

SKÚMANIE ZVYŠOVANIA TEPLoty PRUŽNÝCH ELEMENTOV POUŽÍVANÝCH V DOPRAVNÝCH ZARIADENIACH

Jozef Krajňák, Pavol Tarbajovský²

¹Faculty of Mechanical Engineering, Technical University of Kosice Letna 9, 042 00, Kosice, Slovak
Republic e-mail: jozef.krajnak@tuke.sk,

²Faculty of Mechanical Engineering, Technical University of Kosice Letna 9, 042 00, Kosice, Slovak
Republic e-mail: pavol.tarbajovsky@tuke.sk.

RESEARCH ON THE TEMPERATURE INCREASE OF FLEXIBLE ELEMENTS USED IN TRANSPORTATION EQUIPMENT

Abstract: *This article examines elastic elements used in various transport and handling equipment. The article examines the increase in rubber temperature during dynamic loading of elastic elements. It investigates whether there is an increase in the temperature of elastic elements used in transport and handling equipment and whether this increase in temperature can cause a failure of the transport equipment.*

Key words: *elastic elements, transport equipment, handling equipment, temperature, rubber.*

INTRODUCTION

Flexible elements are used very often in transportation equipment. They are important for shock absorption, force transmission, vibration compensation, maintaining preload or flexible connection between parts of mechanisms.

They are used in conveyors for springs and silent blocks - they absorb shocks when starting and stopping the belt conveyor, tensioning elastic elements - they maintain the necessary belt tension, flexible couplings - they connect the engine with the gearbox or shaft, reduce shocks during start-up and rubber rollers and damping pads - they reduce noise and wear when transporting material. They are also used in the design of elevators and lifting equipment. Flexible elements serve as shock absorbers - they absorb shocks when moving the cabin. Spring buffers - under the cabin or counterweight serve as safety elements. Rubber stops - they limit hard impacts when reaching the end position.

Cranes and handling equipment can be included in the group of elements where elastic elements are also used. Spring buffers - they protect the structure from dynamic shocks during lifting or braking. Flexible couplings and shafts – transmit torque without damage during sudden changes in load. Rubber segments – are used in pulleys and drums to reduce rope wear.

Flexible elements are used in trolleys and track equipment and in transport and logistics robots. They reduce vibrations and protect the load. They reduce noise and shock transmission to the structure [4].

These flexible elements are made of rubber. Heat has a significant effect on rubber – it changes its physical, mechanical and chemical properties. This effect depends on the type of rubber (natural, synthetic, silicone, nitrile, etc.), the temperature and the length of exposure.

At normal elevated temperatures (up to 70 °C), rubber softens and becomes more flexible, it can temporarily elongate under load, and its properties are mostly restored when cooled.

At higher temperatures (70–120 °C), accelerated aging begins – a process called thermal degradation, hardening occurs (it loses elasticity), it can crack or deform, the color changes and the surface can become dull or sticky.

At very high temperatures (above 150 °C), polymer chains decompose, the rubber chars or burns, completely losing its flexibility and mechanical strength [1].

Long-term exposure to heat and even slightly elevated temperatures over a longer period of time cause rubber aging - hardening, reduced elasticity and strength, changes in dimensions or shape (e.g. deformation of seals), and deterioration of resistance to chemicals and UV radiation [2].

The aim of this article is to determine whether there is an increase in the temperature of flexible elements used in transport and handling equipment and whether this increase in temperature can cause a failure of the transport equipment.

FLEXIBLE PNEUMATIC ELEMENTS UNDER INVESTIGATION

In the measurement, we used double-corrugated elastic elements commonly used in transport and handling equipment in elevators and conveyors. shown in Fig. 1. We use these elastic elements in our laboratories. The diameter of this elastic element is 70 mm and the height is 90mm.

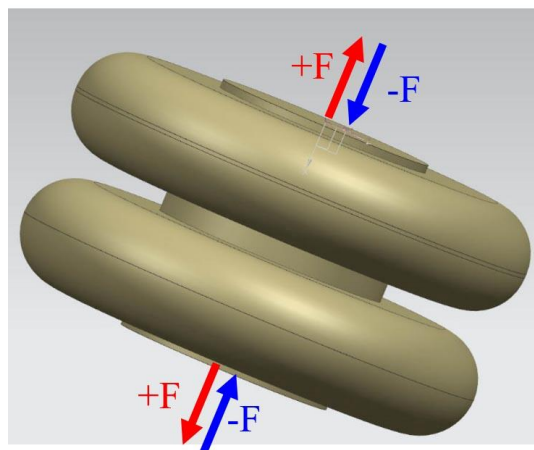


Fig. 1 Diagram of an elastic element with load direction

We loaded this double-wave element with alternating stress in the direction of the force +F and in the opposite direction -F. The directions of these forces can be seen in the schematic representation of the element.

