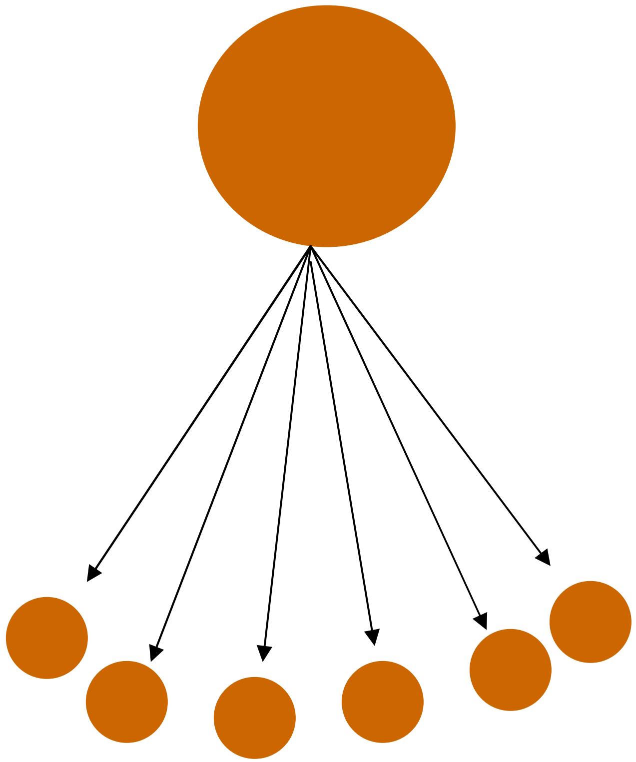
ATOMIZATION OF LIQUID FUELS

THE PRINCIPLE OF LIQUIDS ATOMIZATION



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

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

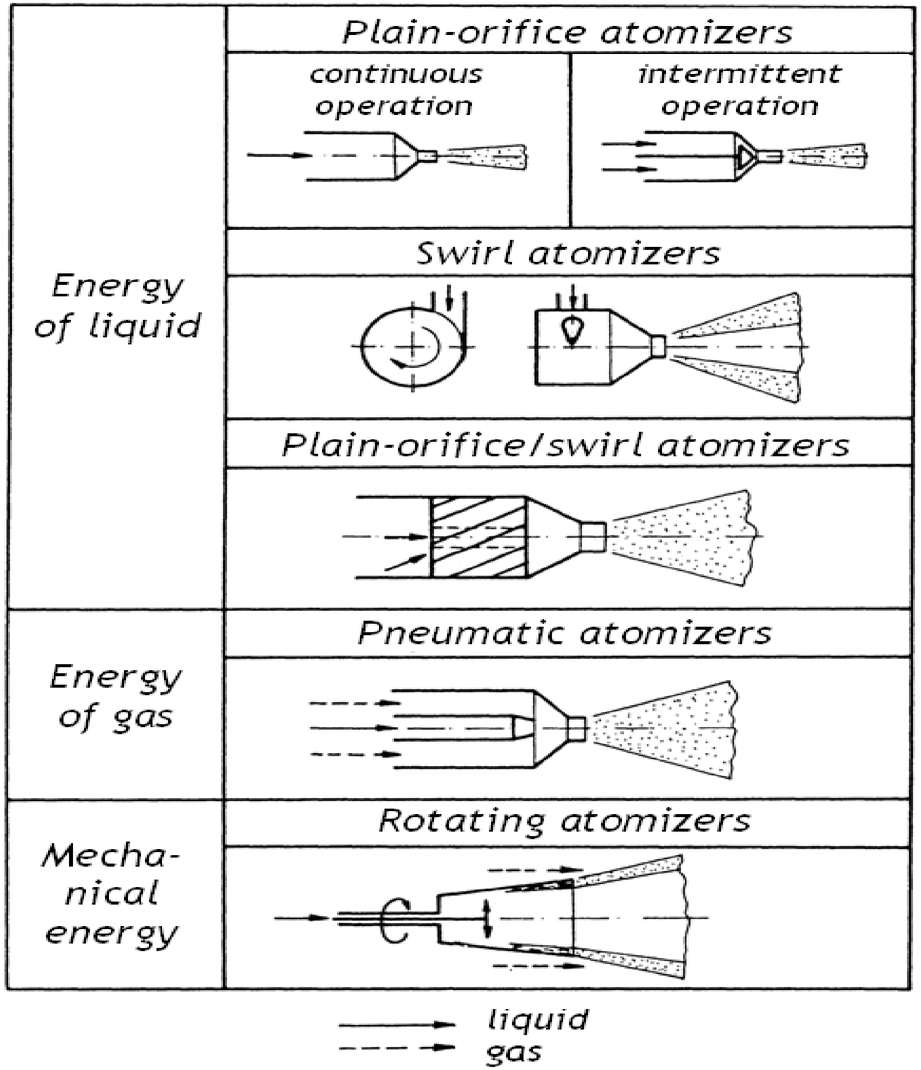
MECHANISMS OF LIQUIDS ATOMIZATION

