

Design and Manufacturing of Ball Valve

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Abstract— The availability, performance and distribution of petroleum products in the oil and gas industry depend largely on the workability of pipeline and its fittings. Pipelines and its fittings, used for the transportation of crude oil are regarded as one of the most important asset to the economic development of any nation, and to ensure the safety of the environment and the population living and working around the lines, there is need for a regular test, assessment and study of the design, materials and the manufacturing processes.

Ball valves are widely used industrial fittings for the construction of liquid and gas products transportation facilities (piping systems). They are quarter-turned (90 degrees), straight through flow valves having a round closure element with complementing rounded seats, which permits uniform sealing stress. The type of seat can vary according to the valve pressure rating and materials of construction. The main objective of this dissertation is to analyse the design and manufacturing processes of the ball valves used in the oil and gas industry, with special attempt to identifying and proposing solution to the major problem with its applications (leakage).

Leakage in a valve is not only a concern in terms of safety, but can also contribute to high maintenance costs and the loss of supply. Any improvements to the methods available for monitoring the condition to the valve may yield substantial cost savings and safer working conditions. The dissertation covers area like cost reduction, changing manufacturing process, the analysis of the materials used for the design, analysis of the design model (computer aided design CAD) using the finite element method FEM, simulation, rapid prototype of the ball valve and the manufacturing process of the ball valve (computer aided manufacturing CAM).

Keywords: Design CAD, Computer Aided Manufacturing CAM

I. INTRODUCTION

The movement of petroleum products and its derivatives from the producing area to the actual processing facilities is the central operation between the upstream and downstream section of the industry. Due to the nature of the products produced in this sector there is need for an effective and extensive transportation system in the movement of the products, where this transportation system consists of a complex network of pipelines. However there are other means of transporting petroleum products like the use of the rail system (trains), roads (truck) and on water (ship). The pipeline system plays an important part in the industrial application, and are generally believed to be more economical and capable of covering a very long distance as compared to other transportation system, as such they are the most widely

used means of transporting petroleum products and their derivatives all over the world.

The cost of transporting crude products in the oil and gas sector annually usually surpasses billions of dollars, this is due to the large volumes of crude products that is transported over a long distances on a daily basis, hence the need for the critical analysis of the design and manufacturing processes of the fitting equipment (ball valve) used in the piping system. Valves are mechanical devices specifically designed to stop, start, mix, direct, or regulate the flow, temperature or pressure of a process fluid in a piping system (pipeline). They are designed to handle either gas or liquid application. The operation of Valves may be required continuously as in case of control valves, or they may be required to be operated intermittently as in isolated valves or may be installed to operate rarely if ever e.g. safety valves.

II. LITERATURE SURVEY

A. Background

The role of valves in the piping industry as well as in the distribution of petroleum products in the oil and gas industry cannot be over emphasize as it is required in all aspect of the production and distribution of the products, starting from the exploration through the extraction of the crude from the oil well.

Valves are the component in a fluid flow or pressure system that regulates either the flow or the pressure of the fluid. This duty may involve stopping and starting flow, controlling flow rate, diverting the flow, preventing back flow, controlling pressure or relieving pressure. This duty is performed by adjusting the position of the closure member in the valve. (Zappe, 2003)

B. Ball valve designs

In order to reach some specific industrial requirement, ball valves are designed with specific consideration to their assembly exist when inserting the ball into the body of the valve, and these assembly exist point's affects not only the ease of assembly but the maintainability of the valve.

- 1) Single piece valve: The single piece valve assembly method is designed such that the ball is enclosed in the body of the valve by an insert fitted along the valve's axis, such that the possibility of leakage through its body joint and any chance of disconnection whilst in service are eliminated.
- 2) Two piece valve: In the two piece valve assembly method, the valve is designed such that it can be split into two places in the same plane as the valve flange, and these pieces are bolted together. It has the advantage of simplified, in-line maintenances.
- 3) Three piece valve: The three piece valve assembly method is similar to that of the two piece valve method,

only that the valve is split into three places in the same plane as the valve flange. (Isolation valves-Rotary movement, 2011).

