Study of machining accuracy in ultrasonic elliptical vibration cutting of alloyed iron alloy carbon with a germanium

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Abstract. Engineering materials refers to the group of materials that are used in the construction of manmade structures and components. The primary function of an engineering material is to withstand applied loading without breaking and without exhibiting excessive deflection. The major classifications of engineering materials include metals, polymers, ceramics, and composites. The germanium is an excellent material for infrared optical devices, whereas ultraprecision micro-machining of the germanium is difficult due to its brittleness. In Uzbekistan, alloyed engineering materials are mainly produced by the “Almalyk” plant and “Navoi” plant. Mechanical processing of these materials is one of the problems of today. The article analyzes the process of ultrasonic vibration treatment of an alloyed iron alloy carbon with a germanium alloy. Experiments were carried out in the mechanical processing departments of the plant 'Almalyk'. Graphs are given based on the results obtained. Based on the results of the experiment, the conclusion was given.

1. Introduction
Technically, germanium is classified as a metalloid or semi-metal, one of a group of elements that possess properties of both metals and non-metals. In its metallic form, germanium is silver in color, hard, and brittle. Germanium's unique characteristics include its transparency to near-infrared electromagnetic radiation (at wavelengths between 1600-1800 nanometers), its high refractive index, and its low optical dispersion. The metalloid is also intrinsically semi conductive.
Germanium transistors had a tendency to fail at high temperatures, a problem that could be solved with silicon. An estimated 60% of germanium used in IR systems is now recycled. The largest germanium producing nations are led by China, where two-thirds of all germanium was produced in 2011. Other major producers include Canada, Russia, the USA, and Belgium. Major germanium producers include Teck Resources Ltd., Yunnan Lincang Xinyuan Germanium Industrial Co., Umicore, and Nanjing Germanium Co. In Uzbekistan, alloyed engineering materials are mainly produced by the Almalyk plant [1,2]. Mechanical processing of materials based on Germanium alloy is a problem of the machine industry today.

2 Materials and methods
The important manifestations of incomplete elasticity of materials relates to the elastic aftereffect. It indicates that not all reversible deformation of the metal is purely elastic. The effect of an elastic aftereffect, a part of the elastic deformation grows instantly, and the rest develops overtime. Elastic aftereffect is the phenomenon of relaxation, consisting in the change with time of the deformed state of a solid body at a constant stressed state [3,4]. The elastic aftereffect is
characterized by the unambiguity of the equilibrium conditions (complete recoverability) between stress and strain, the equilibrium value of which is reached after a sufficient time has passed. The duration of the change — the relaxation time — depends on the mode and temperature of the deformation, as well as on the prehistory and the properties of the solid. The Bauschinger effect is to reduce the resistance to plastic deformation when the sample is reloaded. The Bauschinger effect reduces the flow effect. The cause of the effect is the instability of the structural state under alternating loading. From manufacturing practice it is known that the diameter of the materials after turning is somewhat larger than the diameter in the unloaded condition when the carriage is supplied due to the phenomenon of elastic aftereffect of materials. For certain combinations of technological factors of the turning process, the magnitude of the elastic aftereffect of the metal is comparable to the tolerance field for qualifications of accuracy. In industrial conditions, the task of ensuring a given qualification of accuracy is complicated by the fact that the scientific and technical literature still lacks the necessary generalizations of materials and methods on the question of quantifying the magnitude of the elastic aftereffect of a metal depending on the technological factors of the germanium turning process. This makes it difficult to design and implement modes of production of parts from Shelman with high dimensional accuracy. To study the effect of the nature and magnitude of the resulting stresses on the elastic aftereffect of the material, a study was conducted with the output of results below [5]. We made number of grooves, determine elastic compression with using of microscopy. Comparing it with knowledge about conventional cutting, we obtained value of elastic deformation of Ge in a process of UV cutting.

3 Results and Discussion

![Figure 1](image.png)

**Figure 1.** Surface deformation profile:

a - zero-level cutting =750 nm; b - cutting with depth of cut= 1.9 μm.

Approximately elastic deformation of Ge with the cutting depth of more than 1 pm is 250 nm. This data has a perfect correlation with research of Dr. Gruby in cutting without UV.

As we can see elastic deformation of Ge in a process of cutting with using of ultrasonic vibration is equal with the other ones, where they don’t use.
The phenomenon of reducing strain in time after removal of the load is called reverse creep. The phenomenon of the inverse creep of a number of materials, in particular metals, has been studied relatively little, and therefore, in the calculations of structural elements for creep is not taken into account [6,7].

![Figure 2. Surface deformation profile: a - cutting with depth of cut = 1.7 $\mu$m.; b - cutting with depth of cut = 1.25 $\mu$m. c - cutting with depth of cut = 1 $\mu$m.](image)

Figure 2. Surface deformation profile: 
 a - cutting with depth of cut = 1.7 $\mu$m.; b - cutting with depth of cut = 1.25 $\mu$m. c - cutting with depth of cut = 1 $\mu$m.

We note that reverse creep along with elastic unloading is called recovery. The reverse creep of polymers is directly related to the viscoelastic component of total deformation. Recoverability after creep is the simplest additional experiment. In another case, the rapid unloading of the machine by the mechanism may lead to some loading by the voltage of another sign, which is also unacceptable. In turn, the complete restoration of deformations in such an experience gives an invaluable check on the correct functioning of the equipment [8-11].

![Figure 3. Graph of elastic deformation with a different depth of cut](image)

Figure 3. Graph of elastic deformation with a different depth of cut
It is recommended that the creep test be carried out together with the recovery without interruption. You should prepare a series of tests and then make the necessary selection of results based on them [12-13]. The isochronous stress-strain ratio can be obtained directly in an experiment on one sample, if the time interval is small, and the stresses do not cause significant viscoplastic deformations [14-15].

4 Conclusions
Based on the above experiments, the following conclusions can be made. This information let us deeply understand processes which take a place during machining of hard and brittle materials.

1. Elastic deformation of Germanium in a process of cutting with using of ultrasonic vibration is equal to the other ones, where they don’t use.
2. Surface, produced with using of UVA, good enough for machining Fresnel lens. Roughness criteria for this type of surfaces limited are Sa=0.3 μm. So, we take into consideration conventional cutting roughness, UVA cutting roughness that is even better.

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