Three mechanisms:

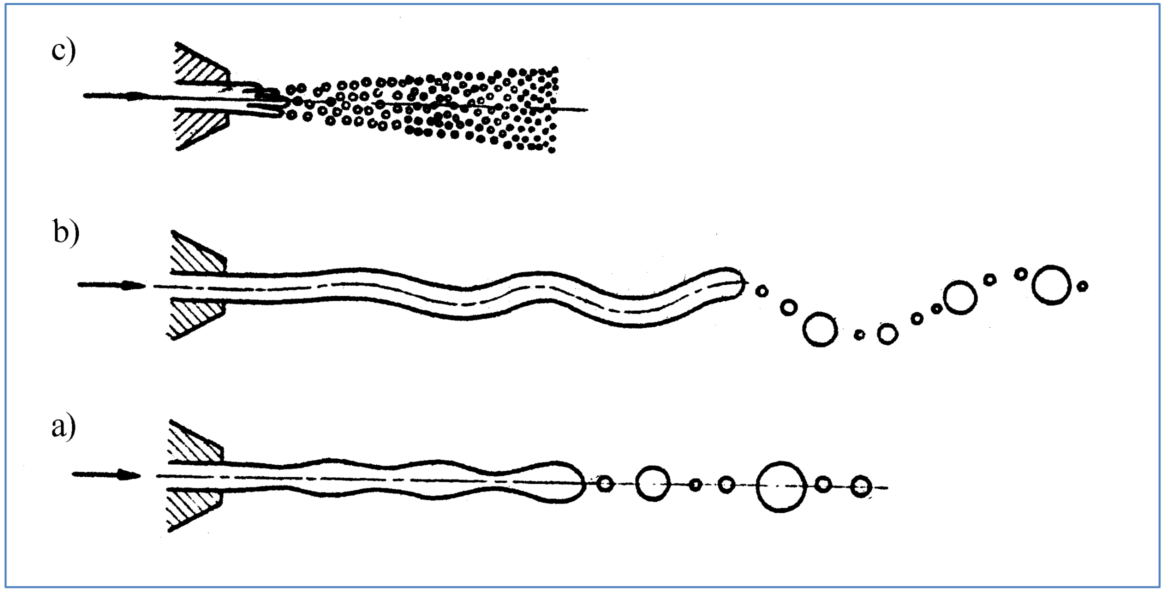
Disintegration of a liquid jet into a number of filaments, and then into small droplets, requires the surface tension forces of liquid to be overcome. It may happen on the three ways:

- 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.

