



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**Design and Development of Prototyping High
Pressure and High Temperature Steam
Cleaning Jet**

Thesis submitted in accordance with the partial requirements of the Universiti
Teknikal Malaysia Melaka for the Bachelor of Manufacturing Engineering
(Manufacturing Process)

By

Wong Yu Wah

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Date :

APPROVAL

This PSM submitted to the senate of UTeM and has been as partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Process). The members of the supervisory committee are as follow:

EN. MOHD. AMRAN B. MD. ALI
.....

(Supervisor)

(Official Stamp & Date)

ABSTRACT

Grease, grime, and dirty surface are hardly dissolved for most of the cleaning method and yet the superheated steam can solve this problem if used regularly with its advantage of high temperature. Steam cleaning jet was designed for using in commercial, industrial, and domestic applications. This project presents the method of designing and developing of a high pressure and temperature steam cleaning jet which consists of an electric miniature boiler in producing superheated steam. The methodology for designing and developing involved the comparison of various components and equipments available in the market, such as immersion water heaters, solenoid pump, water level sensor, solenoid valve and safety valves. The selected components have been used to construct the steam cleaning jet boiler system with the concern of hydraulic circuit design and analysis. 3D modeling has been used to design the steam cleaning jet using Computer Aided Design (CAD) software of SolidWorks 2006 and COSMOSWorks 2006. The results here have shown the complete method of designing and developing of steam cleaning jet with the aid of 3D modeling software. The complete analysis of steam cleaning jet boiler with Finite Element Analysis (FEA) was solved with showing the maximum allowable pressure for the designed boiler of the system. The model of steam cleaning jet prototype has give more clear of the actual structure of steam cleaning jet. The steam cleaning jet prototype with frame and housing cover will use for the future research of steam cleaning jet.

ABSTRAK

Permukaan yang berminyak, berdaki, dan kotor adalah sukar dicair bagi kebanyakan kaedah pembersihan tetapi wap lampau panas boleh menyelesaikan masalah ini apabila digunakan selalu dengan kelebihan pada suhu tinggi. Jet wap pembersihan telah direkabentuk untuk dipakai dalam aplikasi-aplikasi komersial, industri, dan isi rumah. Project ini menerangkan cara rekabentuk dan pembentukan jet wap pembersihan yang bersuhu tinggi dan tekanan tinggi dimana ia mengandungi satu elektrik dandang mini dalam mengeluarkan wap lampau panas. Kaedah untuk rekabentuk dan pembangunan melibatkan bandingan pelbagai komponen-komponen didapati di pasaran, contohnya seperti pemanas air rendaman, pam solenoid, pengesan aras air, injap solenoid, dan injap keselamatan. Komponen terpilih telah digunakan untuk membina sistem dandang bagi jet wap pembersihan dengan keseimbangan rekabentuk dan analisis litar hidraulik. Gambaran 3D untuk rekabentuk jet wap pembersihan telah dibantu dengan perisian RekaBentuk Berbantuan Komputer (RBK) SolidWorks 2006 dan COSMOSWorks 2006. Keputusan yang telah di perolehi mempamerkan kaedah yang lengkap dalam rekabentuk dan pembentukan jet wap pembersihan dengan bantuan perisian gambaran 3D. Analisis yang lengkap bagi dandang jet wap pembersihan dengan Analisis Unsur Terhingga (AUT) telah menyelesaikan tekanan maksimum yang dibenarkan bagi sistem hasil rekabentuk dandang. Prototaip jet wap pembersihan model telah memberi lebih jelasnya struktur sebenar bagi jet wap pembersihan. Prototaip jet wap pembersihan dengan rangka dan penutup akan digunakan untuk penyelidikan masa depan bagi jet wap pembersihan.

DEDICATION

For my beloved mother and father.

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LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

AISI	American Iron and Steel Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
BSP	British Standard Pipe thread
BST	British Standard Thread
CAD	Computer Aided Design
DIN	Deutsches Institut für Normung
FEA	Finite Element Analysis
FOS	Factor of Safety
MAWP	Maximum Allowable Working Pressure
MIG	Metal Inert Gas
MVQ	Methyl Vinyl Silicone
NBR	Acrylonitrile Butadiene Rubber
NC	Normally Closed
NO	Normally Open
NRV	Non-Return Valve
PE	Polyethylene
PLC	Programmable Logic Controller
PRV	Pressure Relief Valve
PTFE	Polytetrafluoro Ethylene
SRV	Safety Relief Valve
SS	Stainless Steel
TIG	Tungsten Inert Gas

CHAPTER 1

INTRODUCTION

1.1 Background

Grease, oil, and grime surface usually are hard to dissolve or decompose when we perform cleaning process. Apparently, these problems cause difficulties to people especially cleaning contractor, workers, home user, and hotel cleaner, whenever they need to clean environment, such as kitchen, industrial unit, air conditioning system, washroom, hospital, hotel, machine shop, and so forth. These difficulties will probably reduce their work time efficiency as they need to perform harder effort and longer cleaning time. By using normal means of cleaning methods, grease and grime are hardly dissolve and the result may not be as clean as desired.

One method to dissolve the contaminants of grease, oil and grime problems in such circumstances is to have a cleaning device with a high temperature (approximately 180°C) called superheated dry steam. Superheated dry steam can perfectly dissolves grease and grime on all types of surfaces and equipment, leaving them completely clean and sanitized. In fact, this superheated dry steam cleaning system can effectively kill or reduce bacteria population with the present of high temperature by their abilities [1-5].

