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Correlation Development for Sauter Mean Diameter of Rotary Atomizer

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Abstract: - Atomizers are of many types, among that simplex and duplex types of atomizers are used and recognized often as fuel injectors in aircrafts. Types of atomizers and features are read. Among many types of atomizer, rotary type of atomizer is selected due to its naked evident like easy retrofit to existing spreading system , able to handle large quantities, feed is possible, better economy, high peripheral speed and spread of droplets, uniform liquid feed rate, uniform distribution of feed, higher level of atomization etc., The rotary atomizer specifications and its features are listed, the droplets of rotary atomizer are visualized and readings are taken from experimental methods, such as Laser visualization method .After the droplets data alignment, the (SMD) Sauter Mean Diameter is to be taken in and considered, SMD means it is a average particle (droplet) size of a given particles, and it is further explained with its given relation. By SMD's given equated form it is used to compare data between rotary atomizer particles and given particle size. By SMD it is simplified further and used to create a co-relation between SMD and rotary atomizer. The rotary atomizer data values are taken through out with the SMD to find and form a co-related derived pattern for ROTARY ATOMIZER.

Keywords: *Co-relations, Droplets, Injectors, Rotary atomizer, SMD Sauter Mean Diameter, Types of atomizer*

I INTRODUCTION

Atomization

The development of the jet or sheet and the growth of small disturbances, which eventually leads to disintegration into ligaments and then small droplets.

Atomizer

Atomizer is a device for emitting water, perfume, or other liquids as a fine spray.

Types of Atomizer

1.Pressure Atomizer,
Plain Orifice,
Pressure Swirl,
Square Spray,
Dual Orifice,
Duplex,
Fan Spray.
Rotary Atomizer,
Air – Assist Atomizer,
Air Blast Atomizer.

Rotary Atomizer

One widely used type of atomizer comprises a high speed rotating disk with means for introducing liquid at it center. The liquid flow radially outward across the disk and is discharges at high velocity from it periphery.()

At high flow rate, ligaments or sheets are generated at the edges and disintegrate into droplets. Small disk operating at high rotational speeds and low flow rate are capable of producing spray in which drop size are fairly uniform at low flow rate droplets from near the edge of the disk. The sizes of the liquid droplet diminish with increase rotational speed, increases with flow rate. Rotary atomizers are used throughout the process and allied industries to produce a spray of relatively small mean droplet diameter. A typical application of atomizer is atomization of feedstock in spray dryer. The principle of operation of centrifugal atomizers is the addition of centrifugal energy of liquid feed to increase the surface area. Disintegration of liquid film results in the formation of droplets stream. Rotary atomization has been widely studied and today it is well-known that the degree of atomization depends on the speed, feed rate, liquid properties, and atomizer design.

The majority of experimental conditions under which spray analysis studies have been conducted neglect influences of drying air entry around the atomizer and air flow produced by wheel rotation.A detrimental effect of wheel rotation is generation of a region of low pressure air at the wheel center. This region establishes an air flow that flows radially inward through clearance gap between wheel and atomizer body and on reaching the cavity in wheel center, the flow then changes direction and flows radially outward through the ports.

This air stream typically draws air from hot inlet air in dryer roof and can simultaneously aerate and partially dry feedstock within atomizer wheel. Dried particles deposited on wheel will over dry and can constitute a source of product contamination and potential ignition for fire and explosions.Pumped air stream, which possesses a largeamount of radial momentum, can significantly affect dryer flow pattern in pilot plants in diameter up to 2 m.

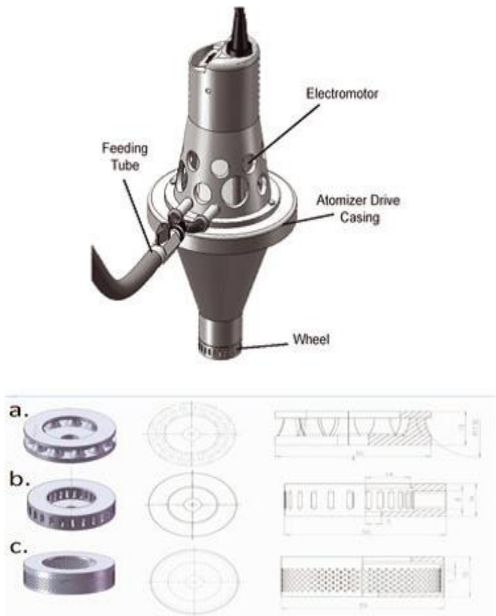


Figure 1. Rotary atomizer and wheels

II METHODOLOGY

Dimensional Analysis:

$$\mathbf{SMD = 0.26N^{-0.79}Q^{0.32}d^{-0.69}\rho_L^{-0.29}\sigma^{0.26}(1+1.027\mu_L^{0.65})}$$

The above equation is taken from the following journal Bachalo, W.D, and Houser, M.J, Phase Doppler Spray Analyzer for Simultaneous Measurements of Drop Size and Velocity Distributions Opt.Eng., Vol.23, No.5, 1984, PP 583-590

$SMD = f\,[Q\sigma\mu_L/Nd\rho_L]$

$n = 7$

$Q = m^3/sec = L^3T^{-1}$

$\sigma = N/m = Kgm/sec^2m = MT^{-2}$

$\mu_L = Kg/msec = ML^{-1}T^{-1}$

$N = 1/sec = T^{-1}$

$d = m = L$

$\rho_L = Kg/m^3 = ML^{-3}$

$j = n-K = 3$

We take N, d, ρ_L as not as π form.

$\pi_1 = N^a.d^b.\rho_L^c.Q = M^0L^0T^0$

$T^{-a}.L^b.M^cL^{-3c}.L^3.T^{-1} = M^0L^0T^0$

$M = c = 0$

$L = b-3c+3 = 0$

$T = -a-1 = 0$

$a = -1$

$b = -3$

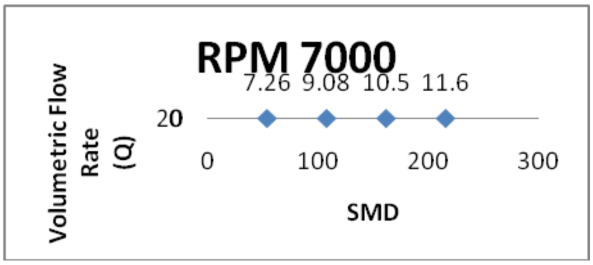
$c = 0$
$\pi^1 = N^{-1}d^{-3}\rho_L^{\ 0}$
$= d^{-3}/N$
$= Q/Nd^3$
$\pi_2 = N^a d^b \rho_L^{\ c}\sigma$
$= [T^{-1}]^a[L]^b[ML^{-3}]^c \,.\, MT^{-2}$
$= M^0L^0T^0$
$= T^{-a}L^bM^cL^{-3c}ML^{-2}$
$M = c+1 = 0$
$L = b-3c = 0$
$T = -a-2 = 0$
$a = -2$
$b = -3$
$c = -1$
$\pi_2 = N^{-2}d^{-3}\rho_L^{\ -1}\sigma$
$= \sigma/N^2d^3\rho_L$
$\pi_3 = N^a d^b \rho_L^{\ c}.\mu_L$
$= [T^{-1}]^a[L]^b[ML^{-3}]^c[ML^{-1}T^{-1}] = M^0L^0T^0$
$= T^{-a}L^bM^cL^{-3c}ML^{-1}T^{-1}$
$M = c+1 = 0$
$L = b-3c-1 = 0$
$T = -a-1 = 0$
$a = -1$
$b = -2$
$c = -1$
$\pi_3 = N^{-1}d^{-2}\rho_L^{\ -1}.\mu_L$
$= \mu_L/Nd^2\rho_L$
$\pi_4 = N^a d^b \rho_L^{\ c}.SMD$
$= [T^{-1}]^a[L]^b[ML^{-3}]^c[L]$
$= T^{-a}.L^b.M^cL^{-3c}.L$
$M = c = 0$
$L = b-3c+1 = -1$
$T = -a = 0$
$a = 0$
$b = -1$
$c = 0$
$\pi_4 = N^0d^{-1}\rho_L^{\ 0}.SMD$
$= SMD/d$
$f(\pi1, \pi2, \pi3/\pi4)$
$= Q/Nd^3 * \sigma/N^2d^3\rho_L * \mu_L/Nd^2\rho_L * d/SMD$
$\mathbf{SMD = Q\sigma\mu_L/N^4d^7\rho_L^{\ 2}m}$

