

# The characteristic of steel and titanium cylinders microstructure after the explosive joining

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# The presentation outline

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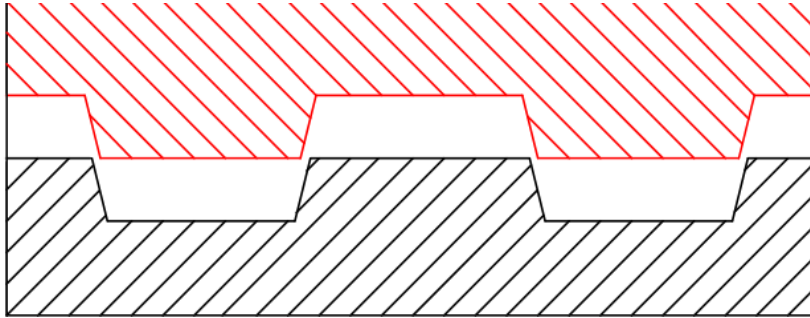
- ① Work relevance
- ② Experiments
- ③ Results

# Work relevance

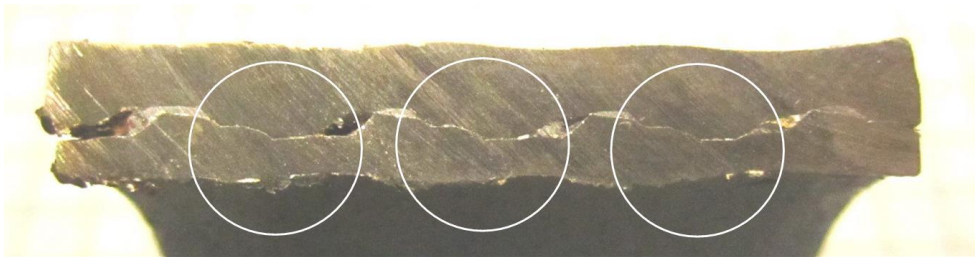
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- The steel (stainless steel) and titanium cylinders explosive joining was carried out for obtaining the **transition element with specified performance parameters.**
  
- **Why explosion loading?**
  1. Optimal cost
  2. Useful results in a short time
  3. Suitable for limited production

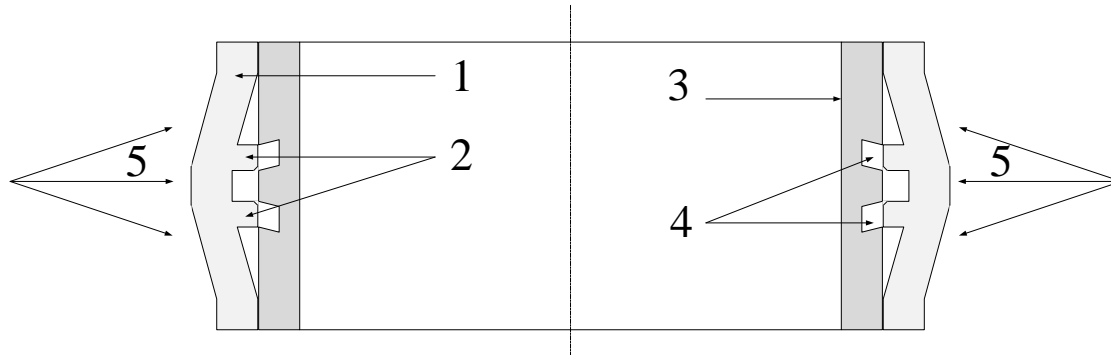
# First schemes of joining



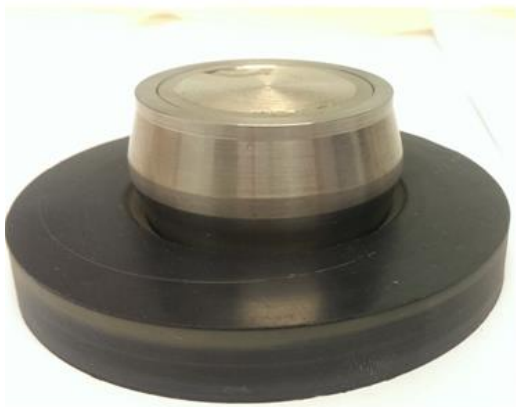
First schemes of joining were not strong and tight