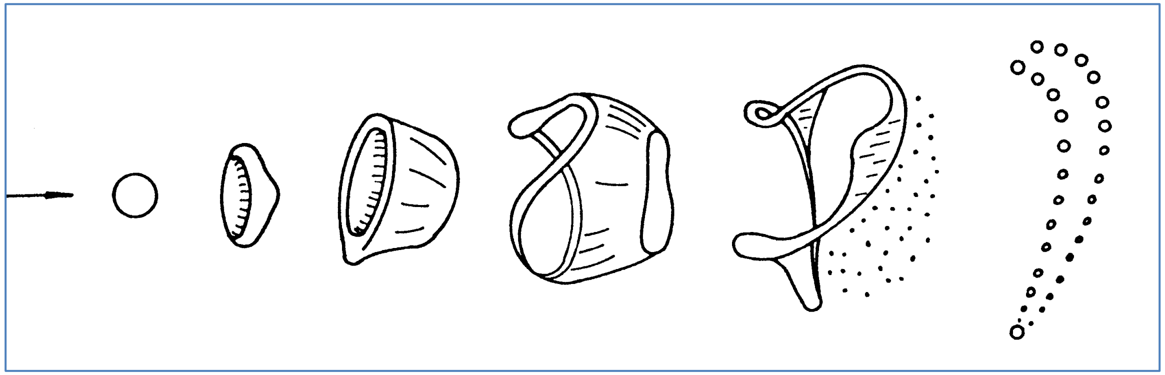
FLUID ATOMIZATION WITH DIFFERENT ENERGY



JETS DISINTEGRATION AND DROPLETS BREAKUP

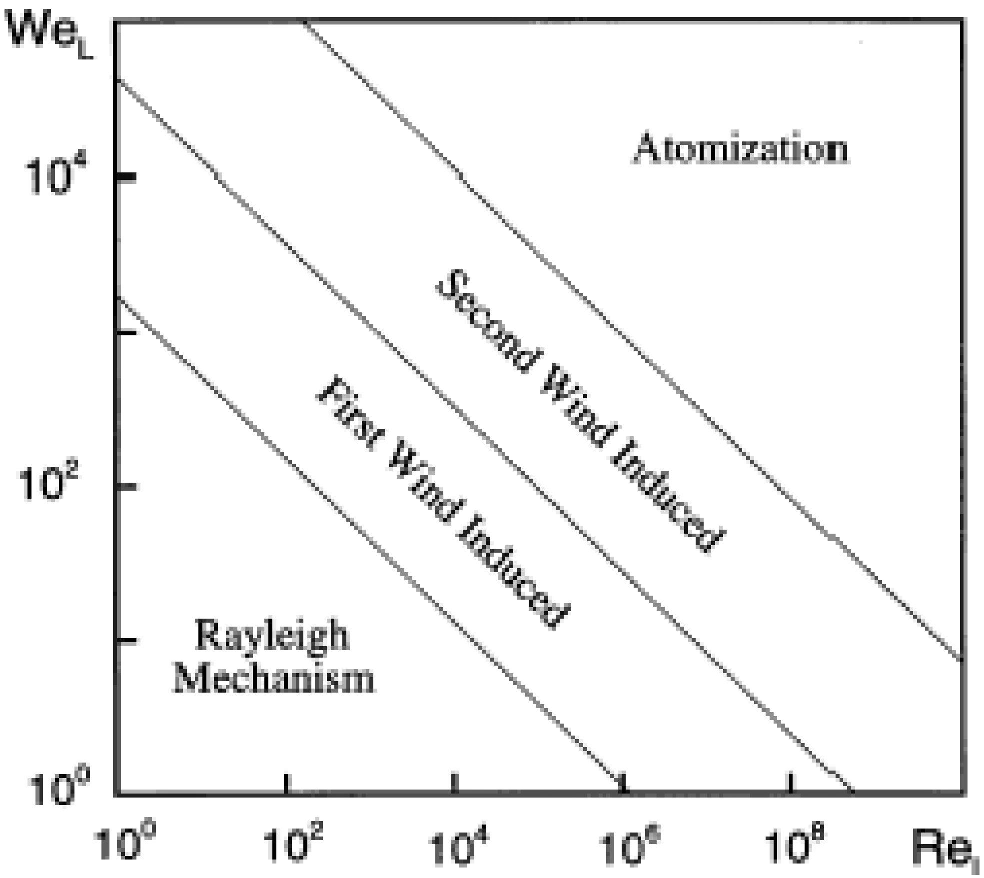


Primary liquid jet disintegration



Droplets break-up

RANGE OF LIQUID ATOMIZATION

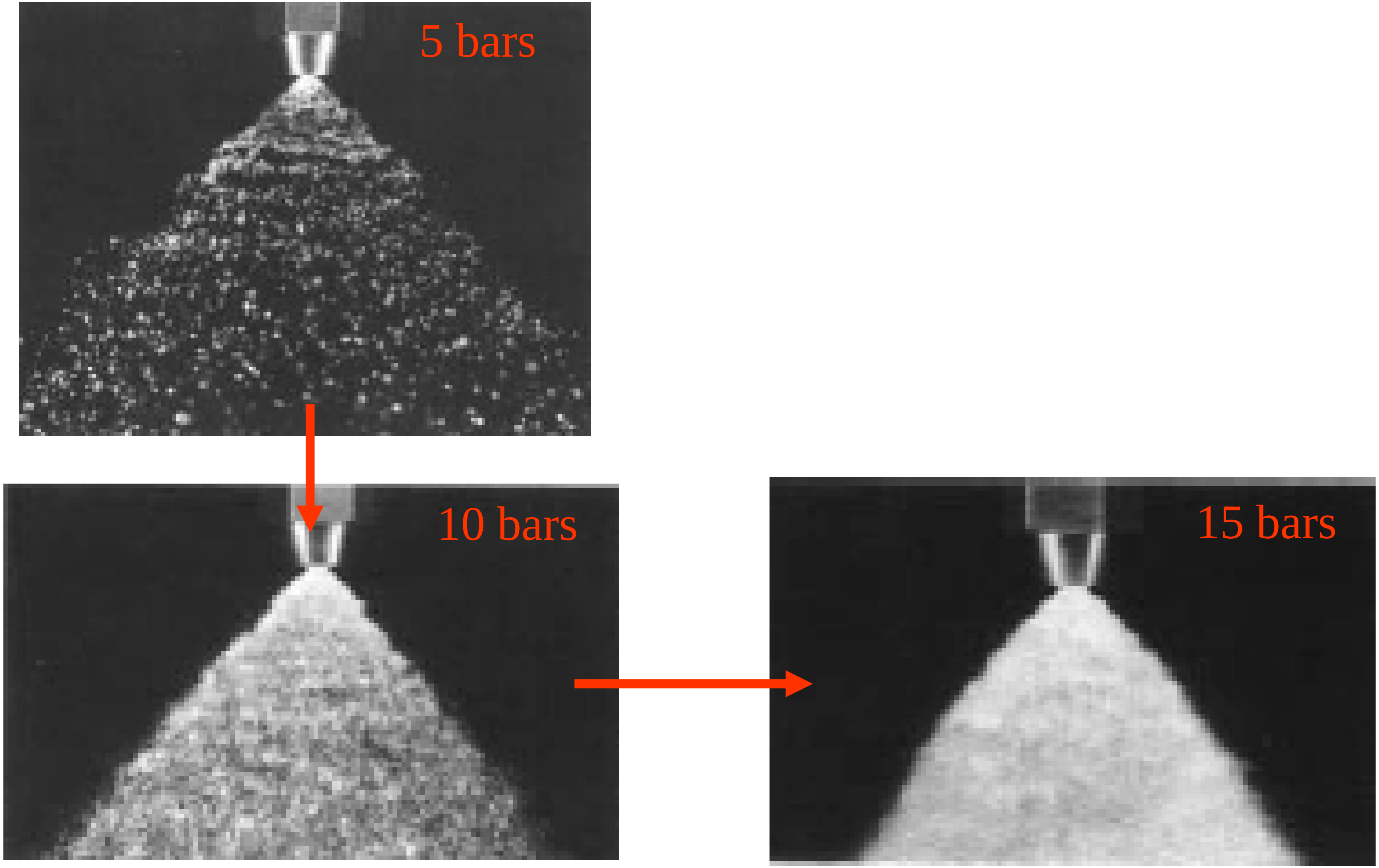


