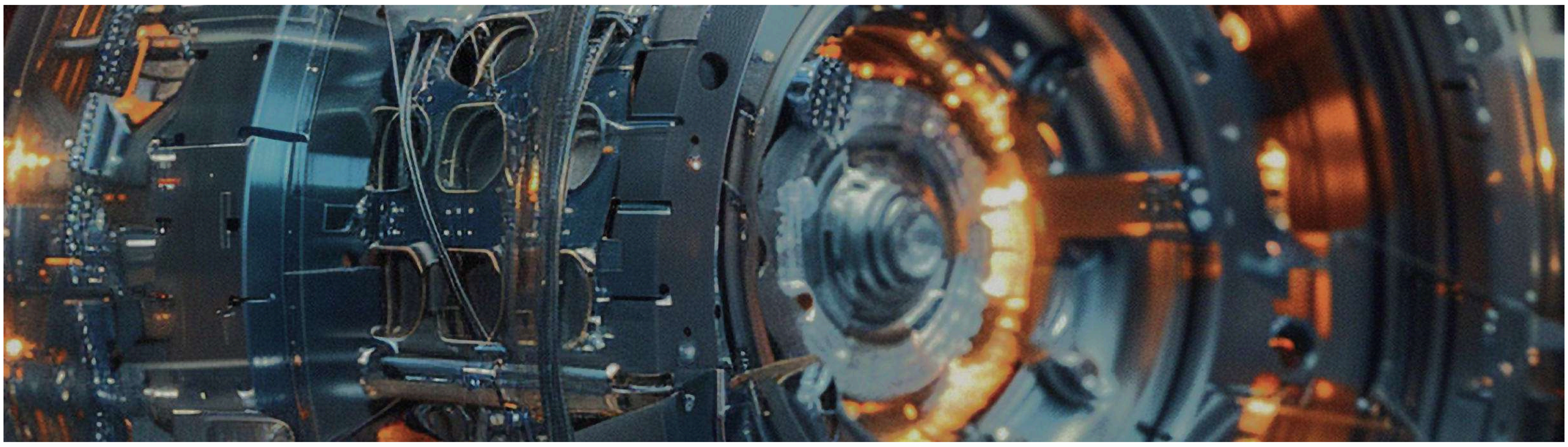
USE TECH

CUSTOMER CASE STUDY

VIBROMONITORING
BALANCING TECHNOLOGY

OVERVIEW

Vibromonitoring— is a method of equipment technical condition monitoring based on vibration data mathematical analysis. On of the most important ways to increase the efficiency and reliability of equipment is constant monitoring of its technical condition. Diagnostics is an integral part of repairs, allowing the user to identify equipment defects and analyze causes of its failure. The solution is based on the technology of three-dimensional vibrations recording at a surface point. The feature of the technology is the lack of phase and time delays among the axes (4D = 3D + time / synchronization). The analysis of the turbine trajectory vibration pattern is carried out, and any abnormalities, defects and cracks are revealed. This allows the user to conduct three-dimensional balancing of large turbines, eliminate imbalance and establish the vibration plane.



ADVANTAGES OF TECHNOLOGY

- Our measures and analyzes complex vibrations and determine precisely how they arise in nature (i.e. measurement approach corresponds with physical nature of vibration)
- The technology is based on measuring the three-dimensional vibration at any point on the surface of an object and therefore takes into account spacial movement of vibrating point
- Building a more complete and informative trajectory image
- Objects' total energy numerical evaluation (too high energy level leads to breakage/accident, shows state of the equilibrium, etc.)
- Always kept time information between axes (4D = 3D + time / synchronization)

PROBLEMATICS:

- **Excessive repair costs**

  Scheduled repairs are conducted to reduce equipment failures and maintain its good working condition. At the same time, scheduled repairs involve both faulty and non-faulty parts replacement.

- **Equipment downtime because of failure**

  Unpredictable failures lead to unforeseen equipment downtime and financial losses. Moreover, each emergency stop breaks the manufacturing process and causes extra risks and financial losses.

- **Large assortment of operating equipment**

  Operating a wide variety of equipment is not critical, but leads to some problems, which may cause financial losses, i.e., difficulties related to repairs and maintenance planning, inventory management, etc.