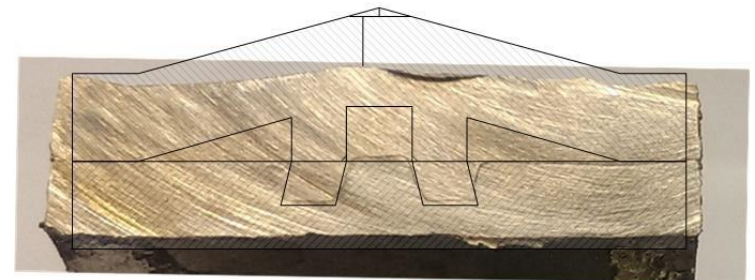
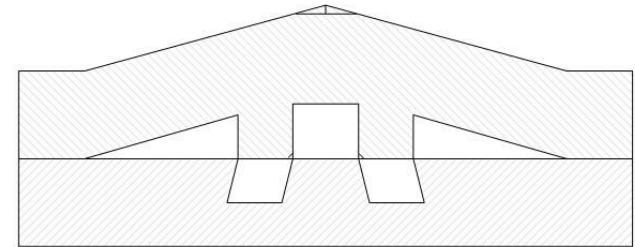
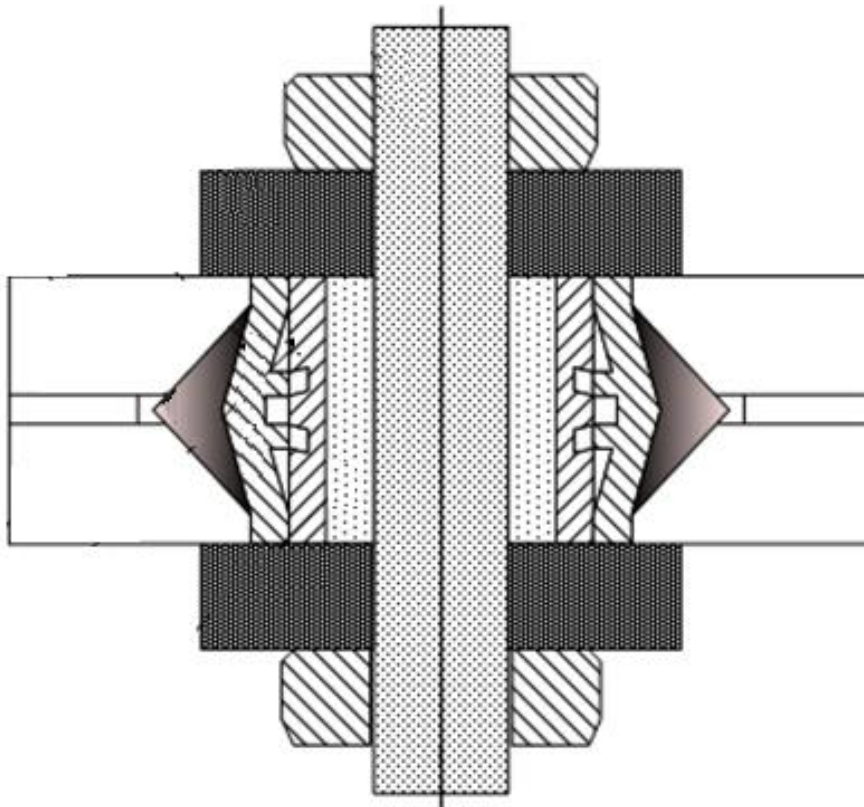
# A «dovetail» scheme



- 1 - Outer cylinder (steel)
- 2 - Rectangular teeth
- 3 - Inner cylinder (titanium)
- 4 - Rhomboid grooves
- 5 - Disc-shaped explosive charge

