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Design and Development of an Attachment for a Drainage Cleaner

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Abstract – The jetting machines used by Health Department of Nagpur Municipal Corporation for drainage cleaning has several problems. The current nozzles used in jetting machines are to be changed every time according to the type of blockage in the sewer lines. This paper is advancement in existing nozzles making them both multi functional and economical by incorporating a jet and cutter mechanism which will penetrate into the firm blockages and free the sewer lines. The innovated nozzle consists of sharp blades to cut the solid waste so that blockage can be removed.

Keywords— Jetting Machine, Nozzle, Power Transmission

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INTRODUCTION

The essential part of running sewer jetters on a truck is identifying beforehand what type of sewer lines lie underneath and how much pressure they can withstand. As sewers are constructed of anything from concrete to steel, a hasty consideration could cause a lot of damage. To maintain the municipal sewers clean, municipalities require powerful vacuum and septic trucks with additional equipments. Cleaning of the drainage system is done by suction mechanism and jet spray mechanism. Apart from jetter, the most important tools are high quality nozzles, proficient of handling anything in the sewer lines. Nozzles are the fundamental part of any high pressure jetting unit. Changing the nozzle can change the function of an entire unit. Different types of nozzles used for drainage cleaning are regular dome nozzle, closed nozzle, rotating nozzle, rocket nozzle and sand nozzle. Regular nozzles are used for initial penetration of 3''-10'' sewer lines. Closed nozzles are used as rear facing jets. Rocket nozzles are used for cleaning heavily compacted debris whereas sand nozzles are used to clear out heavy sand build up. Each time the nozzle is changed according to the time of blockage. In this paper the nozzle implemented is a fast, efficient penetrating nozzle along with a cutter which can clear out total blockage, hard scale deposit along with the root vegetation.

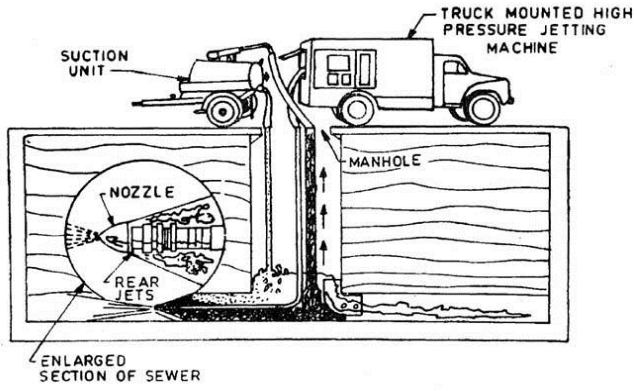

Fig. 1 Suction and jet spray mechanism used for drainage cleaning

POWER TRANSMISSION FROM THE JETTING MACHINE

The jetting suction machine is directly placed above the manhole and nozzle is inserted into a manhole. The engine generates the power which then goes to the gear box. The function of gearbox is to reduce speed of output shaft thereby increasing the torque. With the help of Power Transmission Shaft (PTO), power from engine is given to three components, compressor, jetting box and differential. The power from differential is used to drive wheels of the truck and compressor further increases the pressure. Here we are mainly concerned with the jetting box. From the jetting box water goes to the inlet filter and further to the high pressure plunger pump. Further a valve is used to regulate the fluid flow. Lastly, water comes out from the nozzle and the drainage pipes are cleaned.

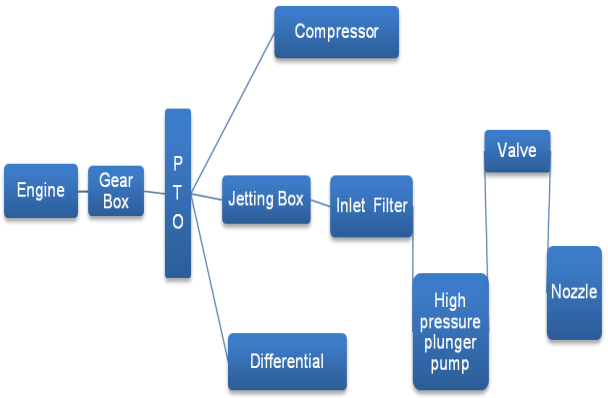

Fig. 2 Power transmission flow diagram

Nozzle Components

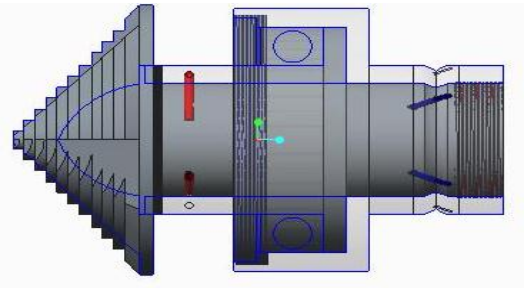

Fig. 3 Design of nozzle

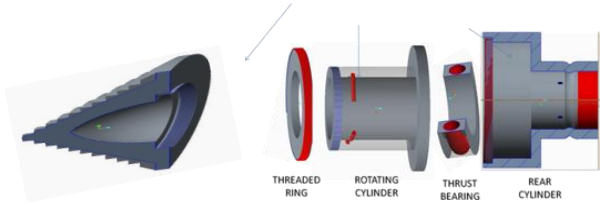

Fig. 4 Nozzle components- cutter, threaded ring, rotating cylinder, thrust bearing, rear cylinder

DESIGN CONSIDERATIONS

- Commensurate the exit and atmospheric pressure as closely as desired.
- Reduce jet noise and Infrared Radiation if desired.
- Allow for cooling of walls if necessary.
- Expedite the flow to high velocity with minimum total pressure loss.
- Allow for thrust reversing if desired.

