Overhead Water Tank Cleaning Using Water Jet

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Abstract : To be mention here in necessity is mother of invention have personally been experienced by me when it came to clean the overhead water tank of my house at that time I noticed that how difficult it is to climb and do the required cleaning of overhead tank it was revealed that there is a need of designing a semi- Instance automated overhead tank cleaning system. The current procedure used for cleaning and draining of overhead tank is requires a lot of manual handling. Which seems to be very difficult so with this intention I came up with the solution of overhead tank cleaning system which should be portable and comfortable to handle This system will help in increasing the safety of the workers, the working efficiency and saving the time and efforts of the workers, working principle of the system is that the water is released with pressure from the nozzle .The pressure and the speed of the water flowing or coming out through the nozzle is use for removing the dirt from the surface of the tank. To generate required pressure and the speed of the water high pressure pump is used .high pressure reciprocating plunger / piston pump develops high pressure due to smaller diameter orifice of the nozzle, which develops high pressure which in thru converts in to high velocity causing water jet blasting on the surface of the overhead tank. Appropriate flow rate and pressure can easily clean the overhead water tank. This report is focus on the study and design of a tank washing system .The redesigned model will thus help in reducing time in carrying out the cleaning operation and reduce the user's effort required for cleaning..

***Keywords* - Nozzle, Water Jet Characterization.**

I. INTRODUCTION

Storage vessels must be cleaned periodically in order to avoid contamination and safe storage of goods and other products Importance of storage vessel cleaning in some sectors are mentioned below .In the last few years, numerous studies on aspects of cleaning, and on related processes such as spray technology and air-jet impingement on flat smooth and rough surfaces have been conducted, in addition to related research in similar sectors such as droplet impact dynamics, soil erosion and soiling mitigation.
Many manufacturing industry uses stationary water-jets for cutting and cleaning operations. The main difference is that the cutting water jet requires jet penetration throughout the solid surface, whereas the high pressure water-jet is use for cleaning purposes and does not require jet penetration into the solid, but does involve an erosion process by which dirt particles are removed from the surface.

II. LITERATURE REVIEW

Research findings on water jet cleaning from last few decades focused on jet impingement and related cleaning aspects based on experimental tests Those research findings, except for the most recent studies, lack an underlying mathematical model. Therefore the understanding of the effect of parameters in the cleaning process was Incomplete and limited by the outputs that were accessible to those early stage experiments.
Experimental and numerical studies on a water-jet cleaning process conducted by Guha et al., based on the semi empirical model to capture the air entrainment process and to bypass the theoretical limitations, reveal the optimal standoff distances are in the range 5D - 26D. Upper and lower bounds represent the critical stand-off distances outside of which no cleaning ability was observed. Furthermore researchers inferred that dirt particles or soil located at a radial distance $RPPPP > 1.68D$ from the jet axis is definitely irremovable by the cleaning jets.
Leu et al., established a mathematical model of significant importance for cleaning operations, highlighting that cleaning occurs when the shear stress generated by water droplets impact is greater or equal to the endurance limit of the coating material. This study established that the maximum cleaning width is linearly proportional to the critical standoff distance, and optimal cleaning occurs at 0.576xc
Mixing air and high pressure water spray techniques are the most traditional methods available for cleaning purposes. Dirt particles ejectment by a high pressure water jet is strongly connected to the shear stress generated on the target surface. Cleaning efficiency depends upon the fluid velocity, efficiency of cleaning increases by maximizing the fluid velocity on the surface and decreases as the spray breaks into smaller droplets on the target surface.
Accordingly to Adler's research study, the dirt particles or soil removal process from the surface is strongly dependent upon material erosion by droplet impingement on the surface.

It consists of four mechanism types:

1) Direct deformation
2) Stress wave propagation
3) Lateral outflow jetting

4) Hydraulic penetration.
The first two are responsible of crack initiation in the erosion process as reported by many researchers.