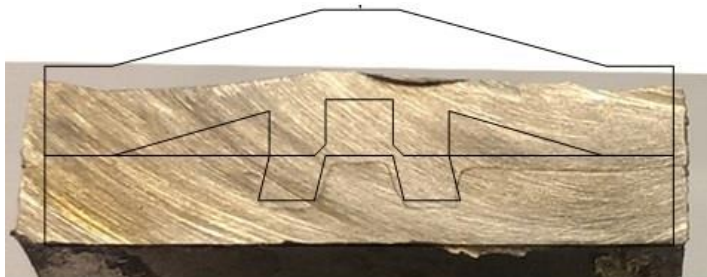
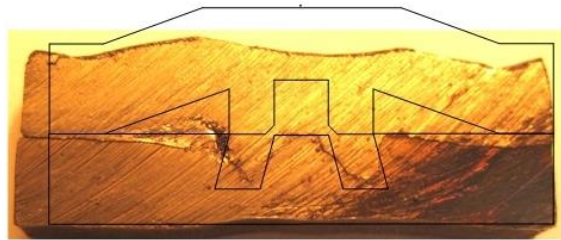
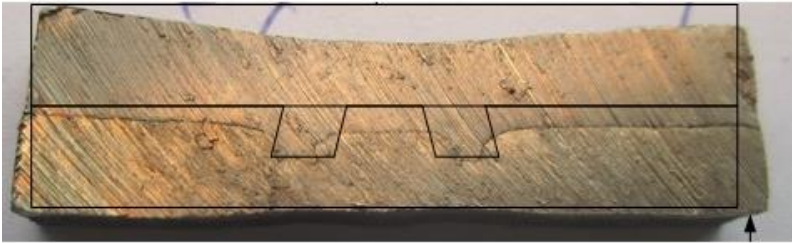


# A «dovetail» scheme – general view



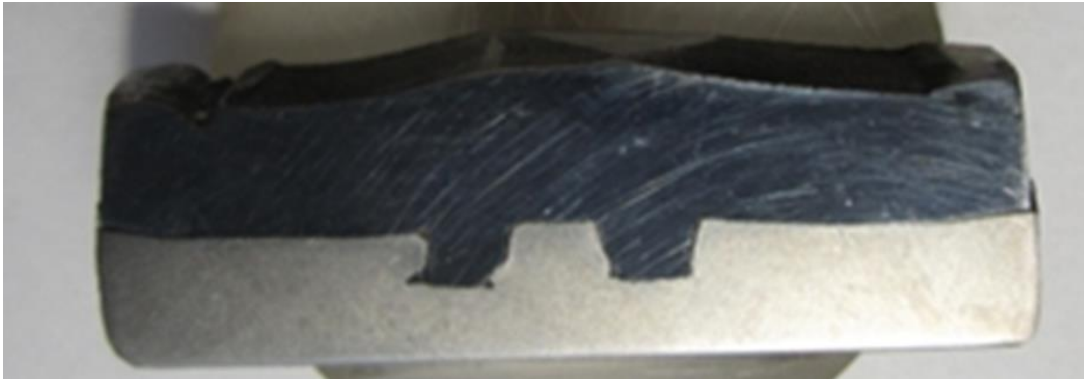


# A «dovetail» scheme

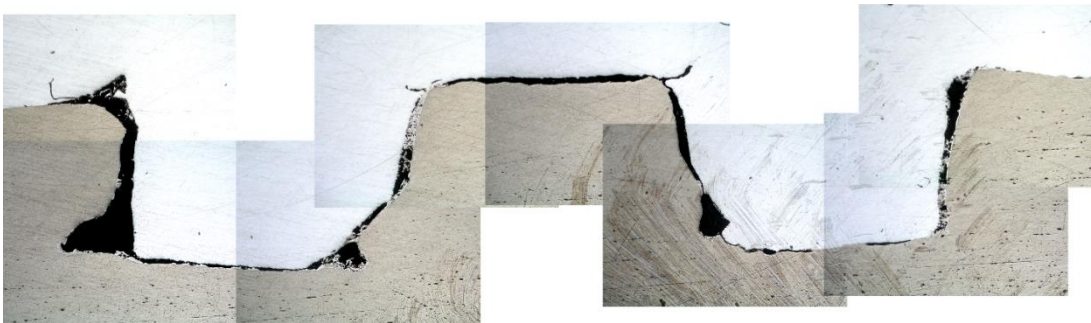


Changing size and shape of the external (steel) cylinder is achieved the best link between teeth and grooves.