III. CONSTRUCTION AND WORKING

Casting can be referred to as a manufacturing process by which molten material (metal) is poured into a mould, which contains a hollow cavity of the desired shape, and then allowed to solidify, and the solidified shape is then ejected or broken out of the mould to complete the process.

The casting of ball valves can be carried out using the following casting processes, Die casting, Sand casting, investment casting and Centrifugal casting, the Manufacturing process selection is the task of choosing a method for transforming a set of material into a given shape using one or more processes. The best process is normally considered to be the economic, subject to it meeting the technical constraints.

The selection of the casting process influences other major decisions such as the type of tooling, process parameters, and extent of machining, heat treatment, and quality control procedures. These in turn affect the economic quantity, tooling, labour costs, and lead time forecasting. Casting process combination is characterized by different range of geometric features that can be produced (minimum section thickness, minimum core size, etc), achievable quality (surface finish, porosity...etc) and production parameters (sample lead-time, economic lot size etc), but for the purpose of this work only the investment casting process will be considered in details.

In metalworking, metal is heated until it becomes liquid and is then poured into a mold. The mold is a hollow cavity that includes the desired shape, but the mold also includes runners and risers that enable the metal to fill the mold. The mold and the metal are then cooled until the metal solidifies. The solidified part (the casting) is then recovered from the mold. Subsequent operations remove excess material caused by the casting process (such as the runners and risers)

A. Quality Inspection

The casting quality inspection comprises of the determination of the following;

- The chemical composition and structure of the casted ball valve using spectrometer and metallographic.
- The internal casting quality (X-ray, ultrasonic)
- The casting surface finishes (capillary methods)
- Mechanical properties (tensile strength, hardness, ductility, etc.) and
- The dimensional accuracy

B. Investment Casting

Investment casting can be referred to as a metal casting process that pours molten metal into a ceramic mould that is the shape of the desired product. This type of metal casting process is used to make a wide variety of products. It is used generally for small castings, however, it has been used in the casting of a complete aircraft door frames, aluminium castings of up to 30 kg and steel castings of up to 300 kg. There are different procedures involved with this process and

it depends on which type of material (metal) being used and what it is being used for, however Investment casting generally can be said to consist of the following steps, (Gates, 2010) 70 -Tooling This is the process by which pattern die of the ball valve is design and manufactured using the CAD/CAM techniques, where the dies are manufactured using precision CNC machining/EDM techniques. The investment tools are

C. Advantages

- 1) High production rates for small parts.
- 2) High dimensional accuracy.
- 3) Extremely good surface finish.
- 4) Complex shapes are possible.
- 5) Machining can be completely eliminated.
- 6) Almost any metal alloy can be cast in this way.
- 7) Relatively environmentally friendly.

D. Disadvantages:

- 1) Specialist equipment is needed.
- 2) Expensive due to refractive materials and multiple processes involved.
- 3) Due to the possible high quality finish many parts are scrapped due to defects.

E. General properties of stainless steel

- 1) Corrosion resistance
- 2) Cleanability
- 3) Resistance to fire
- 4) Mechanical properties
- 5) Recycling

IV. DESIGN& CALCULATION

A. Body

- Three piece design
- Forged or cast body
- Full compliance with ASME B16.34 (wall thickness) and API 6D
- Easily serviced in-line with swing-out body
- Large range of end connections for full or standard port valves
- Rugged top mounting
- Carbon steel valves are black oxidized to MIL-DTL-13924 standard or available in epoxy paint finish upon request
- Stainless steel and high alloy valves provided with natural finish
- Steam jacket - upon request