Studies regarding a single droplet impacting on several types of surface which can absorb more or less energy have been carried out experimentally and theoretically by many researchers. Preliminary studies, based on water hammer theory on one-dimensional approximation and a single droplet impacting on rigid surface, showed a misshapen droplet compressed at its base or point of contact and explain the soil erosion is due to the pressure generated from planar shock wave at a constant speed C0.
According to this theory the following relations holds:

$P = \rho 0 C0 V0$

Further experiments provided a two-dimensional model for a better approximation of the maximum pressure before droplets spread on the surface and rectified the previous hypothesis of single shock wave with a multiple wavelet structure
Dirt particle removal is correlated to the magnitude of the shear stress imposed on the target surface and it can be achieved using a different kinds of methods of generating sufficient shear stress.
Air-jet impingement is one effective dirt particle removal method, and probably the most common for cleaning purposes, as it imposes a consistent shear stress. Several studies have been conducted with this cleaning technique.
Zhang et al., conducted experimental research based on particle removal, using glass spheres of 40-50 micron diameter, removed by a single air jet using a converging nozzle with 3mm diameter. The experimental results showed how the standoff distance, the impinging jet angle, inlet pressure and time elapsed strongly affect the particle removal efficiency. It was found that the most efficient particle removal occurred at 30° impinging angle, in conjunction with impinging distance from 13D to 20D (39mm to 60mm).
Vachon et al., conducted a study on dust mitigation where particulate matter strongly adheres to surfaces such as solar panels, clothing, equipment and mechanical devices by imposing a bound vortex surface impingement method.
The purpose of this paper is to provide a practical procedure for a more effective cleaning operation by using high pressure water jet. It focuses on the variation of parameters such as nozzle selection and water jet structure, angle of impingement and standoff distances, and their combination, aiming to enhance the shear stress on a specific portion of the target surface for an efficient cleaning process.

III.RESEARCH METHODOLOGY

Data accumulation
Literature survey
Selection of the Nozzle
Calculation of the Nozzle

1. Concept
A nozzle is a device designed to control the direction or characteristics of a fluid flow (especially to increase velocity) as it exits (or enters) an enclosed chamber or pipe. A nozzle is often a pipe or tube of varying cross sectional area and it can be used to direct or modify the flow of a fluid (liquid or gas). Nozzles are frequently used to control the rate of flow, speed, direction, mass, shape, and/or the pressure of the stream that emerges from them.

Figure 1: nozzle

2. Calculation
The nozzle consider in this study is of the type of "High Pressure Sprayer". Selection of the nozzle provides high and uniform impact capabilities. Even spray pattern eliminates the need to overlap patterns from adjacent nozzles.
Spray Angle - 5o to 65o.

Velocity of the flowing liquid through the nozzle can be calculated with the help of the equation of continuity.

Equation of continuity:-a1v1= a2v2

Where:-

a1, a2 are area of cross-section of the nozzle inlet and outlet respectively.

v1, v2 are velocity of the fluid or liquid flowing in and out through the nozzle.

Formula used in this study for various calculations of the numerical parameters.

The flow rate of the fluid can be calculated with the help of the following formula as:-

Q=P*n/ΔP

Where the various parameters are:

Q = Fluid flow rate in m3/s

P = Power of the pump in watt

n = Efficiency of the pump

ΔP = Change in pressure in Pa

The change in pressure for the nozzle inlet and outlet can be calculated with help of the Bernoulli's equation, which can be given as:-

ΔP= ((v2)2 - (v1)2)/2 + ΔZ*g + ΔP static /d

ΔP = Change in pressure in Pa

v2, v1 = Velocity of inlet & outlet fluid in m/s.

ΔZ = Change in height in m.

g = Acceleration due to gravity m/s2.

d = Density of the fluid in kg/m3.

ΔP static = Change in pressure at static condition in Pa.