Such device or machine namely High Pressure High Temperature Steam Cleaning Jet or in the abbreviation namely Steam Cleaning Jet currently is available in the global market and is designed for use in commercial, industrial and domestic applications. In addition, this device is used in Malaysia by cleaning industries

contractors, usually for cleaning air conditioning system, supermarket, market and so forth, where this device was initially introduced by CRT Technologies Sdn. Bhd.

Mechanism of the steam cleaning jet basically includes a miniature boiler to produce high pressure (10 bar) and high temperature (180°C) of superheated steam. These high pressurize steam is create to allow an output of high velocity steam to maximize effectiveness of cleaning process. Components of the steam cleaning jet require high pressure and high temperature resistant. In the principle of boiler industry, this miniature boiler uses electricity to drive the heaters to create steam source. The voltage rating for electricity is usually 220V/3P/60Hz with the input capacity varies from 3 to 20 kW and pressure rating varies from 15 to 100 psig [6].

This project is to design and develop a prototype of steam cleaning jet with the aid of 3D modeling Computer Aided Design (CAD) tools, SolidWorks 2006 and COSMOSWorks 2006. These tools are used to sketch design drawings and analyze the boiler in various conditions. Besides, circuit simulation and analyzing tool, Automation Studio 5.0 is used to simulate and analyze the system operation principle. This project studies the steam cleaning jet design currently available in the market, with focuses on refine the boiler operation principles to improve its efficiency and operation period. This miniature boiler is designed, constructed, and inspected in accordance with the general requirements of part PG and specific requirements of part PMB of American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code Sec I [6].

1.2 Problem Statement

Surfaces with grease, oil, and grime contaminants are hard to dissolve and clean. Commonly, these problems occurred at the environment such as machine shop, air conditioning system, industries site, kitchen, and so forth. Cleaning contractors and cleaning workers are the ones who mainly encounter these problems thus affecting their work effectiveness. These grease, oil, and grime contaminants are hard to

dissolve by normal means of cleaning procedure, since it can only be decomposed completely with high temperature source. Steam cleaning jet is design to produce high pressure and high temperature superheated steam to clean, dissolve, and decompose any environment and places with grease, oil, and grime contamination in commercial, industrial and domestic applications.

1.3 Objectives

The aim of this project is to design and develop the prototype of High Pressure and High Temperature Steam Cleaning Jet. The main objectives are:

- To sketch 3D modeling and drawings using SolidWorks 2006.
- To conduct Finite Element Analysis (FEA) for 3D model using COSMOSWorks 2006.
- To fabricate prototype of High Pressure and High Temperature Steam Cleaning Jet.

1.4 Scope

This project focuses on designing and developing an electric miniature boiler driven steam cleaning jet device. The design and development process of steam cleaning jet includes identifying specifications, concept generation, boiler and frame structural design, components selection and placement, boiler performance calculation, boiler analysis, and product prototyping. To develop the whole steam cleaning jet device visibly, SolidWorks 2006 is used to design and sketch the architecture or structure design, COSMOSWorks 2006 is used to analyze the boiler stress, pressure, and deformation, and Automation Studio is used to simulate, analyze, and study the system operating principle. Prototyping of the steam cleaning jet device is used to illustrate the concept generated and to examine its architecture and structure design.

CHAPTER 2

LITERATURE REVIEW

2.1 Steam Cleaning Jet

“Steam Cleaning Jet” or “Steam Cleaner” is a tough and robust machine designed to enable cleaning of the highest quality to be undertaken whatever and wherever the job. It is a high temperature and high pressure cleaning device with producing superheated steam that can simply dissolves and eliminates grime, grease, dust mites, smells and dirt away. Figure 2.1 shows two types of common market available steam cleaning jet, electric powered Portotecnica Steamer Jet 7140 T II [7] and fuel powered Steamtech Series V [8].



Figure 2.1: Portotecnica Steamer Jet 7140 T II (Left) and SteamTech Series V (Right)

It is recommended to steam clean in any place where people live or work, from industrial to domestic applications such as: guest houses, hotels and restaurants, fast food outlets, butchers, bakeries, nursing homes, leisure centers, swimming pools, kitchen, lounge, hospitals, industry site, workshop, machine, air conditioning system, oven, worktable, residences, etc. Steam can be used on any surfaces except for those that are extremely heat sensitive. Market available steam cleaning jet has a heavy duty trolley for use on rough external terrain such as pavements and concrete as well as uneven factory floors. In Figure 2.2, the Technovap SteamTech 12000 equipped with heavy duty trolley degreasing hydraulics with superheated steam using high pressure steam lance [9].



Figure 2.2: Technovap SteamTech 12000 equipped with heavy duty trolley

When superheated steam touches a cold surface it expands, explosively loosening dirt, grease and grime. Gill and Bryant [1], Trivedi, Reynolds and Chen [2], and Shull and Ernst [3] have proved that high heat of superheated steam can instantly kills bacteria, fungus, mold, mildew and other micro organisms without the use of harsh chemicals.

Basically, the steam cleaning jet consists of a boiler with a heating element, normal tap water and the electric power supply. The technology and performance which make the steam cleaning jet so effective are it can deliver superheated steam with temperature 160°C to 180°C nominal and pressure 8 to 10 bar. With this steam