B. Ball

- Mirror polished solid ball
- Bidirectional as standard
- High flow capacity with low pressure drop at full opening
- Floating ball concept for positive shutoff
- Pressure equalizing hole in the stem slot

C. Stem

- One piece solid stem
- Blowout proof design

- Antistatic device
- Fire lip

D. Stem seal

- High endurance up to 500 thousand cycles
- Anti-abrasion mechanism
- Live loaded

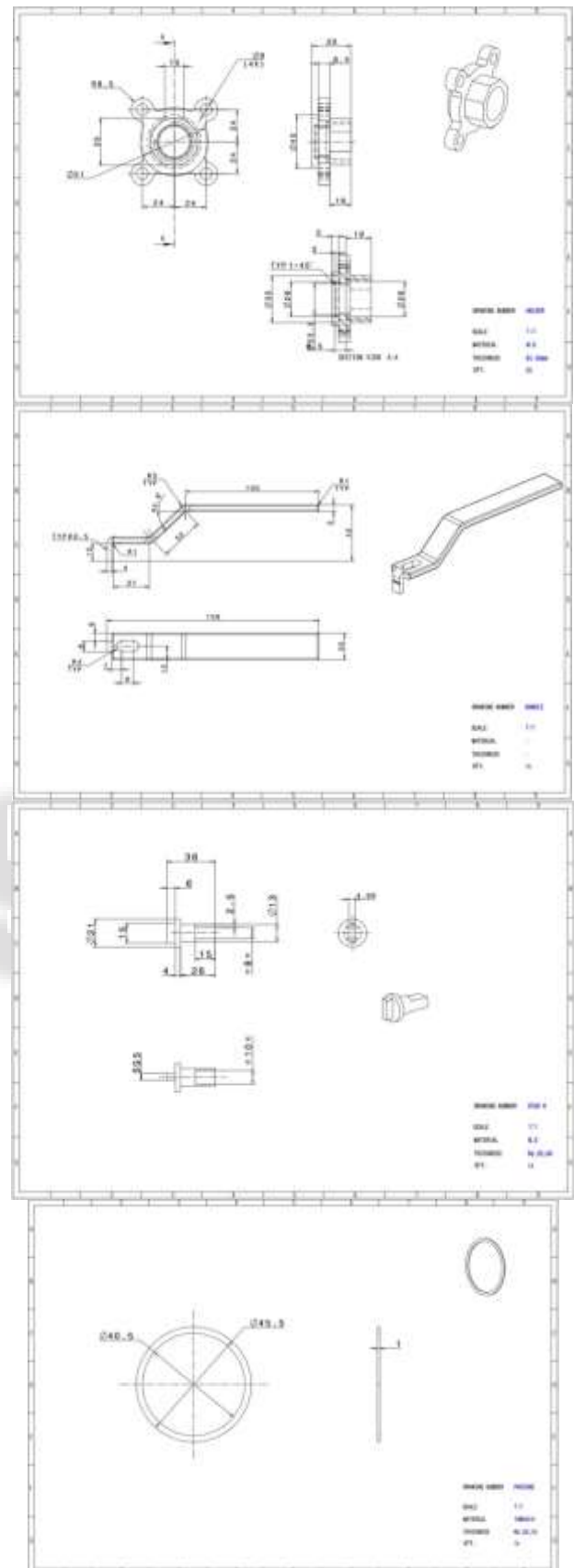
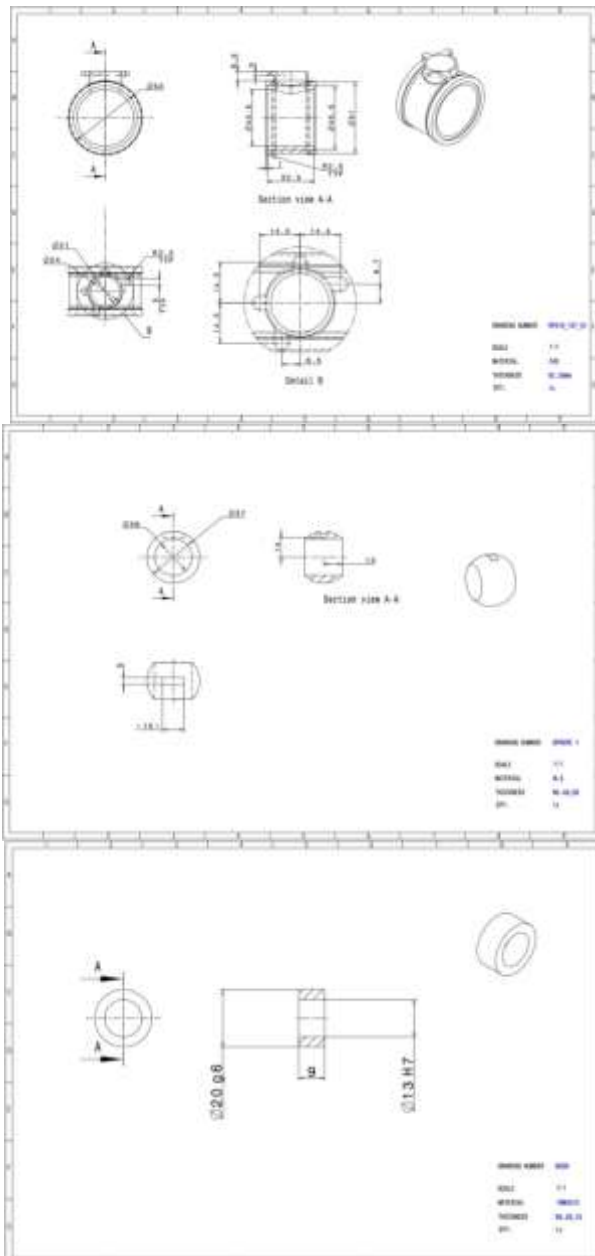
E. Seats and seals

