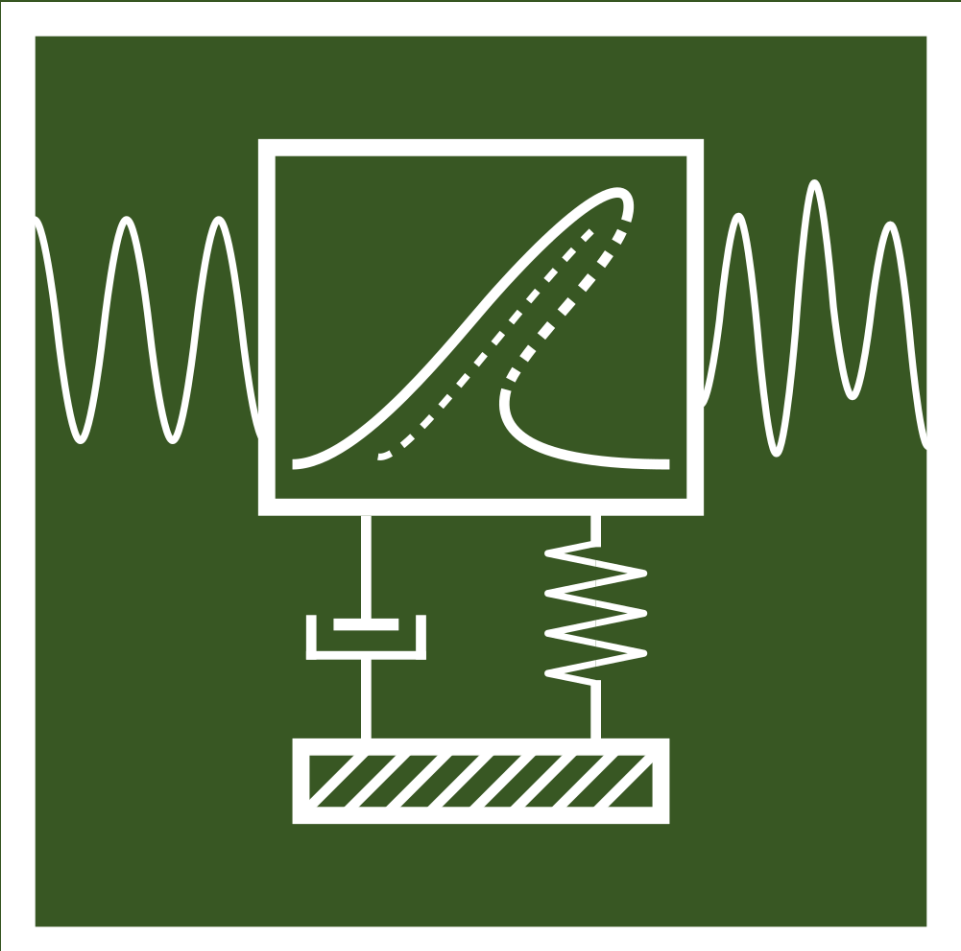


From pneumatic vibrotransducers to graphic technology engineering. KTU research 1969-2026



Edmundas Kibirkštis¹, Kęstutis Vaitasius¹, Darius Pauliukaitis¹, Ingrida Venytė¹, Laura Gegeckienė¹, Kazimieras Ragulskis

¹ Department of production engineering, Kaunas university of technology, Kaunas, Lithuania

