ORIGINAL ARTICLE

INTERNATIONAL JOURNAL OF ARTIFICIAL INTELLIGENCE

ISSN: 2692-5206, Impact Factor: 12,23
American Academic publishers, volume 05, issue 05,2025

Journal: https://www.academicpublishers.org/journals/index.php/ijai

DEVELOPING STUDENTS' KNOWLEDGE AND SKILLS ABOUT JOINTS IN TECHNOLOGY LESSONS

Abdulloyev G'iyos G'ulomovich
Lecturer, Department of Technological Education,
Bukhara Regional Institute for Advanced Pedagogical Studies

Abstract: The article describes the types of separable and non-separable joints that contribute to the formation and improvement of students' technological and polytechnical knowledge, as well as their fields of application.

Keywords: Separable and non-separable joints; butt, lap, and corner welds; single-row, multi-row, staggered rivet joints; triangular, rectangular, and metric threaded joints; prismatic, cylindrical, and segmental key joints.

In mechanical engineering, various parts are joined together during the assembly of mechanisms and machines, forming either separable or non-separable joints. Separable joints can be disassembled without damaging the parts. Among them, threaded joints are the most common and are classified as bolts and studs. These serve both fastening and sealing purposes. Thread shapes can be triangular, rectangular, or trapezoidal. In simple fastening threaded joints, a bolt or screw is inserted into a hole with a specified clearance. In sealing joints, bolts are driven in tightly. To prevent loosening, locknuts and washers are used.
Key and spline joints are used to connect rotating parts on shafts or axles. Keys come in prismatic, cylindrical, and segmental forms and are selected based on the stress they need to withstand. Proper usage of joints requires understanding their structure, application fields, and parameters.
Advantages of threaded joints include their reliability under high loads, ease of assembly and disassembly, cost-effectiveness, and standardized dimensions. Threads are cut on cylindrical or conical surfaces, though cylindrical threads are most common. For tight joints, conical threads are used. Threads are called right-hand if they run from left to right, and left-hand if from right to left. The most common type in mechanical engineering is the metric thread, which has a triangular profile and an angle of 60°. Metric threads can be coarse or fine, depending on their pitch.
With key and spline joints, components like pulleys, gears, and couplings are mounted on shafts. These joints primarily bear torque. A key joint typically consists of a shaft, a key, and a hub (e.g., pulley, gear, sprocket). The key transmits the torque. The main **advantages** of key joints are their simple structure, ease of assembly/disassembly, and cost-effectiveness. **Disadvantages** include the need to machine keyways, which reduces shaft strength. Therefore, key joints are not recommended for dynamically loaded or high-speed shafts. Also, each key must be custom-fitted, making them unsuitable for mass production.
Key joints can be interference or clearance fits. Prismatic and segmental keys are used for clearance fits, while cylindrical and wedge-shaped keys are used for interference fits. Standard keys are made from carbon or alloy steel with a minimum strength of 500 MPa. Permissible stress values depend on the operating conditions and material strength of the shaft and sleeve.
A spline joint is formed when grooves are cut on both the shaft and hub, aligning with each other. Advantages over key joints include: better centering of parts, ability to move components

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along the shaft, higher torque transmission capacity for the same size, and reliable performance under impact loads. All spline dimensions are standardized, and shapes include rectangular and triangular profiles, with rectangular being the most common. Triangular splines are used in fixed joints for transmitting smaller torques.

Among non-separable joints, welded and riveted joints are widely used today. Welded joints are used to join parts in butt, lap, and corner configurations. Welding is the process of permanently joining components by heating and deforming them to create atomic bonds. There are over 60 types of welding, including arc, electroslag, electron beam, plasma, laser, and gas welding. Welding can be manual, semi-automatic, or automatic. In mechanical engineering, electric arc and gas welding are most common.

Welding is used for cracks, notches, fractures, and broken parts, as well as for joining components. Arc welding uses AC or DC power sources (welding transformers or rectifiers). In DC welding, parts can be connected to the negative (reverse polarity) or positive (direct polarity) terminal. More heat is generated when the part is connected to the positive terminal.

Before welding, edges are beveled, cleaned, and degreased using solvents or caustic soda. After cooling, welds are finished flush with the surface or smoothed for a uniform appearance.

Steel parts are welded with wire electrodes (Sv-08, Sv-08GA, etc.) of 1–12 mm diameter. The wire is coated with a flux that stabilizes the arc, protects the weld from atmospheric effects, and improves weld quality. Easily weldable low-carbon and low-alloy steels (e.g., 15X, 20X) are welded with E-34, E-38, E-42, E-42A, and E-46 electrodes using AC without preheating or post-treatment. Medium/high-carbon and alloy steels require preheating to 150–700°C and are welded with reverse polarity DC. After welding, the metal is tempered to relieve stresses.

Large parts are welded with direct polarity or AC; thin-walled parts are welded with reverse polarity. Gas welding is used for thin parts (2–3 mm), with wires like Sv-08, Sv-08A, Sv-08GS, and similar. Before welding, the joint is heated to 650–700°C using a torch.

Cast iron can be welded using gas or arc welding in three ways:

1. Fully heating the part to 500–700°C in a furnace.
2. Partial heating with a torch to 250–450°C.
3. Cold welding without preheating.

Welded cast iron parts are cooled slowly. Electrodes include copper-iron rods, CSh-4 steel rods, brass, or Monel alloy rods (3–4 mm diameter).

Aluminum and its alloys are cleaned, heated to 250°C, and welded with arc or gas using neutral acetylene flame. Copper and its alloys are welded with arc or gas. For arc welding, M1 copper wire or phosphor bronze wire and carbon or graphite electrodes are used. Brass and bronze are welded with carbon electrodes. Welding materials should match the base material in composition.

Welded joints can be butt, lap, or corner configurations. Welds are classified by shape as lap or corner welds. **Advantages** of welded joints over other non-separable joints include less labor, material savings, and lighter steel components replacing heavy castings, saving up to 30–40% material.

Welding methods are divided into fusion welding and pressure welding. Fusion welding includes arc, electroslag, gas, electron beam, plasma, laser, and others. Pressure welding includes resistance welding, friction welding, explosive welding, and cold welding. In industry, arc, gas, and resistance welding are most common.

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Electrodes used in welding are metal rods coated with a flux layer. During welding, the metal melts to form a joint, and the coating melts to protect the weld from air, resulting in high-quality welds.

In **resistance welding**, the joint is heated by electric current until plastic deformation occurs, then pressed together to form the weld. Parts can be welded in butt, lap, or corner configurations.
Riveted joints are made from steel, copper, or aluminum wires no thicker than 20 mm. The rivet is slightly smaller than the hole for easier installation. Rivet patterns can be single-row, double-row, or staggered. Joints can be single-shear, double-shear, or multi-member.
Riveted joint strength depends on shear stress on the rivet shank, bearing stress on the shank surface, and tensile stress on the joined plates. Riveted joints are mainly used in aircraft and rocket construction.

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