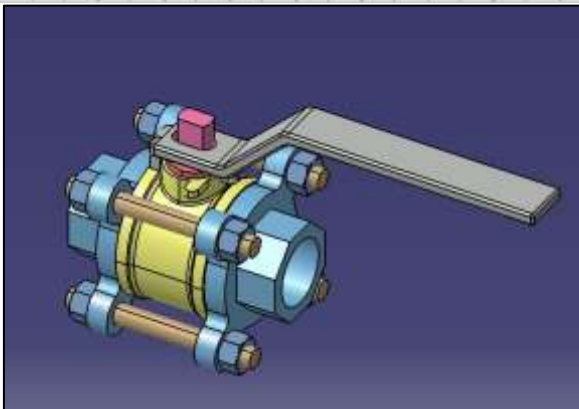
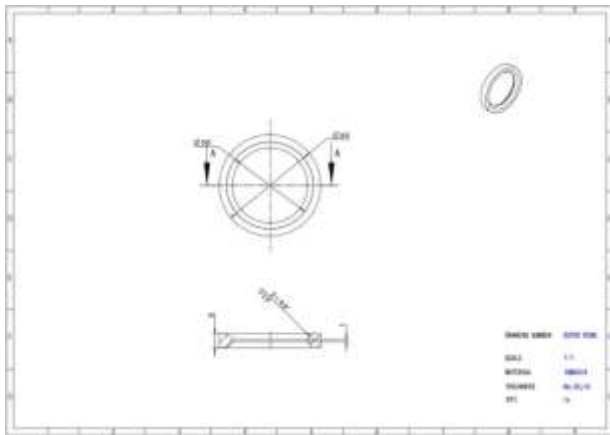
- Flexible seat design
- Reduced wear
- Low torque
- Rate A leakage tightness
- Self-relief seats (SRS) - upon request

F. Handle

- Rigid handle indicating flow direction
- Optional locking devices

G. Part of ball valve





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