Corresponding author e-mail: edmundas.kibirkstis@ktu.lt

A Abstract

Over the past 57 years, research on self-excited pneumatic vibrotransducers operating in the auto-oscillation mode has been developed at KTU. The pioneers of this research at the KTU Vibrotechnical Science Center were dr. A. Galinskas, prof. habil. dr. K.M. Ragulskis, prof. habil. dr. R.Bansevičius and dr. A. Šermukšnis (since 1969). The theory in this area was further developed by prof. habil. dr. E. Kibirkštis and his doctoral students - dr. K.Vaitasius and dr. D.Pauliukaitis. Multifunctional vibrotransducers with several degrees of mobility, harmonic and non-harmonic laws of motion, were investigated. After the establishment of the KTU Polygraphy Science Laboratory (1997), and later the Department of Graphic Communications Engineering (2000), research into printing and packaging technologies, Braille was developed. In this area, 6 doctoral dissertations were defended: supervisor prof. E. Kibirkštis, (A.Kabelkaitė, A.Dabkevičius, L.Gegeckienė, I.Venyte, V.Miliūnas, V.Bivainis). Particularly significant in this area were the works of Academician K.M.Ragulskis and dr. L.Ragulskis.

01 Methods

A test stand was constructed for the investigation of pneumatic vibrotransducers (Fig. 1 c,d). Modern methods for measuring vibrations were used in the experimental studies. In the theoretical study, the De Saint Venant and Vantzel equations and Runge-Kutta method was used to solve a system of nonlinear differential equations, based on a variable and a fixed number of integration steps. The solution was obtained using MATLAB software.

The photoelasticity method was used to investigate packaging technologies and Braille dots and relief elements in polymeric films, determining the distribution of residual stresses that may affect the qualitative parameters of Braille. A special experimental setup was assembled to conduct the stress analysis; its schematic diagram and general view are shown in Fig. 2 a,b. In addition, methods of mathematical and statistical analysis were used for the calculations.

An experimental methodology was applied to investigate the packaging, including static and dynamic loading tests of cardboard packages with different geometries, uniaxial tensile tests in the machine and cross-machine directions, stress-strain analysis, vibration and shock-load testing (Fig. 2 c), and evaluation of the effects of packaging geometry and structural elements on mechanical performance and stability under static and dynamic loading.

02 Results

The characteristics of transient processes, operating modes, and stable vibration characteristics of pneumatic vibrotransducers were determined. The results of the synchronization of the two pneumatic vibrating exciters were obtained by installing connection channel between the excitation chambers and applying pulsating pressure component (Fig. 3 a,b). The obtained results of researches could be used for design of vibrating mechanical systems.

The study of Braille dots and relief elements showed that residual stresses develop during forming, with the highest stresses occurring on the element surfaces, potentially reducing product durability. The stress distribution was evaluated using numerical modelling and a proposed numerical methodology (Fig. 3 e,f).

The research demonstrated that the mechanical performance of cardboard packaging is strongly influenced by its structural design, geometry, and the configuration of individual packaging elements. The influence of packaging shape and geometric parameters on its response to static and dynamic loads was investigated. In the process, were founded by optimising the design of cardboard packaging, material use can be reduced by approximately 30% while maintaining the required mechanical properties.