# A «dovetail» scheme – under microscope



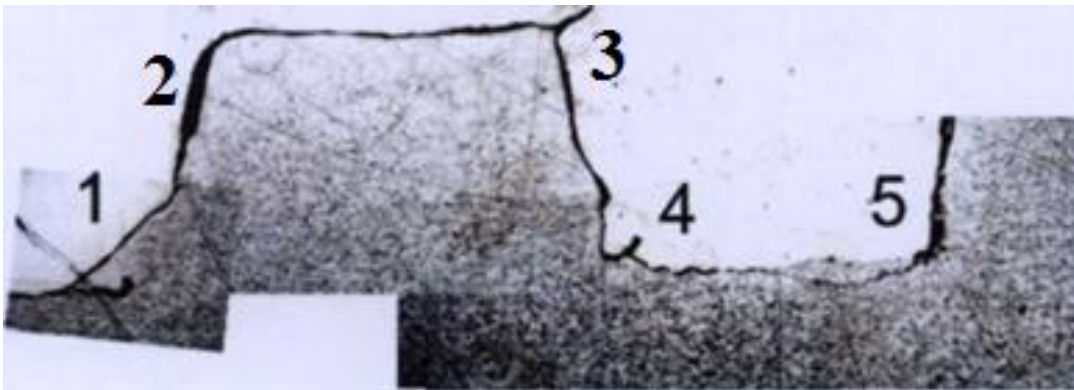
The obtained slice were polished for further analysis under an electronic microscope





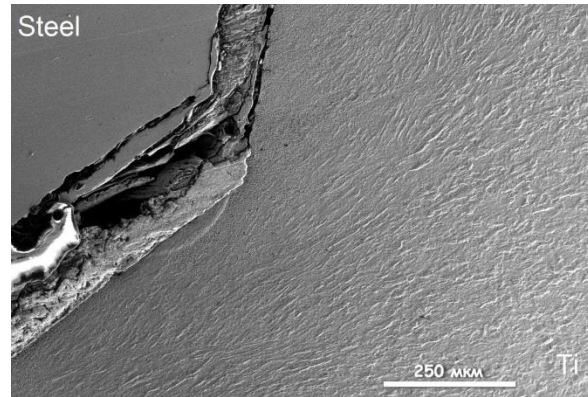
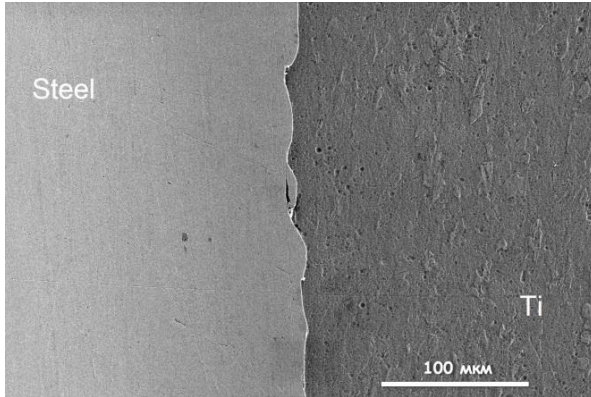
# Typical defects in area of joining

In area of joining material deformations, shifts, cracks, cuts, etc. can appears.

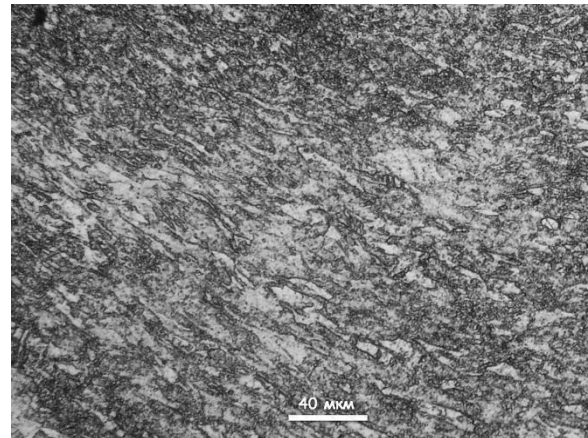
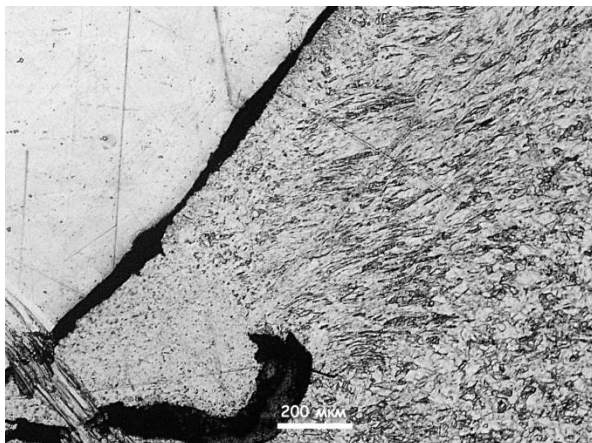