$$Re = (UL)/\nu$$

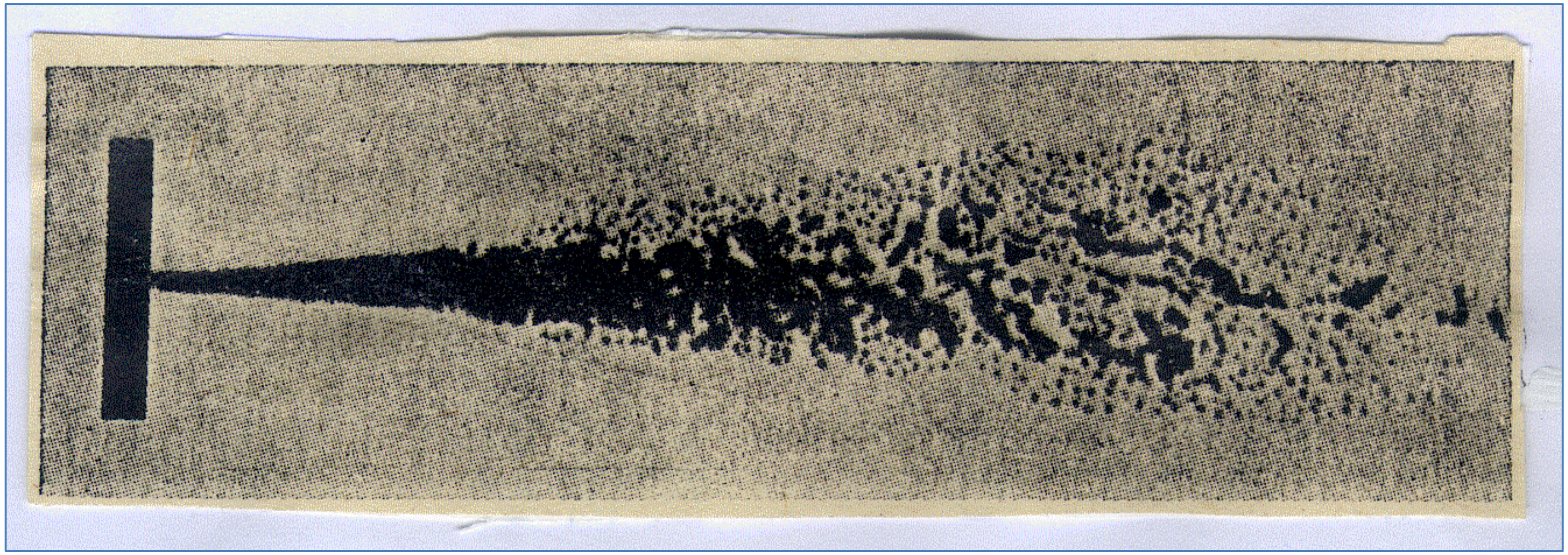
$$We = (U^2L)/\sigma$$

σ - the surface tension coefficient

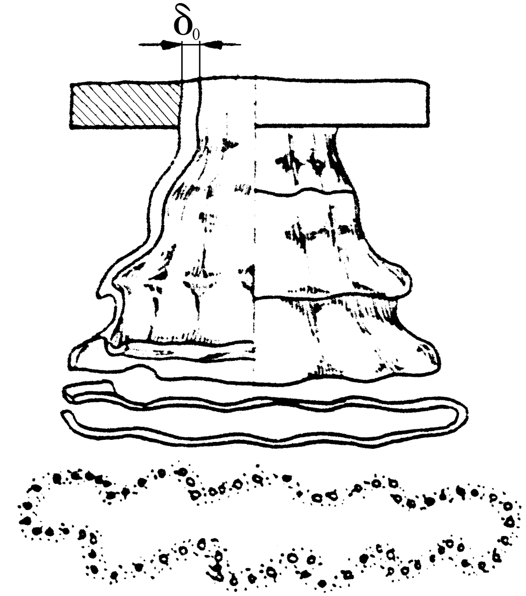
INFLUENCE OF PRESSURE-INJECTION ON ATOMIZATION EFFECTIVENESS



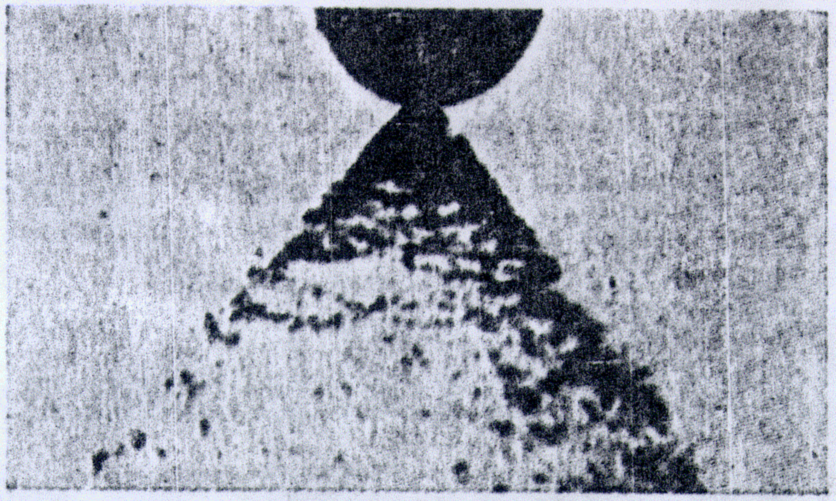
TORCH OF PLAIN-ORIFICE ATOMIZED OIL