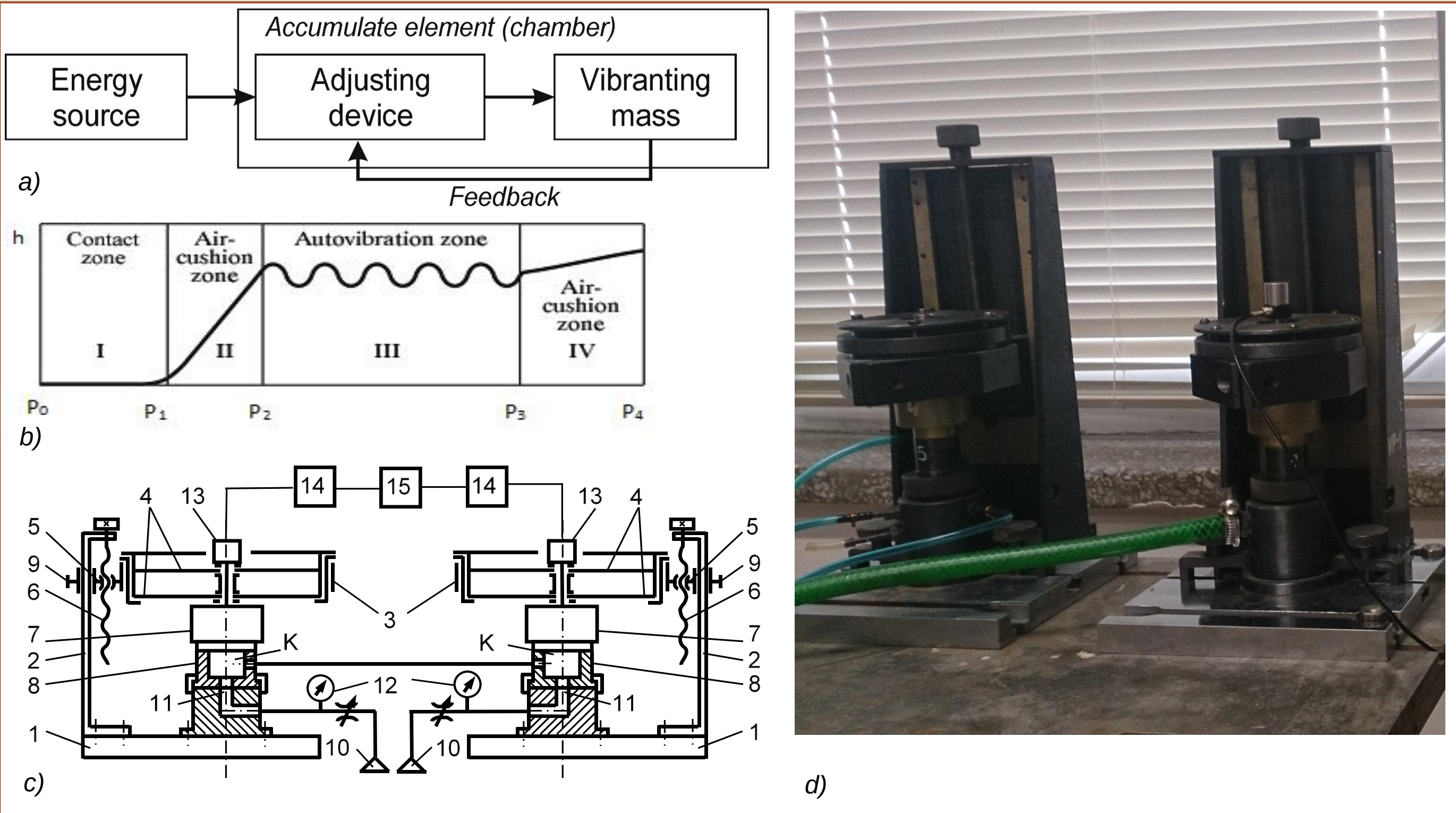


Fig 1. Scheme of system operating in autovibrations regime (a), operating regimes of working body of pneumatic vibroexciters (b), structural scheme (c) and general view (d) of pneumatic vibroexciters connected via synchronization channel.

03 Discussion

Other methods can be used to describe theoretical studies of pneumatic vibroactuators operating in the self-oscillation mode and the synchronization of multiple vibroexciters.

The obtained findings are used for improving the Braille forming on polymeric materials and the designing of relief elements.

By optimising the design of cardboard packaging, material use can be reduced by approximately 30% while maintaining the required mechanical properties.

04 Conclusions

An experimental stand and mathematical model of nonlinear equations has been created that describes the dynamics of two vibroexciters. The results obtained allow to argue that mathematical model helps to solve deeply the dynamics of mechanical system. Several different vibroexciters synchronization methods were proposed and various papers in this field were published.

Braille areas with highest values of equivalent stresses were determined where begins the decrease.

Packaging shape and geometric parameters were found to significantly influence structural performance under both static and dynamic loading conditions.

