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Fabrication of small size seamless reservoirs by tube forming

L.M. Alves, M.B. Silva, P.A.F. Martins*

IDMEC, Instituto Superior Técnico, TULisbon, Av. Rovisco Pais, 1049-001 Lisboa, Portugal

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ABSTRACT

The purpose of this paper is to introduce an innovative manufacturing process that is capable of shaping industrial tubes into small size, seamless, reservoirs made from a variety of materials and available in many shapes. The process is carried out by axial pressing the open ends of a tube against two shaped dies, while providing internal support by means of a low melting point (recyclable) mandrel, until achieving the desired shape of the reservoir. The elimination of weld seams leads to major improvements in economy and reliability and offers potential for fabricating reservoirs in medium to large batches for a wide variety of industrial and commercial applications.

Special emphasis is given to practical aspects related to the tools and techniques that were utilized for fabricating spherical reservoirs and cylindrical reservoirs with semi-ellipsoidal ends.

The presentation is supported by experimentation and numerical modelling based on independently determined mechanical properties of the materials with the purpose of understanding the deformation mechanics, identifying the formability limits and demonstrating the overall performance and feasibility of the proposed manufacturing process.

1. Introduction

Large size reservoirs like silos and tanks are commonly fabricated from a large number of curved steel panels joined by circumferential and meridional welds. The presence of welds add defects, residual stresses and geometrical imperfections due to joint mismatching between panels that may lead to reduction in the overall performance, namely the buckling strength [1].

Medium size reservoirs (with diameters up to 1 m) are fabricated by joining of panels or by alternative procedures involving two-stage manufacturing processes. For instance, medium size cylindrical reservoirs can be fabricated by rolling a sheet into a cylindrical surface and then joining the two ends by meridional welding [2], while medium size spherical reservoirs can be fabricated in two-half shells by deep drawing or spinning and then joined by circumferential welding [3].

However, conventional fabrication processes running on panel joining or two-stage manufacturing technologies are only suitable for producing single or small numbers of reservoirs because they involve long production lead times and are usually not appropriate to fabricate reservoirs in other materials than steel. This prevents conventional fabrication processes to meet the challenges of increasing demand upon small reservoirs for a wide variety of applications such as, anaesthetic and analgesic medical systems, supplemental and emergency oxygen needs for patients, scuba divers, high altitude mountain climbers and transportation systems, high pressure gas storage systems for automotive and aerospace vehicles and compressed air tanks for paintball and other leisure equipment, among others.

Despite recent efforts in fabricating small size reservoirs from stainless steel and aluminium by casting, conventional or hydro mechanical deep drawing [4] and explosive forming [5] there is a need for developing an innovative manufacturing technology that is capable of producing medium to large batches of small size reservoirs in a wide range of materials. This is because casting is limited to simple shapes (e.g. cylinder liners) and its operating costs demand high rates of production, explosive forming suffers from industrialization problems and conventional or hydro mechanical deep drawing, although being the most flexible solution, requires secondary operations for joining the half-shells into a reservoir by means of tungsten inert gas (TIG), laser or electron beam welding. As it is well known, the presence of weld seams considerably limits the scope of application of small size reservoirs.

This paper focuses on the above-mentioned problems and presents an innovative manufacturing process for producing low-cost, small size, axisymmetric seamless metallic reservoirs by tube forming (Fig. 1). The process shapes tubular preforms into reservoirs by forming the open ends with profile shaped dies and, therefore, avoids joint mismatching and geometrical imperfections due to welding of panels or half-shells. In addition, it allows

* Corresponding author. Fax: +351 21 8419058.
E-mail address: pmartins@ist.utl.pt (P.A.F. Martins).

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