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IMPROVING THE MANUFACTURING PROCESS AND INCREASING THE WEAR RESISTANCE OF SHUT-OFF VALVES IN THE OIL AND GAS INDUSTRY

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ARTICLE INFO	ABSTRACT
Article history: Received:2025-11-02 Received in revised form:2025-11-14 Accepted:2025-12-15 Available online:2026-06-30 Keywords: gate valve; pipeline valves; corrosion resistance; titanium alloys; durability JEL Classification: L60; L71; O33	This study presents the design of a combined-type slide gate valve incorporating titanium alloy locking elements to enhance the corrosion and wear resistance of shut-off valves used in the oil and gas industry. The purpose of this work is to improve the operational reliability and durability of gate valves under harsh production and transportation conditions typical for Azerbaijan's oil fields. Modern shut-off valves must ensure not only reliability and continuous operation but also satisfy key design criteria such as full-bore configuration to minimize hydrodynamic resistance, laminar flow conditions, and the absence of stagnant zones that may impede valve closure or accelerate failure. The paper analyzes existing valve types and identifies the gate valve as a critical component in pipeline safety systems. Furthermore, it proposes an innovative structure using titanium-based components to mitigate wear and corrosion at critical contact interfaces. The proposed design aims to extend the service life of valves, reduce maintenance costs, and enhance safety performance in hydrocarbon transport infrastructure.

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1. INTRODUCTION

The operational reliability and cost efficiency of hydrocarbon extraction, transportation, and processing in the oil and gas industry are determined by the technological advancement and reliability of shut-off valves. These valves operate under extreme conditions, requiring high performance across a broad range of pressures, temperatures, and environments, including exposure to aggressive fluids and gases, seismic loads, and humidity fluctuations. Environmental protection and personnel safety are key priorities for the industry, thereby increasing the design and performance demands for shut-off valves.

Today, several main types of shut-off valves are commonly used in oil and gas systems: globe valves, gate valves, butterfly valves, and ball valves. Each type offers specific advantages and limitations. For example, **globe valves** are inexpensive and easy to manufacture but suffer from high hydraulic resistance and one-directional flow. **Butterfly valves** operate effectively only within a narrow temperature and pressure range. **Ball valves** provide excellent tightness, quick

operation, and low maintenance costs, but their manufacturing is costly, and they cannot be repaired outside factory conditions.

In contrast, **knife gate valves** possess numerous benefits: simplicity, compact design, low cost, and wide applicability across varying operational environments. Among these, the gate valve remains the most widely used device for fluid shut-off in oil and gas pipelines.

2. MAIN DISCUSSION

In oil and gas systems, the reliability of hydrocarbon production and transportation processes largely depends on the performance of technologically advanced and durable shut-off valves. These devices must operate safely under extreme pressure, temperature, and environmental conditions (including humidity, seismic activity, and aggressive fluids).

The main categories of shut-off valves include **globe valves**, **gate valves**, **butterfly valves**, and **ball valves**, each with specific characteristics:

- **Globe valves** are low-cost and easy to manufacture but feature high hydraulic resistance and can handle flow in only one direction.
- **Butterfly valves** are suitable for narrow temperature and pressure ranges.
- **Ball valves** offer excellent tightness and low maintenance but cannot be repaired in the field and fail above 2000°C.
- **Knife gate valves**, however, offer several advantages, including simplicity, small size, cost efficiency, and adaptability to various working conditions.

This paper focuses on **gate valves**, which are widely used to shut off the working fluid in oil and gas systems. The movable part—the gate—is positioned perpendicular to the fluid flow, and its movement controls the passage opening or closure. The actuator force is transmitted through the spindle mechanism.

A typical gate valve comprises the following key components: **body**, **gate**, **stem (post)**, **sealing elements**, and **gland packing** (Fig. 1). Tight sealing in the closed position is achieved by pressing the gate against the seat under pressure from the working medium. Gate valves are designed with either single- or double-sided sealing and may include rising or non-rising stems.

The valve body, usually rectangular or cylindrical, can be cast as a single piece or welded from multiple sections. It may include features such as a removable bottom cover and through-gate design. Body materials range from **gray or ductile cast iron** to **carbon, low-alloy, and stainless steels**, as well as **non-ferrous alloys (e.g., aluminum)** and **non-metallic materials (e.g., PVC)**.