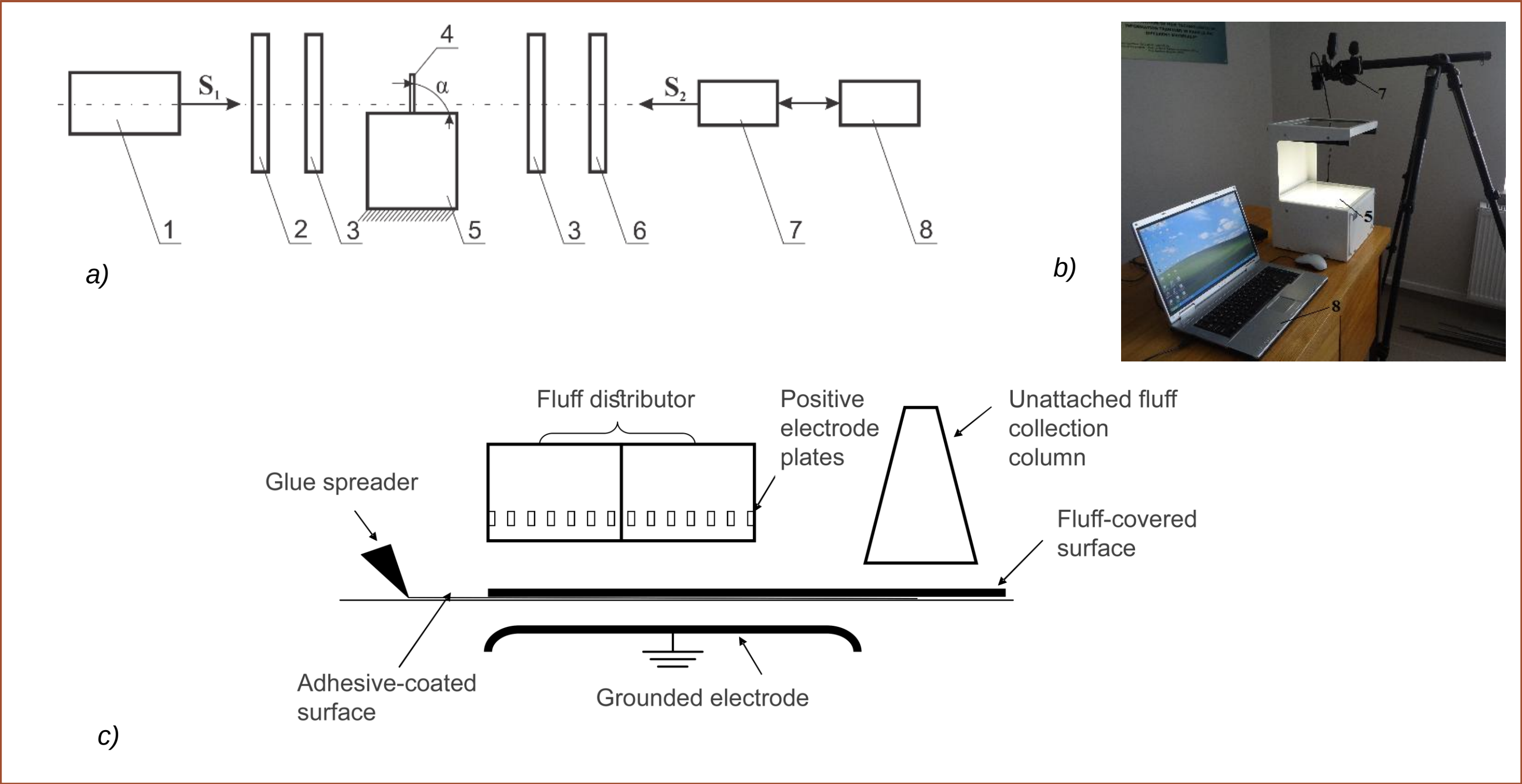


Fig 2. Schematic diagram of the stress analysis (a) and a general view (b) of the testing bench for determining stress distribution in Braille dots and relief elements using the photoelasticity method, (c) schematic diagram of flock application using the vibration method.