LIQUID SHEET BREAKUP



Swirled jet



Rys. 4.39. Tworzenie się kropel w żagwi rozpylacza wirowego

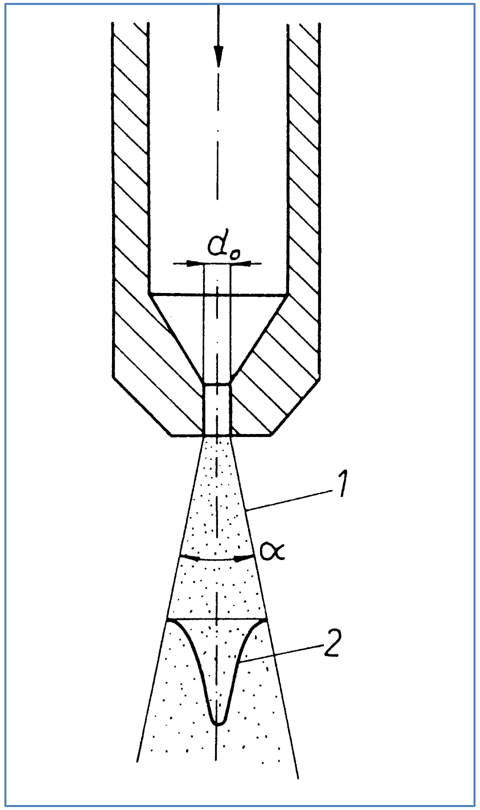
TYPES OF OIL INJECTORS/ATOMIZERS

Types of atomizers:

- pressure
  - plain-orifice
  - swirl type
- pneumatics
  - Y type
  - with x- cross shape flow
- rotating