III RESULT & DISCUSSION

$\mathbf{SMD = 0.26N^{-0.79}Q^{0.32}d^{-0.69}\rho_L^{\ -0.29}\sigma^{0.26}\,(1+1.027\mu_L^{\ 0.65})}$

Table 1. Volumetric flow rate Vs SMD at 7000 rpm

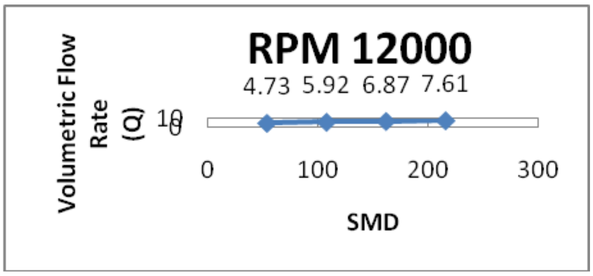
Volumetric Flow Rate (Q) ($\times 10^{-7} m^3/s$)	SMD ($\times 10^{-5}$m)
54	7.26
108	9.08
162	10.5
216	11.6



Graph 1. volumetric flow rate Vs SMD at 7000 rpm

Table 2. volumetric flow rate Vs SMD at 12000 rpm

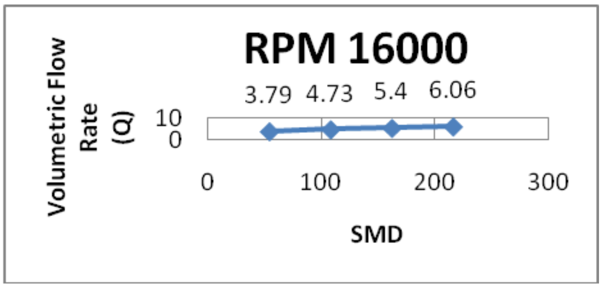
Volumetric Flow Rate (Q) ($\times10^{-7}m^3/s$)	SMD ($\times10^{-5}$m)
54	4.73
108	5.92
162	6.87
216	7.61



Graph 2. Volumetric flow rate Vs SMD at 12000 rpm

Table 3. Volumetric flow rate Vs SMD at 16000 rpm

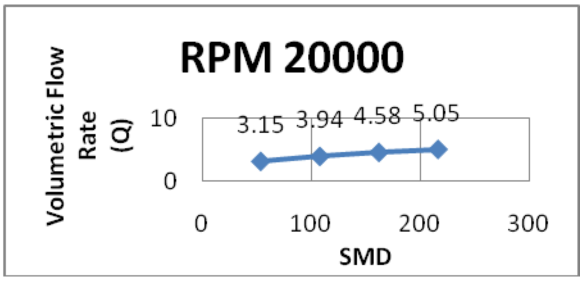
Volumetric Flow Rate (Q) ($\times10^{-7}m^3/s$)	SMD ($\times10^{-5}$m)
54	3.79
108	4.73
162	5.4
216	6.06



Graph 3. Volumetric flow rate Vs SMD at 16000 rpm

Table 4. Volumetric flow rate Vs SMD at 20000 rpm

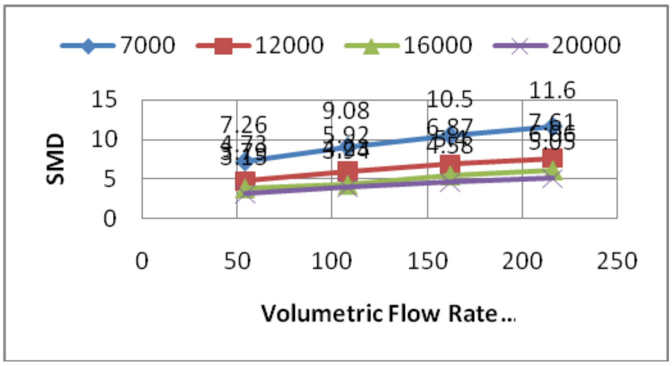
Volumetric Flow Rate (Q) ($\times10^{-7}m^3/s$)	SMD ($\times10^{-5}$m)
54	3.15
108	3.94
162	4.58
216	5.05