The **gate** may be a plate made from rolled steel with parallel sealing surfaces or a sharpened “knife edge” for cutting through viscous or contaminated fluids. Polished stainless steel gates ensure smooth sliding against sealing materials, minimizing friction and preventing jamming.

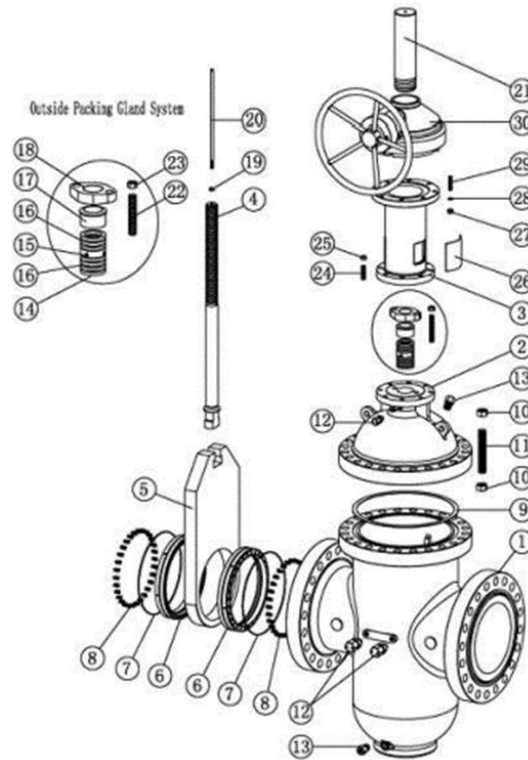


Fig. 1 Gate valve design

1 - body; 2 - cover; 3 - yoke post; 4 - spindle; 5 - gate; 6 - seat; 7 - radial seal; 8 - spring; 9 - gasket; 10 - nut; 11 - stud; 12 - lubricant fitting; 13 - drain fitting; 14 - gland seal; 15 - anti-blowout ring; 16 - secondary seal; 17 - gland bushing; 18 - gland flange; 19 - nut; 20 - spindle indicator; 21 - casing; 22 - stud; 23 - nut; 24 - bolt; 25 - nut; 26 - valve; 27 - nut; 28 - washer; 29 - stud; 30 - gearbox.

Gate valves are preferred for several reasons:

- Compact design and short overall length.
- Reliable performance under variable operating conditions.
- Minimal maintenance requirements.
- Absence of stagnant zones allows operation in slurry- or impurity-laden environments.
- Very low hydraulic resistance and laminar flow characteristics.
- Capability for quick shut-off and high tightness.

However, gate valves also suffer from wear and corrosion over prolonged use, particularly at the seat–gate interface, leading to leaks, reduced tightness, and premature failure.

3. OPERATIONAL FAILURES AND WEAR MECHANISMS

In oil field applications, gate valves experience several common malfunctions:

- Leakage between gate and seat sealing surfaces.
- Leakage between seat and body.
- Seal loss at the stem packing or bonnet-body connection.
- Fluid leakage through flange joints.

- Scoring and pitting corrosion on the spindle surface.
- Wear and cracking of sealing surfaces.
- Thread wear in the spindle sleeve.



Fig. 2 Common malfunctions during the operation of a knife gate valve at an oil field

The primary cause of valve failure is wear at the gate–seat interface, as high-velocity gas or oil flow containing mechanical impurities (e.g., H_2S , sand particles) erodes the metal surfaces. The temperature may reach up to $350^\circ C$, accelerating corrosion and abrasion processes.

The seat and bushing materials must therefore exhibit high mechanical strength, wear resistance, and corrosion stability under such conditions.

4. MATERIAL OPTIMIZATION AND TITANIUM APPLICATION

To address the wear problem, this study proposes the replacement of traditional 20X13 steel with titanium alloys, such as VT-14 or VT-6 (Fig. 3). Titanium alloys combine high corrosion resistance, low density, and excellent fatigue strength, making them ideal for harsh fluid environments.