Specifications for the nozzle

Velocity of the fluid at the outlet

r1 = 20mm r2 = 5mm

a1 = 3.14*20*20 a2 = 3.14*5*5

= 1256 mm2 = 78.5 mm2

v1 = 5 m/s (for the inlet) v2 = (a1*v1) /a2 = 80m/s

Change in pressure for inlet and outlet:-

ΔZ= 1m (considering height of 1m).

ΔP static = 0 (at static condition pressure diff. is 0).

ΔP= (6400-25)/2 +1*10 + 0 = 3197.5 Pa

Flow rate of the fluid:-

Efficiency n, = 60% Power of the pump = 80W

Q = .6*80/3197.5 = 0.015 m3/s

3. Water Jet Structure

Three regions characterize the jet structure:

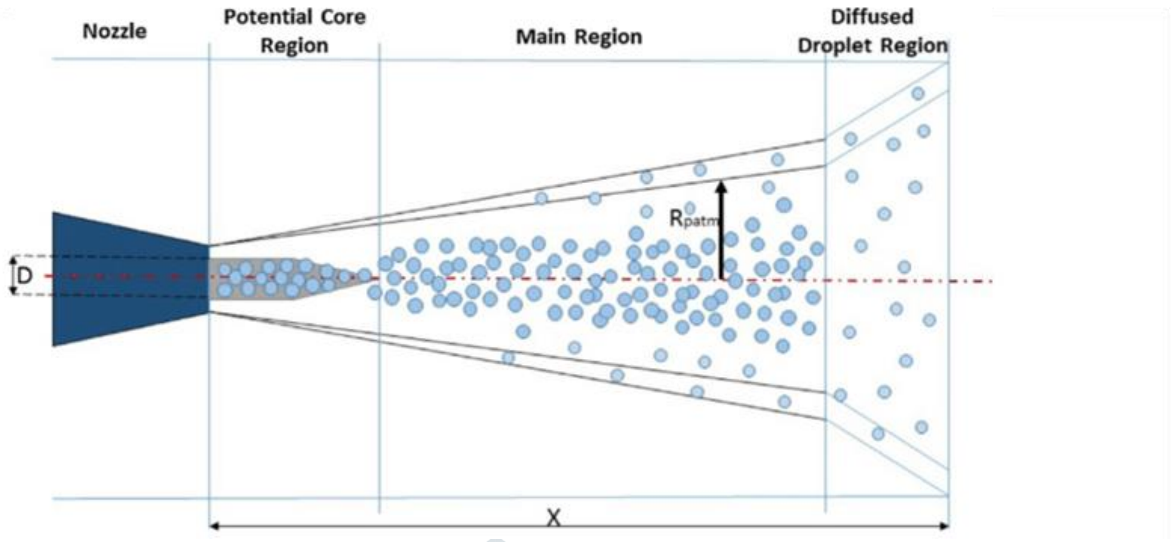

Figure 2 water jet characterization

• Potential core region: It is characterized by a wedge-shape core surrounded by a mixing layer within which the process of air entrainment breaks up the water continuity into discrete droplets due to an intensive transfer of mass and momentum. The velocity at the nozzle exit is equal to the velocity generated inside the core region. This is the closest part to the nozzle exit (Figure 1a),

• Main region: Droplets forms in this region due to the continuous interaction between air and water due to which the breakup of the water jet stream into droplets which decrease in size progressively as the radial distance increases. The droplets form in the area close to the nozzle or jet axis is known as the water droplet zone, and the area further from the axis is referred to as the mist zone, which is characterized by small droplets with negligible velocity and is considered ineffective for cleaning purposes.

• Diffused droplet region: In this region the jet has insufficient velocity for cleaning purposes and it is totally broken up into small Droplets which are undesired for cleaning purposes.

IV. CONCLUSION

In order to overcome the difficulties of cleaning the storage vessels by manual method we investigated and studied about water tank cleaning system. By implementing this system we can reduce the human efforts and time which require for cleaning the overhead water tank. It is designed to provide high safety, high efficiency, less time for cleaning and to avoid water pollution problems. By using more advanced techniques and resources, the mechanism can be modified and developed according to the required application.

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