PRESSURE INJECTORS

PLAIN-ORIFICE ATOMIZER



$D_o > 0.5$ mm

$\Delta p = 0.3\text{-}1(5)$ MPa

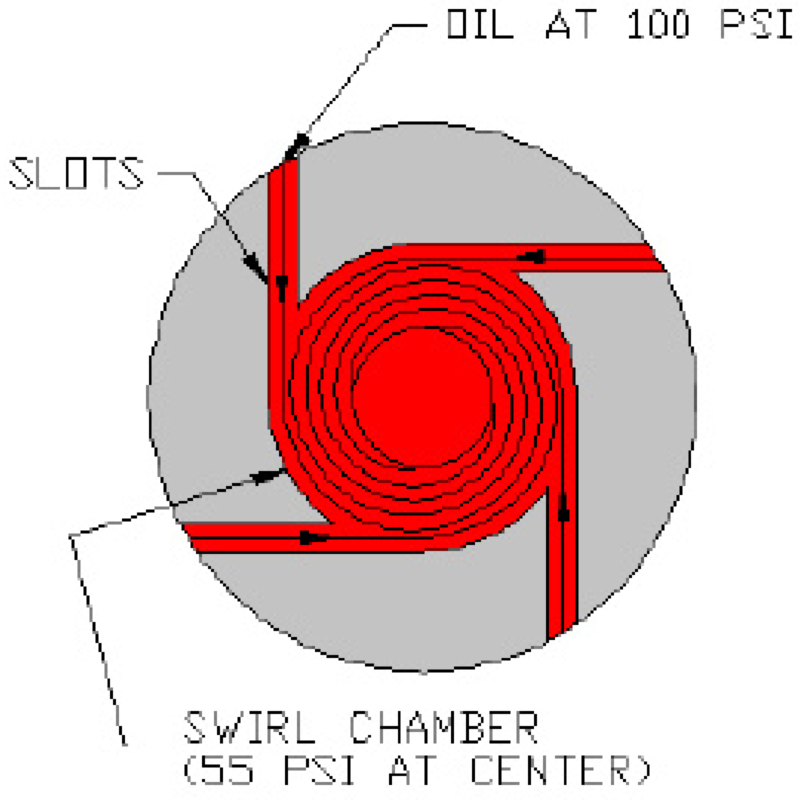
$\alpha = 5\text{-}15^o$

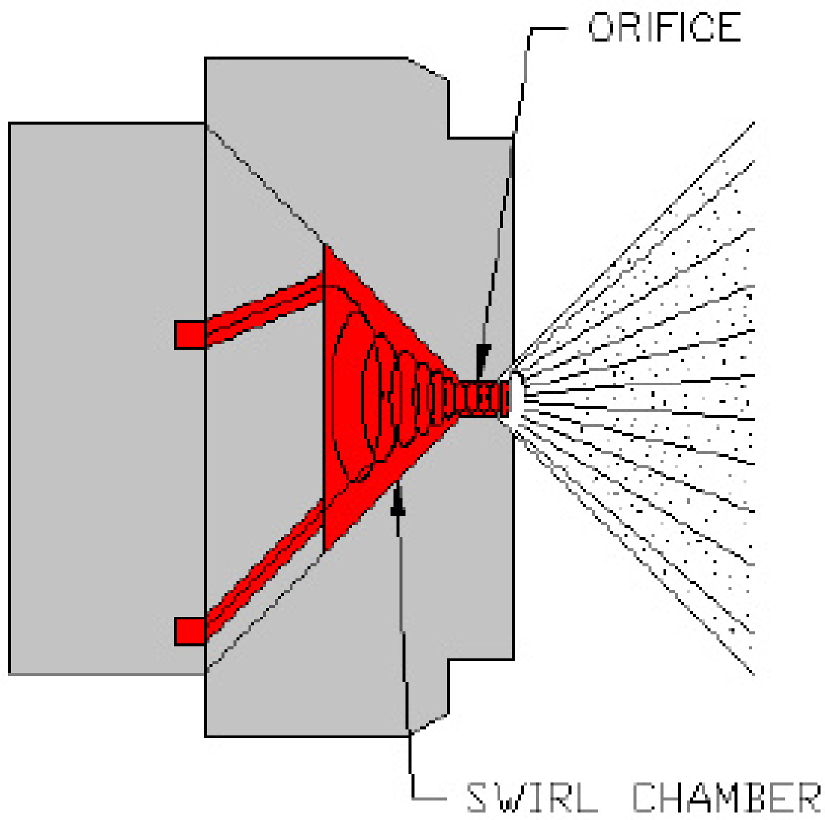