TEST DEVICE FOR TEMPERATURE MEASURING

The test device is precisely illustrated in our previous article. [3]. It consists of an electric motor that drives the crank mechanism through a belt drive. The flexible pneumatic elements are mounted in a rigid frame designed from solid structural steel. For the amplitude of movement, we used a DC electric motor SM 160L with a power of 16 kW with an additional thyristor speed controller of the IRO type with the possibility of continuously changing the speed from 0 to 2000 min⁻¹. To measure the air temperature inside the flexible element T_{air} , we used two digital multimeters M-3870D METEX with an ETP-003 temperature probe and a measurement range of $-50\text{ }^{\circ}\text{C}$ to $+250\text{ }^{\circ}\text{C}$. The temperature probes were placed on the flexible element.

Testing rig was thermally insulated. The part of thermal insulation of testing rig is visible. During experiments, a stable temperature was maintained in isolated volume around the testing rig. Temperature of the surroundings (which is the same as all the temperatures throughout the system at time $t = 0\text{ s}$) was $T_0 = 22\text{ }^{\circ}\text{C}$.

Sampling resolution was 1 min. Temperatures were recorded at times $t = 1, 2, 3, 4, 5 \dots 30$ min at constant frequency and amplitude of oscillations and varying air pressure. During experiments, the influence of the environment was minimized by the use of thermal insulation and by maintaining stable temperature conditions around the testing rig. The maximum resolution of temperature probes was $0.5\text{ }^{\circ}\text{C}$.

The reference value of frequency in the experiment was $f = 13.5\text{ Hz}$. This operating condition represents the resonance condition. Air pressure inside the pneumatic flexible member took up discrete values: $p = 200$ and 600 kPa . The amplitude of linear displacement at the flexible member was constant: $A = 4\text{ mm}$. The results of measurements were plotted. Figs. 2–3 display the temperature evolution recorded by all three probes at oscillation frequency of $f = 13.5\text{ Hz}$ and at

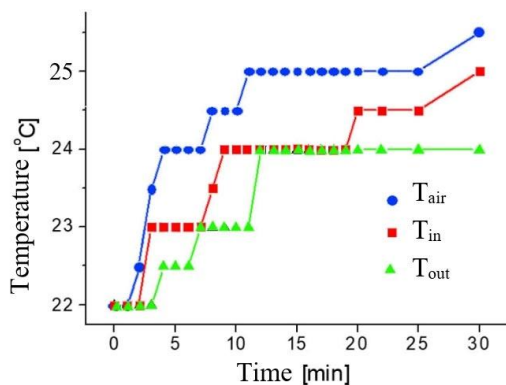


Fig. 2 Temperatures as a function of time at pressure changes of 200kPa in the elastic element.

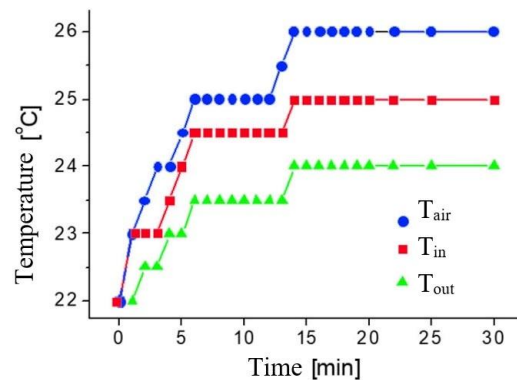


Fig. 3 Temperatures as a function of time at pressure changes of 600kPa in the elastic element.

All three temperatures stabilized at the same time. Maximum temperatures are $T_{air} = 26\text{ }^{\circ}\text{C}$ for air inside, $T_{in} = 25\text{ }^{\circ}\text{C}$ for inner surface and $T_{out} = 24\text{ }^{\circ}\text{C}$ for outer surface. If we compare the results from the measurements presented in Figs. 2,3, we can say that the air temperature inside the tire flexible member T_{air} reached maximum values in the range 25–26 $^{\circ}\text{C}$. At low pressures 200 kPa the air temperature T_{air} reached the maximum value 25.0 $^{\circ}\text{C}$ after 10 min of measurement already.

At higher pressures (600 kPa), a stable temperature of 26 °C was reached only after 15 min of measurement. Interestingly, at these higher pressures the temperature throughout the system stabilized at the same time. On the contrary, the biggest difference in measured stabilization times was recorded at low pressures.

CONCLUSION

This article investigated the increase in temperature of an elastic element used in transport equipment. These elements are subjected to dynamic stress in these equipment, which can increase their temperature and thus cause changes in the properties of the rubber and thus damage to the entire transport equipment. After performing measurements on the test equipment, we can state:

- The temperature stabilized after 10 to 15 minutes during the measurement and then did not change.

- Pressure does not have much effect on the change in temperature.

- The increase in temperature is not significant - it does not change the properties of the rubber that could cause a malfunction or damage to the transport equipment.

We can therefore state that the elastic elements can withstand dynamic loads in various transport equipment and there is no significant increase in temperature that would be dangerous for us.

LITERATURE

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