BRIEF DESCRIPTION OF THE 4D METHOD OF DYNAMIC BALANCING

1. For balancing all three components X, Y and Z of the vector of disbalance are used.
2. The vector of disbalance is considered the real vector of vibration witn maximum length wich is built on rotational speed.
3. For balancing new rotor with two balancing e it is necessary to make three runs:
   - empty run
   - run with known weight on the left balancing plane (trial)
   - run with known weight on the right balancing plane (trial)
4. After this the software returns: mass of the weight and its position (angle) on the left plane; mass of the weight and its position (angle) on the right plane.
5. After 4D balancing the total energy of the system was decreased by 2.5– 7 times comparing to the conventional balancing of the same rotor.
6. The method can be easily adapted to multy-plane balancing.

VIBROMONITORING:
THE WAY TO IDENTIFY DEFECTS

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THREE-DIMENSIONAL VIBRATION MEASUREMENT

Our method is based on three-dimensional vibration measurement at a surface point. This innovative method allows us to draw a detailed three-dimensional phase pattern, which would be substantially changed by any defect.

THREE-DIMENSIONAL VIBRATION MEASUREMENT

Reducing the number of iterations leads to a decrease in balancing weights and the total weight of the system to be balanced. The initial consideration of vector imbalance of components makes it possible to perform balancing with no additional adjustments.

REAL-TIME VECTOR MEASUREMENT

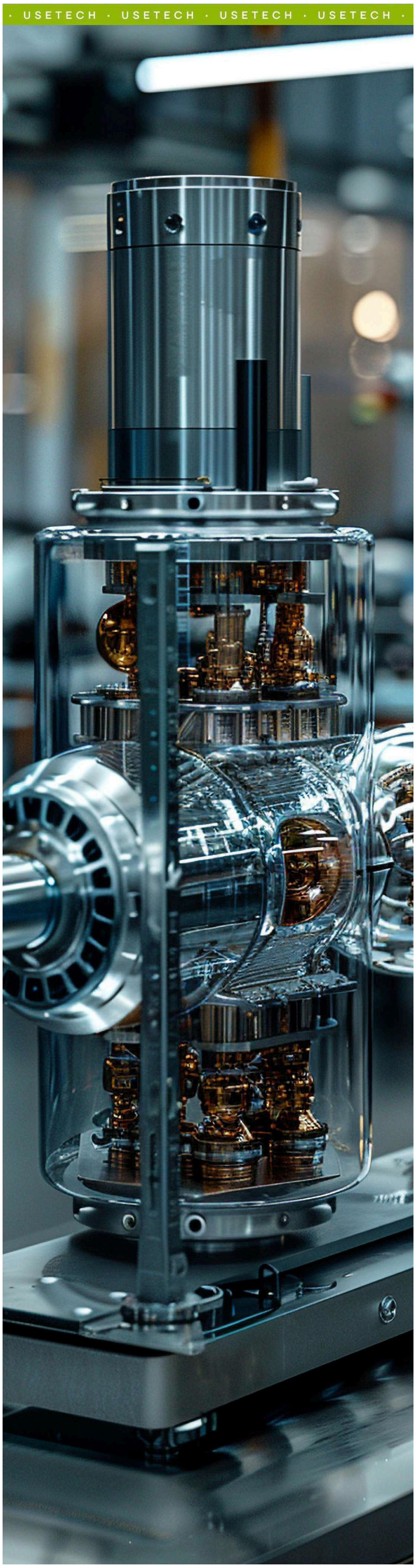
Through real-time vibration vector measurement at a particular material surface point, our method ensures more informative data representation as compared to traditional techniques. This is due to the lack of phase dispersion among measurement channels or axes, which increases the informative value.

SYSTEM ENERGY ASSESSMENT

Three-dimensional vector measurement allows us to assess the vibrational system energy in order to reduce total energy after one-dimensional balancing. This includes solving the problem of real three-dimensional vector imbalance and axial vibration.

THREE-DIMENSIONAL VIBRATION MEASUREMENT

Our method is versatile, it is suitable for dynamic balancing of all rotor types and allows us to perform balancing of a flexible rotor with 1–3 modes using the same number of iterations as for a rigid one. Such efficiency is achieved due to precise assessment and less non-matching vibrations on X and Y axes.