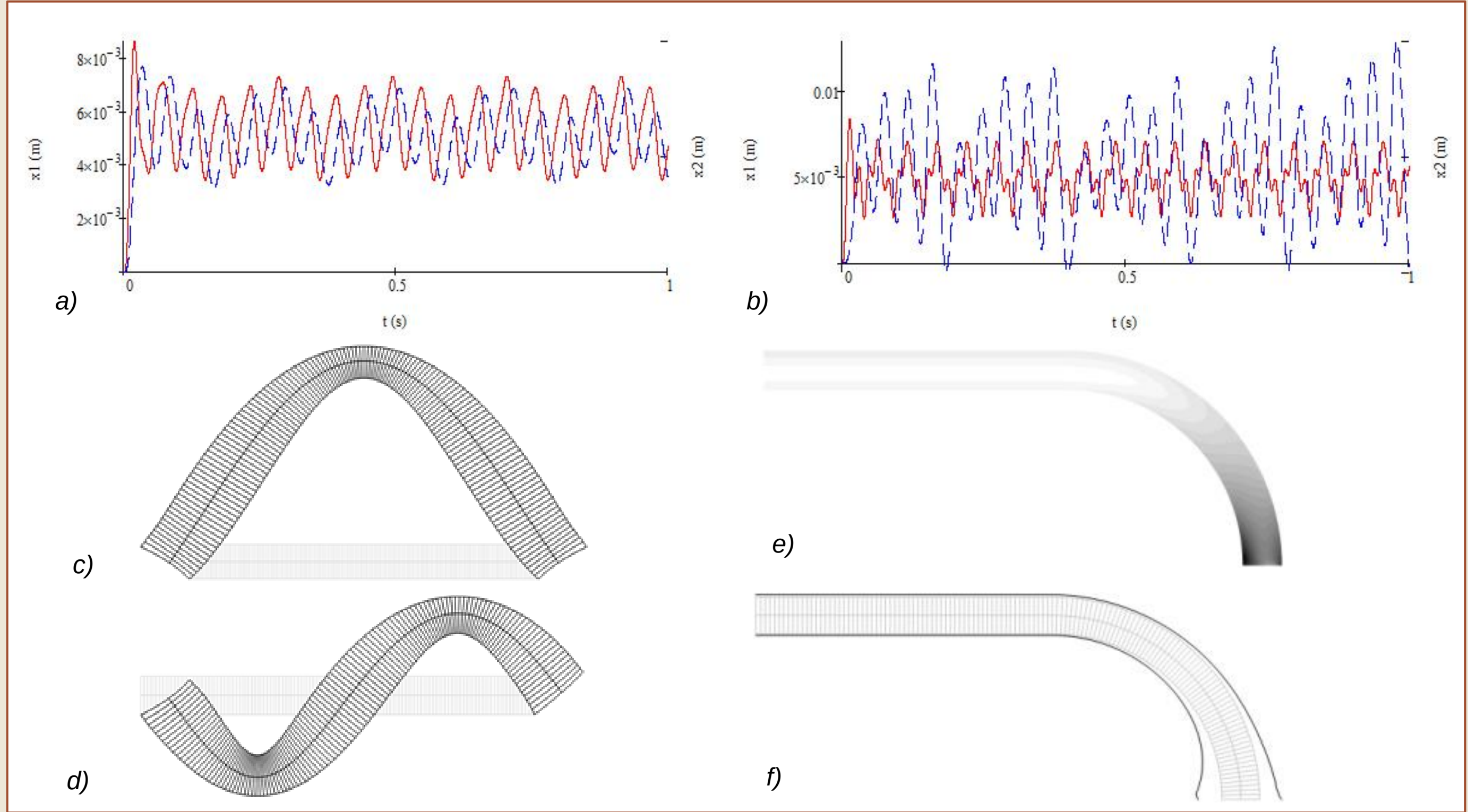


Fig 3. Primary results: vibrations of both working bodies of vibroexciters without (a) and with (b) aerodynamic link of synchronization, (c) first natural mode of vibration, (d) second natural mode of vibration, and equivalent stresses in the Braille dots and relief element (e) and equivalent stresses on the lower and upper surfaces (f).

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