Design of an Autoclave

Ramesh Kumar Patel[1], Saurabh Kumar[2]
[1] *Research scholar,* [2]*Associate Professor, Department of Mechanical Engineering, Raipur Institute of Technology, Raipur-492101, India*

***Abstract*: One of the major problems confronting healthcare professionals is the control of pathogenic organisms. This is because microorganisms are present in our environment and may contaminate healthcare instruments from time to time. An autoclave was designed and constructed to sterilize materials items used in such healthcare institutions. The autoclave has a liquid capacity of 200 liters and is heated electrically with a 6 KW heating-element.**
***Keywords*: Autoclave, pathogenic organisms, design, engineering, sterilization, health applications, cost effective.**

I. INTRODUCTION

The process whereby microorganisms of all kinds are inactivated, killed, or removed from materials is known as sterilization. Sterility is the term used in relation to microorganisms to describe the total absence of all life forms in an environment, surface, object, or in an object which may be ingested, such as food, medical, or pharmaceutical products. Thus an object is said to be sterile when it is free of all forms of life. This is an essential pre-requisite for certain categories of pharmaceutical and medicinal products such as injections, infusions and drops, in order to prevent health hazards through contamination by microorganism. Sterilization may be undertaken by physical or chemical methods. The method used usually depends on the material to be sterilized. Heating is one of the most convenient methods for sterilization. The process whereby water is boiled to 100˚ C is not effective for sterilization because many spores can survive at this temperature. Autoclaves are widely used in medical institutions, laboratories, and industries where the quality of reusable items is maintained with respect to infection control. They are, however, not available locally in many developing nations, and many of those in the system are already broken due to lack of indigenous technology and spare parts. The objective of this work is to design and construct a maintenance-free autoclave that requires little skill to operate and can be readily available for general sterilization purposes.

II. DESIGN OF AUTOCLAVE

A. Capacity design of autoclave

Dimension of sterilizing cylinder = 0.6m diameter and 1.2 m length
Dimension of perforated cylinder = 0.57m diameter and 1.12m length
Volume of the sterilizing cylinder; $V=\frac{\pi}{4}D^2h = \pi/4\times (0.6)^2\times 1.2 = 0.34m^3$
Density of stainless steel used for the cylinder = $7930kg/m^3$
Mass of the cylinder $m = \rho v$
$m = 7930 \times 0.34 = 2696.2kg$
Weight of sterilizing cylinder; $w = mg = 2696.2 \times 9.81 = 26449.73N$
Volume of the perforated container $V = \pi/4\times d^2\times h = \pi/4 \times 0.57^2\times 0.8 = 0.2042m^3$
Mass of the perforated container: $m = \rho v$, Density of the stainless steel = 7930kg/m3
$= m = 7930 \times 0.2042 = 1619.306kg$
Weight of the perforated container $w = mg = 1619.306\times 9.81 = 15885.4N$
The volume of water supplied
$V = \pi/4\, D^2h$ Where D = 0.6m, h = .3m
$V = \pi/4\times (0.6)^2 \times 0.3 = 0.085m^3$
Mass of the water supplied
$M = \rho v$
Density of the water = $1000kg/m^3$, $M = 1000 \times 0.085 = 85kg$
Weight of the water $w = mg = 85 \times 9.81 = 833.85N$

B. Frame design

Dead loads = $W_c + W_p + W_w$
Where W_c = Weight of the sterilizing cylinder = 26449.73N

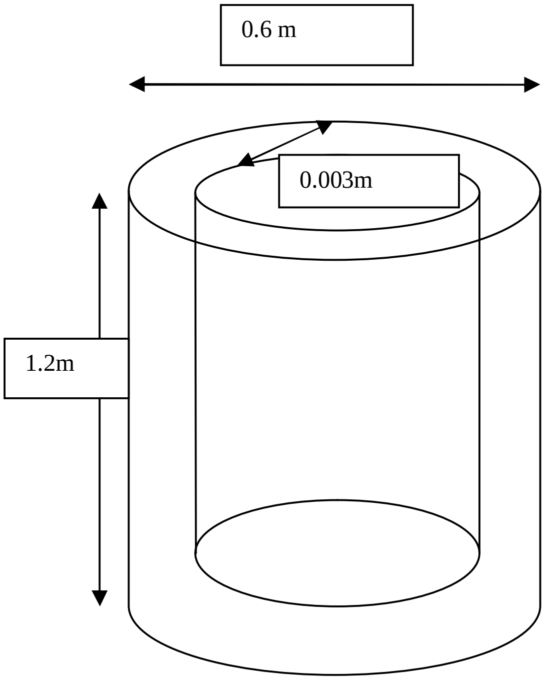
W_p = weight of the perforated container = 15885.4N
W_w = weight of the water =833.85N
Dead loads = 43168.98N
Assuming weight is equally distributed on 4 stands.
∴ Weight on a stand = $\frac{\text{dead load}}{4}$
Downward force on stand = 10792.245N
Area of channel of angle iron:
Ach = $\frac{f}{\sigma}$×factor of safety (Surendra & Singh, 1982)
Where T = shear stress of angle iron material = 68MN/m^2 (hardened steel)
∴ $A_{ch} = \frac{10792.245N}{68 \times 10^6 \ N/m^2}$
$= 1.58 \times 10^{-4} \ m^2$
∴ Dimension chosen are 40 × 40mm of stainless steel pipe