THEORETICAL BACKGROUND

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1. Oscillating processes in objects of mechanical systems reflect the stress-strain states (SSS) emerging as a result of external impacts (force, force moment or distributed stress thereof) or internal power factors (stress leading to defects in the material and/or the structure/detail). The impact may result in local displacements or deformations of the object under observation.

2. Both impact and deformation are of energy origin. Therefore, it is accepted to assess the degree to which impacts influence the object's performance properties through vibration parameters and, in the general case, through oscillation parameters (spectrum of elastic harmonic oscillations, impact, complex elastic-plastic process, etc.). Widly-spread amplitude analysis is the simple approximation of an average SSS assessment.

3. In fact, each point of the observed object by the classical mechanics laws for elastic continuums oscillates along a hodograph (elliptic trajectory) at each frequency of the observed spectrum (superposition) of oscillations. This also refers to stress (Lamé theorem) and strain (Cauchy stress tensor).

4. Stress reflects the kinetic energy of impacts whereas strain – the potential energy of the resistance of the elastic continuum to these impacts. This holds true for the full spectrum of observed frequencies.

5. The sum total of kinetic (Ekin) and potential (Epot) energy determines the perturbed level of the object (EΣ) which must be evaluated (to be subject to diagnostics from the standpoint of operational danger) and eliminated. This is why vibration diagnostics and vibration regulation (balancing) are performed.

6. However, each process in the spectrum of oscillations (frequency spectrum) has its spatial reason (stress) and space-oriented consequence (strain). This very set of diagnostic parameters is related to each diagnostic frequency phase (or time) through measurable 3D components.

7. In this way, by way of measuring the time-space (vector-phase) diagnostic 3D parameters of oscillations in the form of a 4D-hodograph spectrum, one may quantitatively evaluate the perturbed level through total energy EΣ which is proportionate to the area of the hodograph at each diagnostic frequency.

8. A mechanical system which functions properly in compliance with the design has minimum EΣ and any levels in excess of the relative design (proper) level of oscillations testify of pathology (failure) which must be subject to diagnostics. Besides, statistical levels of critical diagnostic parameters are known which, if exceeded, pose the risk of failures and accidents.

BENEFITS OF 4D DYNAMIC BALANCING

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1. Great amount of valuable information

in comparison with known methods by considering the phase of signal between channels– the measuring axes. Our method is based on measurements of the real oscillation vector at every point in time at a real physical point on the surface of an object.

2. Energy estimation of the system's oscillations.

Since we are measuring the 4D vector, we can measure and evaluate the energy of the system's oscillations, which is a prerequisite for high-quality balancing. The method allows us to perform quality control of standard one-dimensional balancing. Our experiments showed that the total energy of the system after one-dimensional balancing can be reduced by using the balancing on vibration changes along other directions. We have proposed a way of three-dimensional balancing based on reducing the real 3D unbalance vector and not its one-dimensional projection, as it is implemented in standard systems that use a single-component vibration sensor.

3. Two sensors - three modes.

While the soft rotors are spinning, volume oscillations of a certain form occur and they correspond to the form of modes, which are detected by our sensors. This information allows us to balance the soft rotor with one to three modes for the same number of iterations as the hard one; i.e. our method is a multipurpose method for the dynamic balancing of all types of rotors.

4. Reducing axial vibration.

During the calculation of the balancing weights we reduce all 3 components of vibration including axial vibration, because our balancing method is based on measuring the three-dimensional vector. This is proven by our experiments.

5. Evaluation and reduction of MISMATCHED oscillations on X and Y.

Our experiments have shown that the unbalance vector projection on the balance planes has unequal components. By default, when balancing using the single-component sensor, it is considered that these projections are equal to each other. This requires additional launches during balancing, which consume time, resources and materials. Our method primarily considers this fact, allowing us to perform balancing without an additional adjustment of results.

6. Reducing the number of weights and their masses.

It is worth noting that performing additional iterations during balancing leads to an increased number of balancing weights, resulting in an increase of their combined mass, and therefore an unreasonable increase of the balanced system.

RESULTS:

Early diagnostics and forecasting systems for the technical condition of production equipment are indispensable for improving the efficiency of a company's production assets. The vibration monitoring system not only prevents emergency shutdowns but also predicts the remaining service life of equipment and its components. As a result, defects and breakdowns identified at early stages help extend the lifespan of the equipment and increase production efficiency.