Graph 4. Volumetric flow rate Vs SMD at 20000 rpm

Table 5. volumetric flow rate Vs SMD at various rpm

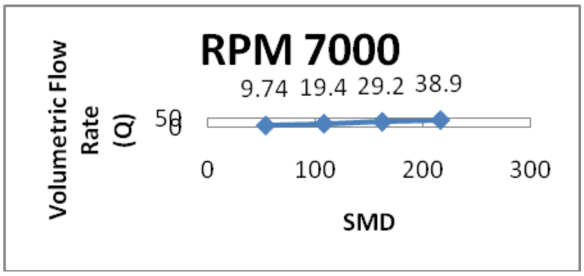
Q RPM	**7000**	**12000**	**16000**	**20000**
	SMD			
54	7.26	4.73	3.79	3.15
108	9.08	5.92	4.73	3.94
162	10.5	6.87	5.4	4.58
216	11.6	7.61	6.06	5.05



$$\mathbf{SMD = Q\sigma\mu_L/N^4 d^7 \rho_L^2 m}$$

Table 6. Volumetric flow rate Vs SMD at 7000 rpm

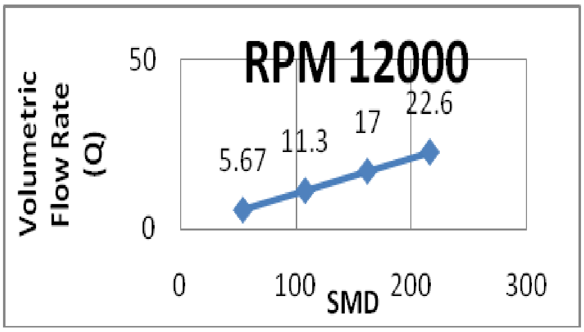
Q(*10^-7) m^3/sec	SMD(*10^-5) m
54	9.74
108	19.4
162	29.2
216	38.9



Graph 6. volumetric flow rate Vs SMD at 7000 rpm

Table 7. volumetric flow rate Vs SMD at 12000 rpm

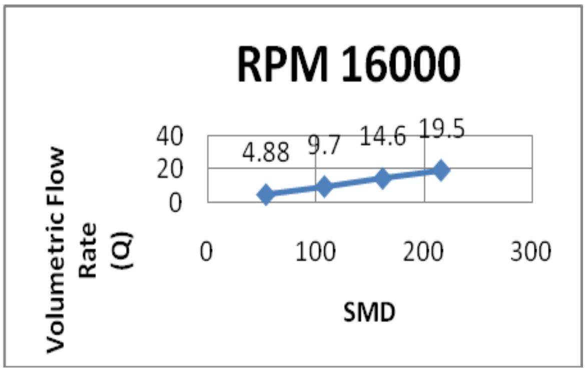
Q(*10^-7) m^3/sec	SMD(*10^-5) m
54	5.67
108	11.3
162	17
216	22.6



Graph 7. volumetric flow rate Vs SMD at 12000 rpm

Table 8. volumetric flow rate Vs SMD at 16000 rpm

Q(*10^-7) m^3/sec	SMD(*10^-5) m
54	4.88
108	9.7
162	14.6
216	19.5



Graph 8. volumetric flow rate Vs SMD at 16000 rpm

IV CONCLUSION

From the study of atomization and types of atomizer, Rotary atomizer is selected for naked evidence and results as:-

Data are collected for kerosene and its properties to use on rotary atomizer of SMD.Then we applied the data in a journal about SMD of rotary atomizer. fter substitute the values for various rpm & volumetric flow rate Vs SMD, by the acquired value graph I has been plotted. Equation taken from the journal and by solving it, we get a correlated pattern using Bucking π Theorem under dimensional analysis. From the taken values of kerosene & substituting in the correlated pattern graph II is plotted for various rpm and volumetric flow rate Vs SMD. Then by comparing graph I and graph II we get similar plotations, where our correlation is proved and unique for SMD of ROTARY ATOMIZER.

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