- 1 - Shift
- 2 - Crush
- 3 - Crack
- 4,5 - Cuts with crushes

# Typical defects in area of joining



Electronic micrographs of dense zones and slit-like contacts



An optical micrographs of the titanium intense plastic shear area



# Typical defects in area of joining

In the area of titanium intensive deformation the group of grains elongated along the plastic shear.



# Typical defects in area of joining

The characteristic size of grains decreased from 20  $\mu\text{m}$  inside the detail body to  $\sim 2 \mu\text{m}$  in the areas bordering with steel

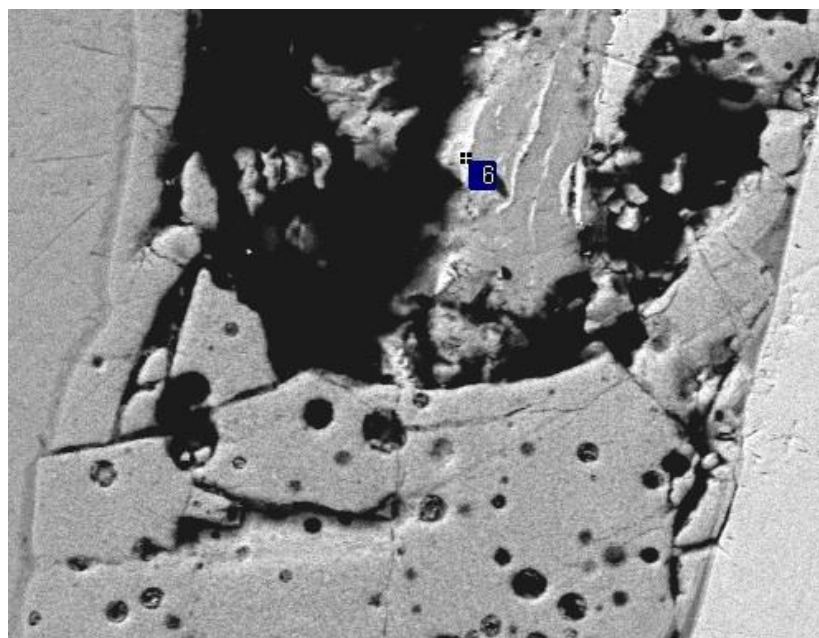


Area inside the titanium detail



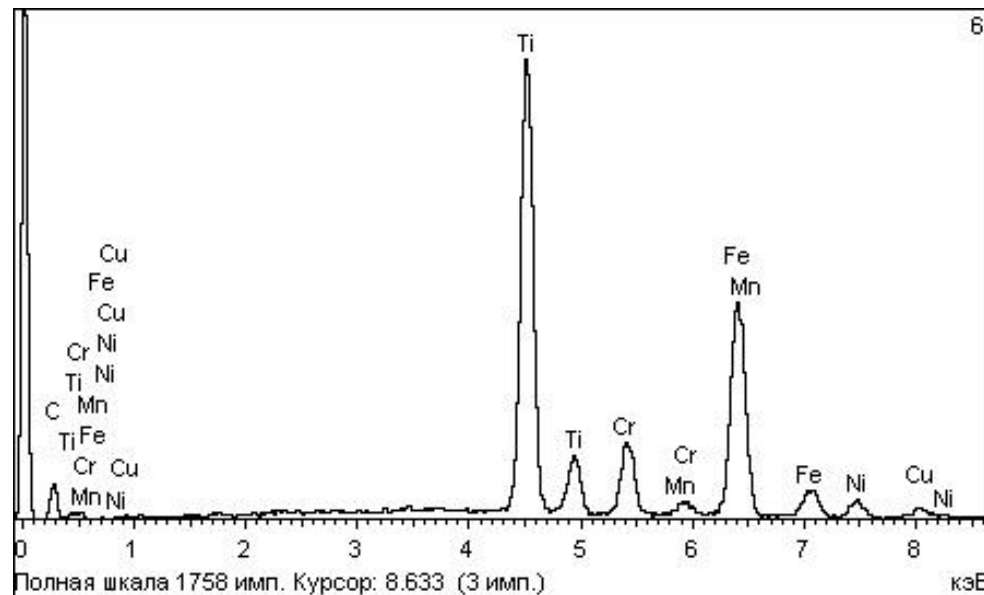
Area bordering with steel

# Elemental analysis of slit-like contact



80μm

Electron Image 1



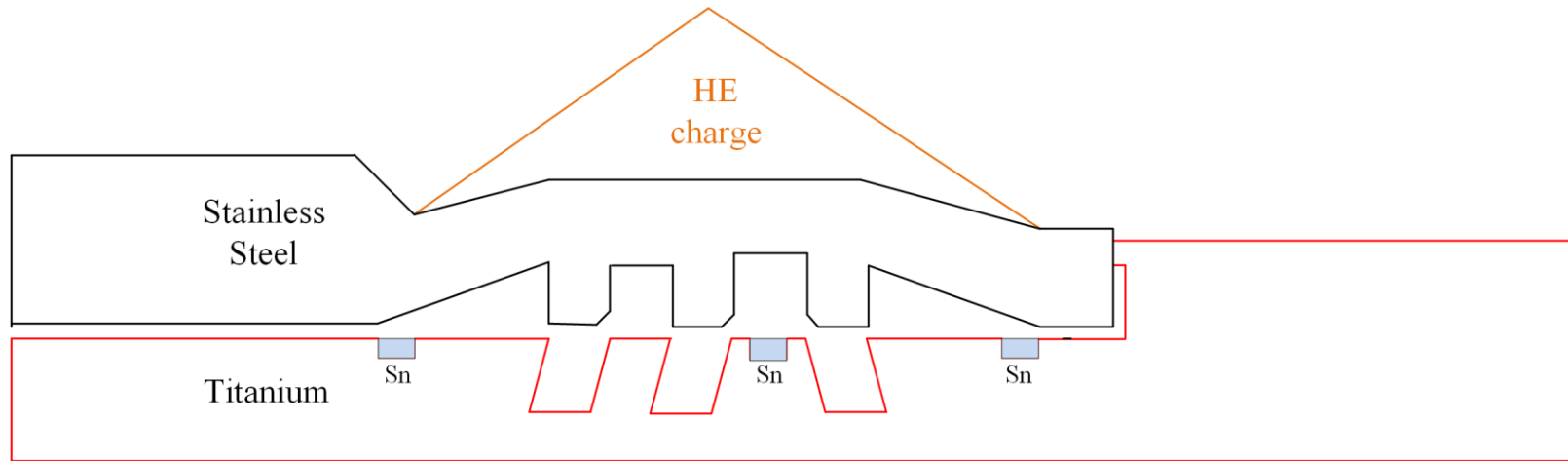
- Remains of materials used for polishing and etching;
- Fragments of the original materials (Steel and Ti);
- Presumably the fragments of newly formed phases on the basis of the original components (requires additional research)



# The X-ray diffraction analysis

- The X-ray diffraction analysis showed that the explosive loading of leads to a transition of a stainless steel state from single-phase austenitic into two-phase ferritic-austenitic;
- The content of ferrite in the different areas of detail, characterized by different loading degree, varies from 56 to 100% vol. The austenite lattice parameter in all the investigated spots exceeds the reference steel lattice parameter to 20 nm;
- Explosive loading also leads to increasing the deformation of austenite crystal lattice. The growth of lattice microdistortions made 1.3–2.7 times in comparison with initial level.

# Configuration with 3 teeth



Tensile strength:  
~ 1000 MPa



# Summary

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- The explosive method of joining of steel and titanium cylinders is simple and effective;
- The «dovetail» scheme with 2 teeth gives quite strong joining despite the presence of defects at the boundaries between materials;
- The «dovetail» scheme with 3 teeth is more promising for small-scale production, but requires a leak test.

A wooden mouse figurine with large ears and red eyes is mounted on a tiered wooden stand. The stand consists of three stacked cylindrical sections of varying heights, with the top section being the tallest and the bottom section being the widest. The mouse is positioned at the top of the stand, facing forward. The entire assembly is placed on a white surface against a light-colored wall.

**Thank you for your attention!**