- Actual equipment condition monitoring
- Maintenance costs optimization
- Increase in consistency of operation
- Repairs scheduling on the basis of actual equipment condition analysis
- Repair interval extension due to unreasonable scheduled repairs elimination
- Increase in efficiency of equipment and production

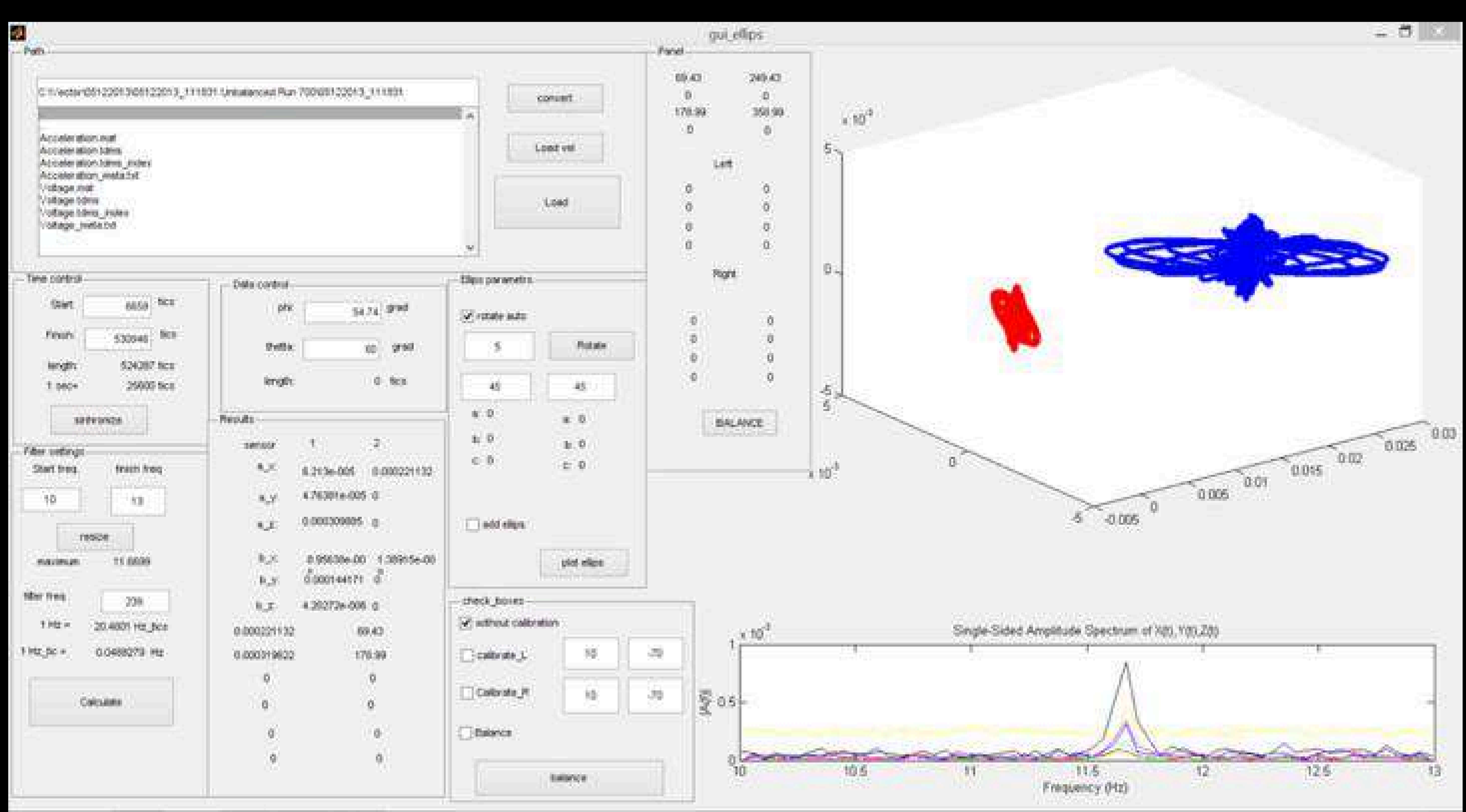
20%

reduction in maintenance and repair costs

Up to 10%

extension of equipment lifespan

Vibration Vector before balancing



Vibration Vector after balancing