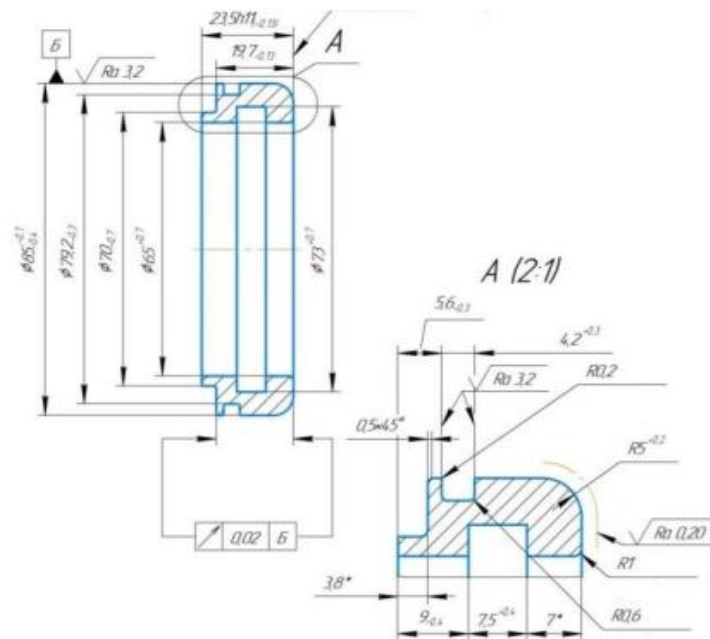


Fig. 3 Titanium seat used in valve assembly

The development was carried out within the “Production of Titanium Products for the Oil and Gas Industry” project. The resulting valve (Fig. 4) represents a **composite design** where titanium components are integrated into the high-wear zones, significantly improving longevity and sealing reliability.

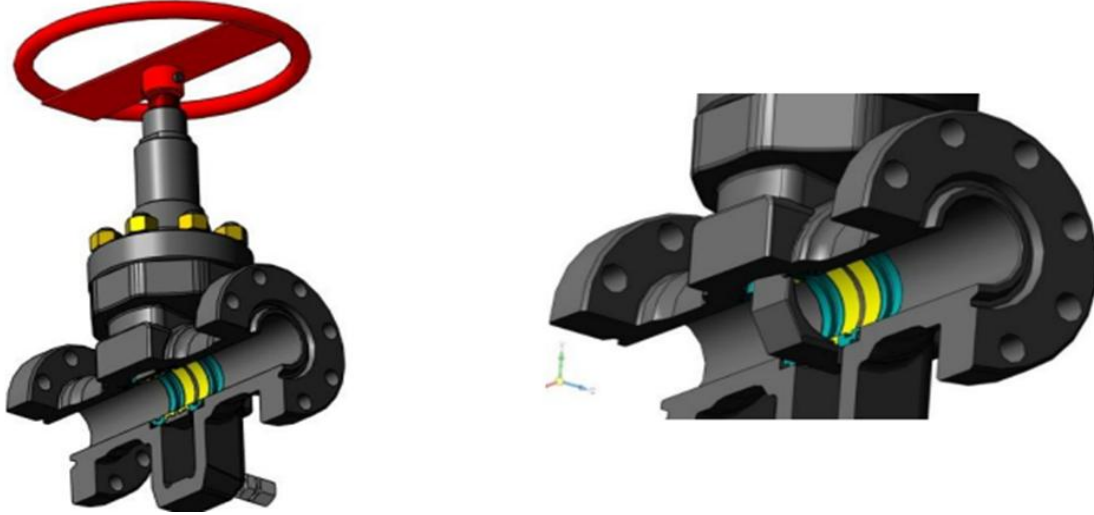


Fig. 4 Gate valve design with titanium alloy components

5. CONCLUSION

Modern shut-off valves must combine reliability, durability, and maintainability. The integration of **titanium alloy components** into gate valves enhances corrosion and wear resistance, extends operational life, and reduces maintenance costs.

Key design criteria that must be achieved include:

- Full-bore flow path ensuring minimal hydraulic resistance;
- Absence of stagnant zones;
- Capability for in-place maintenance without pipeline removal;
- Long-term tightness despite partial wear of seats.

No single conventional valve type fully satisfies all performance demands. Therefore, developing **hybrid structures** combining the strengths of various valve types — such as the titanium-integrated gate valve — is an essential step toward safer and more efficient pipeline operation.

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