ATOMIZATION OF LIQUID FUELS
THE PRINCIPLE OF LIQUIDS ATOMIZATION

Atomisation is the process whereby bulk liquid is transformed into a collection of drops.

This transformation goes through the break-up of liquid jet into number of filaments, which in turn transform into droplets.
MECHANISMS OF LIQUIDS ATOMIZATION

Three mechanisms:

Disintegration of a liquid jet into a number of filaments, and then into small droplets, requires the surface tension forces of liquid to be overcome. It may happen on the three ways:

- by surface tension between moving liquid jet and steady air which destabilise the jet and causes its disintegration into filaments,

- by centrifugal forces of swirled liquid jet,

- outer mechanical and electrostatic forces and by supersonic acoustic.
## Fluid Atomization with Different Energy

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- **Liquid**
- **Gas**
JETS DISINTEGRATION AND DROPLETS BREAKUP

Primary liquid jet disintegration

Droplets break-up
RANGE OF LIQUID ATOMIZATION

\[ Re = \frac{(UL)}{\nu} \]
\[ We = \frac{(U^2L)}{\sigma} \]

\( \sigma \) - the surface tension coefficient
INFLUENCE OF PRESSURE INJECTION ON ATOMIZATION EFFECTIVENESS

5 bars

10 bars

15 bars
TORCH OF PLAIN-ORIFICE ATOMIZED OIL
LIQIUD SHEET BREAKUP

Swirled jet

Rys. 4.39. Tworzenie się kropel w żagwi rozpylacza wirowego
Types of atomizers:
- pressure
- pneumatics
- rotating

- plain-orifice
- swirl type
- Y type
- with x-cross shape flow
PRESSURE INJECTORS
PLAIN-ORIFICE ATOMISER

\[ D_o > 0.5 \text{ mm} \]
\[ \Delta p = 0.3-1(5) \text{ MPa} \]
\[ \alpha = 5-15^\circ \]

Simple construction,
Low quality of atomisation
SWIRL ATOMIZERS
HOW A SWIRL NOZZLE WORKS

- Oil at 100 PSI
- Slots
- Swirl chamber (55 PSI at center)
- Orifice

SWIRL NOZZLE: DESIGN

- \( d_o = 2-6 \text{ mm} \)
- \( \Delta p = 0.6-1.0 \text{ MPa} \)
- \( \alpha = 45-90^{\circ} \)

Simple construction
High reliability
High quality of atomisation
Low energy consumption
SWIRL NOZZLE: AN EXAMPLE

- Steel Orifice Disc
- Distributor with Tangential Slots
- Brass Body
- Brass Screw Pin
- Sintered filter
COMPACT SWIRL ATOMISER
TYPE OF FUEL CONES

Produecent Delavan

Delavan

COMBUSTION AND FUELS
SWIRL ATOMISER IN OPERATION

Dispersed oil jet
PNEUMATIC ATOMISERS
PNEUMATIC ATOMISER: PRINCIPLE OF OPERATION

Consumption of atomising medium: $\delta = 0.06-0.1 \text{ kg/kg}$
PNEUMATIC ATOMISER OF Y TYPE

Pneumatic atomizer of Y type:
1 - oil, 2 - gas, 3 - atomising head, 4 - nozzles
PNEUMATIC ATOMISER OF CROSS-SHAPE FLOW TYPE

Pneumatic atomizer of the cross-shape flow type:
1 - oil, 2 - gas, 3 - oil injection, 4 - gas injection,
5 - mixing chamber, 6 - nozzles
ROTATING ATOMISERS
How does operate rotating atomizer?
OIL BURNER WITH ROTATING ATOMISER

2. Self-closing valve
3. Electromagnetic valves for ignition gas
5. Ignition transformer
6. Flame scanner
7. Outer register ring
8. Self-closing valve
9. Igniter
10. Differential pressure monitor for primary air
11. Rotary cup atomizer
12. Primary air damper
13. Electromagnetic valves for fuel oil
14. Air elbow unit
15. Fan unit for combustion air
16. Pressure monitor for combustion air
17. Air metering unit
18. Control disk unit with 2 cam strips
19. Rotary valve
20. Servodrive
21. Pressure measuring device w/shut-off valve

a) Fuel oil inlet
b) Combustion air inlet
c) Combustion air annulus
d) Ignition gas inlet

1) Automatic quick-closing safety shut-off fittings
2) does not belong to the burner

The exact scope of supply of your plant can vary from that shown here.
ATOMISATION PRESSURE VARIATION

1. The simplest way for oil output/consumption control is variation of pressure of atomisation.

2. Disadvantage of this method of output control is loss of atomisation quality due to reduction of atomisation pressure.

   Rate of oil output $\sim (\Delta p)^{0.5}$
Two-step control of oil flow rate

Scheme of single chamber two-step oil atomizer:
1 - valve, 2, 3 - recalculating pipes
RETURN OIL INNER CIRCLE ATOMIZER

Figure 5-5. The oil pipe arrangement for a return oil inner circle atomizer

Figure 5-6. Cross section view of a return oil inner circle type atomizer
CIRCLE OIL ADJUSTING VALVE

1 - VALVE, 2 - SWIRL CHAMBER, 3 - OIL CIRCLE HOLES
TWO-NOZZLES ATOMIZER

I - nozzle

II - nozzle
QUALITY OF ATOMISATION
PARAMETERS OF ATOMIZATION

- output, kg/s
- angle of dispersion, deg
- droplets distribution,
- mean diameter of dispersion, m.
CHARACTERISTICS OF ATOMIZING NOZZLE

Characteristic of an atomizer

Spraying angle

Distribution of fluid in a stream

Atomizing spectrum
Output $m$ of pressure atomizers is defined as follows:

$$m = \mu A (2\rho_c \Delta p)^{0.5}$$

where: $A$ is the area of nozzle output, $p$ is pressure and $\mu$ is the outflow coefficient.
DROP SIZE DISTRIBUTION

Drop size distribution curves

\[ f_3(D) \% \]
\[ \phi_3(D) \% \]

\[ D_{0.1} \quad D_M \quad D_m \quad D_{0.9} \quad D \]
CHARACTERISTIC OF DROPLETS SIZE

Mean drop size:

mean drop size

SRK = \[\left(\frac{\Sigma nD^3}{\Sigma nD}\right)^{0.5}\],

mean drop size of Sauter

SMD = \[\Sigma \frac{nD^3}{\Sigma nD^2}\].