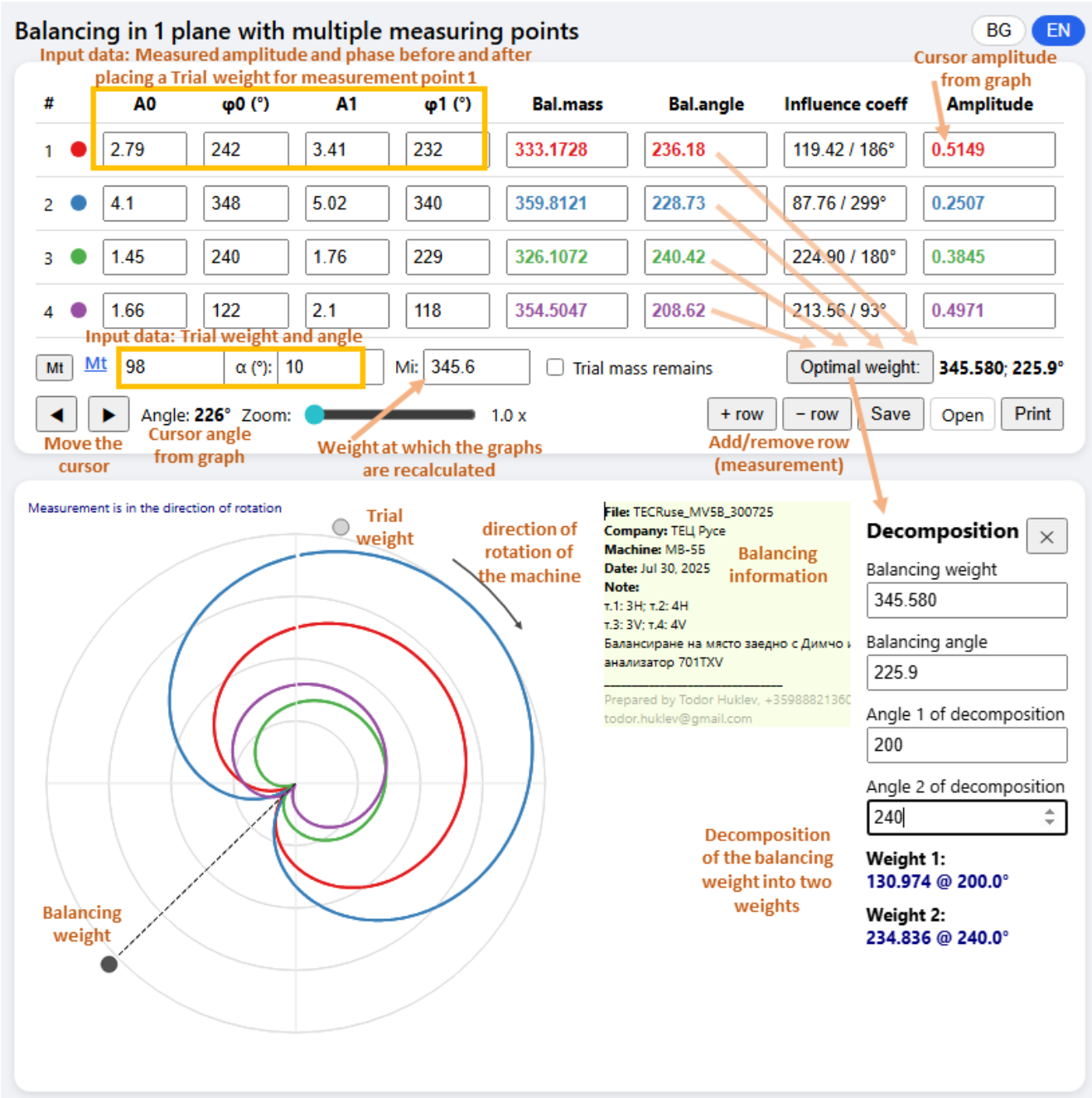
This type of balancing is necessary for certain types of machines that are balanced on-site. In such machines, there is another problem related to loosening, a structural issue, or something else. In these cases, for a number of reasons, this problem cannot be eliminated before balancing on-site. In these cases, when balancing, it can happen that vibrations at one measuring point decrease, but at a certain moment, at another point begin to increase. Then it is necessary to place such a balancing weight at which vibrations are minimal at all measuring points.

Balancing app capabilities:

- Calculation of unbalance with the possibility of optimizing according to several points of measurements of the machine, in different directions (vertically and horizontally), and on different bearing supports.
- Finding the optimal balancing weight and angle by minimizing the vibration energy of all measured points using the method of least squares with complex numbers. This value was previously searched manually from the graphs; now it is calculated automatically.
- The test weight remains/does not remain
- Angle of the weights depending on whether the measurement is in the direction of rotation or vice versa
- Calculation of the required test weight
- Saving the balancing data to a file and loading the saved data from a file
- Language English / Bulgarian
- Printing and saving to a pdf file

The application is universal and works on:
Windows, macOS, Linux, Chrome OS, Android, iOS.

Application description



To install it, you need to load it in the Chrome browser. After that, an installation icon will appear in the upper-right corner of the browser. It can be installed on a computer, laptop, tablet, or phone under operating systems: Windows 10/11, macOS, Linux, ChromeOS, Android, iOS.

Optimization and finding the balancing weight

Моделът за всяка измервателна точка

За **всеки ред i** (измервателна точка) имаме:

- базов вектор на вибрацията (след махане или оставане на пробната маса):

$$z_{0,i} \quad \text{(complex)}$$

- комплексен коефициент на влияние:

$$s_i \quad \text{(complex, от A0}\rightarrow\text{A1 с пробна маса)}$$

Ако сложим някаква **коригираща маса** (m) (също комплексно число – маса + ъгъл), вибрацията в i-тата точка става:

$$z_i(m) = z_{0,i} + s_i\, m$$

Целта е да намерим **едно общо m** за всички точки, така че **общата вибрация да е минимална**.

Какво минимизираме?

Най-естественият критерий е сумата от квадратите на амплитудите:

$$J(m) = \sum_{i=1}^{n} |z_i(m)|^2 = \sum_{i=1}^{n} |z_{0,i} + s_i m|^2$$

Това е „енергията“ на вибрациите във всички точки.

Искаме:

$$m_{\text{opt}} = \arg\min_m J(m)$$

Получената формула за оптималното комплексно m_{opt}

Класическия резултат (комплексен метод на най-малките квадрати) дава **затворена формула**:

$$m_{\text{opt}} = -\frac{\sum_{i=1}^{n} \overline{s_i}\, z_{0,i}}{\sum_{i=1}^{n} |s_i|^2}$$

където:

- $\overline{s_i}$ е комплексно-съпрегнатото на s_i
- $|s_i|^2 = s_i\, \overline{s_i}$

След това вече:

- **модул на коригиращата маса:**

$$M_{\text{opt}} = |m_{\text{opt}}|$$

- **ъгъл на коригиращата маса:**

$$\theta_{\text{opt}} = \arg(m_{\text{opt}})$$

It should be noted that the least squares minimization criterion does not give the best solution with absolute accuracy. This is because another function is minimized - the sum of squares, while we are looking for the minimum of the real amplitudes.

For this purpose, additional optimization has been made after using this criterion.