Table I Design Specifications

Sr. No	Rear Cylinder	Rotating Cylinder	Bearing
1	Material: Cast Iron SAE30	Material: Cast Iron SAE30	Outer Diameter: 60mm
2	Outer diameter :40mm	Outer diameter :40mm	Inner Diameter: 40mm
3	Inner diameter:30 mm	Inner diameter: 30mm	Width : 14mm
4	Hole diameter:2 mm	Hole diameter: 4mm	
5	Pressure:1 30bar	Pressure: 130bar	
6	No of jet:5	No of jet:4	
7	Total length : 70mm	Total length: 40mm	

DESIGN CALCULATIONS

Assume FOS=5

Cast Iron μ=0.27 hence Brittle

So using Lame's Equation: $t = \frac{D_i}{2}\left[\sqrt{\frac{\sigma_t + P_i}{\sigma_t - P_i}} - 1\right]$ Cast Iron SAE-20 S_{ut} =140

$\sigma_t = \frac{S_{ut}}{F_s} = \frac{140}{5} = 20$ N/mm^2

t=9.79mm$\cong$10mm

Cast Iron SAE-30 S_{ut} =271

$\sigma_t = \frac{S_{ut}}{F_s} = \frac{271}{5} = 54.2$ N/mm^2

t=4.15mm$\cong$5mm

Cast Iron SAE-50 S_{ut} =350

$\sigma_t = \frac{S_{ut}}{F_s} = \frac{350}{5} = 70$ N/mm^2

t=3.10mm$\cong$3mm

Assume FOS=2.5

Cast Steel μ=0.29 Ductile an close ends

So using Clavarino's

Equation: $t = \frac{D_i}{2}\left[\sqrt{\frac{\sigma+(1-2\mu)P}{\sigma-(1+\mu)P}} - 1\right]$

Cast Steel IS-CS-65 S_{ut} =650

$\sigma = \frac{S_{ut}}{F_s} = \frac{650}{2.5} =$ 260 N/mm^2

t=0.67mm

Cast Steel IS-CS-85 S_{ut} =850

$\sigma = \frac{S_{ut}}{F_s} = \frac{850}{2.5} =$ 340 N/mm^2

t=0.50mm

Cast Steel IS-CS-125 S_{ut} =1250

$\sigma_t = \frac{S_{ut}}{F_s} = \frac{1250}{2.5} =$ 500 N/mm^2

t=0.34mm

Birne's Equation cannot be used because it is used when both ends are open.

Hence, from the calculations we choose **SAE-30 Cast Iron**

Therefore t=5mm

D_o =30+10=40mm

P=130 bar=13MPa

D_i =30mm

D_o=40mm

F_s =5

Bearings D_o =40mm, So standard Bearing

Therefore, D_i =40mm

D_o=60mm

Width=14

Design of Cylinder:

$A = \pi(40 - 30)35$

=1099.55mm^2

Tensile strength of vertical cylinder,

$$\sigma_t = \frac{F}{A} = \frac{9.18 * 10^3}{1099.55}$$

σ_t =8.34N/mm^2

Design of Collar:

F=9.18KN

$\sigma_{permissible}$ =54N/mm^2

Area= $\pi(d_o - d_i)l$

$$A = \frac{9.18 * 10^3}{54}$$

$$A = 170mm^2$$

$$l = t = 1.80mm$$

Hence, t=2mm

Moment=9.18*15

=137.7 KNmm

Mb=137.7KNmm

Y=2.5m

$$J = \frac{bd^3}{12} = 52.08mm^4$$

$$E = 100 * 10^3 N/mm^2$$

$$Y = \frac{W}{\sigma EI}[(x-a)^2 - 3b^2(x-a) + 2b^3]$$

Putting all the values we get,

$$Y = 6.56 * 10^{-3}mm$$

$$\sigma_b = \frac{137.7 * 10^3 * 6.56 * 10^{-3}}{52.08}$$

$$\sigma_b = 17.34N/mm^2$$

Hence the design is safe.

CONCLUSIONS

The cutter is used to cut the concrete waste, twisted roots of trees and other firm blockages found in the drainage system makes it useful for penetrating various supple and firm blockages in the sewer lines. Hence the time required for changing the nozzle for different types of blockages is reduced.

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