C. Wall thickness determination

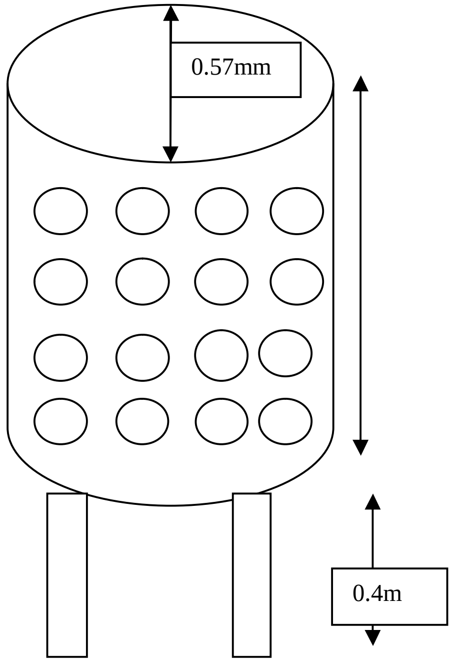
For a given internal pressure p, the maximum stress developed in the shell should not exceed the permissible tensile stress σt of the material.
Recall;
$\sigma_c = 2\sigma_L$
and σ_c is not to exceed σ_t
∴ $\sigma_c \leq \sigma_t$
From the above, it is obvious that the cylinder is a thin one, because the cylinder is required to operate under pressure of 30MN/m^2, and 250MN/m^2 operations require thick cylinders.
Thin cylinders have working stress ranging from 5MN/m^2 to 30MN/m^2.
∴ $\sigma_c = \underline{P_r}$ h
Where h = wall thickness
P = pressure = 1.05 bar ≡ 0.103MPa at 121^{0}C (Source: steam table)
$h = \frac{p_r}{\sigma_c}$
Taking, $\sigma_c = 5MN/m^2$
$h = \frac{0.103 \times 10^6 \times 0.3}{5 \times 10^6}$
$= 0.00618m \approx 0.006m$
Hence, the thickness of the pressure vessel used = 0.006m.
The cylinder wall is 0.006m thick and the internal diameter of the cylinder is 0.6m. The ratio of $\frac{t}{d}$ =.01 which is less than 0.1, hence the thin-cylinder design must be used.

Fig 1. Autoclave with the inner container[ref 8]

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue IX, September 2017- Available at www.ijraset.com



4.1 A. sterilize cylinder



4.2 B. perforated cylinder

III. RESULT

A. An autoclave has been designed to treat 200 liters per cycle.
B. Dimension of sterilized cylinder is 0.6 m diameter and 1.2m in height.
C. Dimension of perforated cylinder is 0.57 m diameter and 0.8m in height.
D. Thickness of sterilized cylinder is 6 mm.

REFERENCES

[1] Oyawale, F. A., & Olaoye, A. E. (2007). Design and Construction of an Autoclave. Pacific Journal of Science and Technology, 8(2), 224-230.
[2] Guangming, Y. G. Y. X. Z. (2003). Design of autoclave for disposal of medical waste [J]. Technigues and Equipment For Enviro. poll. cont, 1, 016.
[3] Cassidy, P. J., Jackson, W. R., Larkins, F. P., Louey, M. B., Rash, D., & Watkins, I. D. (1989). The structure and reactivity of brown coal: 12. Time-sampled autoclave studies: reactor design, operation and characterization. Fuel, 68(1), 32-39.
[4] Yan, D., Liu, W., & Huang, G. (2012). Design study for composites autoclave forming mould. Design Manuf Technol Die Mould, 7, 119-124.
[5] Thomas, M. D., & Ryder, F. E. (1977). U.S. Patent No. D243,556. Washington, DC: U.S. Patent and Trademark Office.
[6] Autoclave Sterilization, Standard Operating Procedure. Division of Comparative Medicine, University of South Florida.
[7] AMSCO Sterilizer Standard Operating Procedure. Department of Laboratory Animal Resources, UTHSCSA.
[8] http://www.akamaiuniversity.us/PJST8_2_224.pdf