Simple construction,

Low quality of atomization

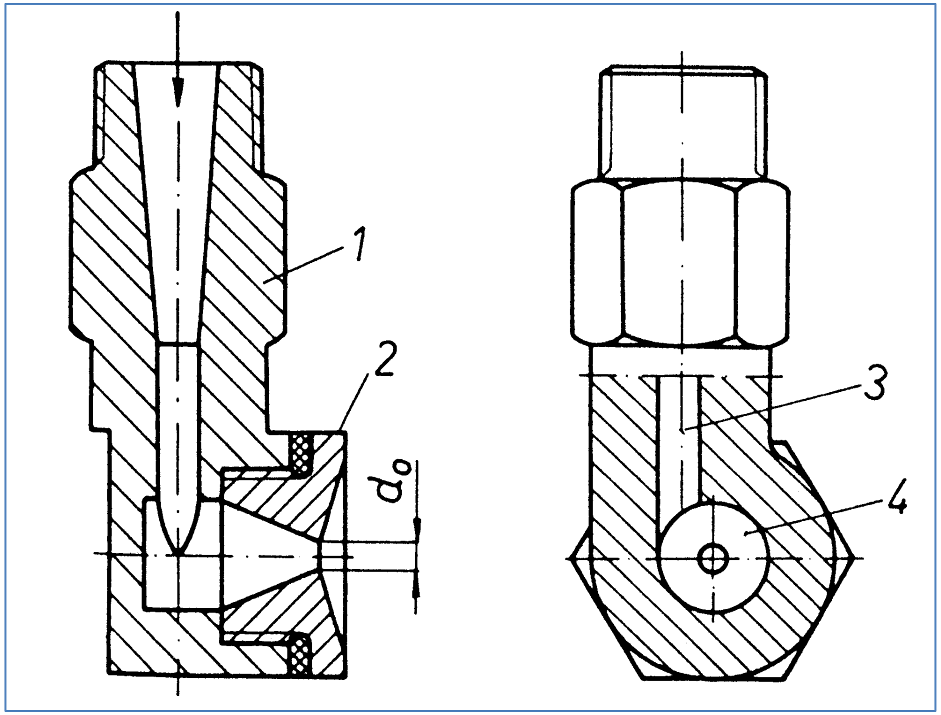
SWIRL ATOMIZERS

HOW A SWIRL NOZZLE WORKS





SWIRL NOZZLE: DESIGN



d_o = 2-6 mm

Δp = 0.6-1.0 MPa

α = 45-90°

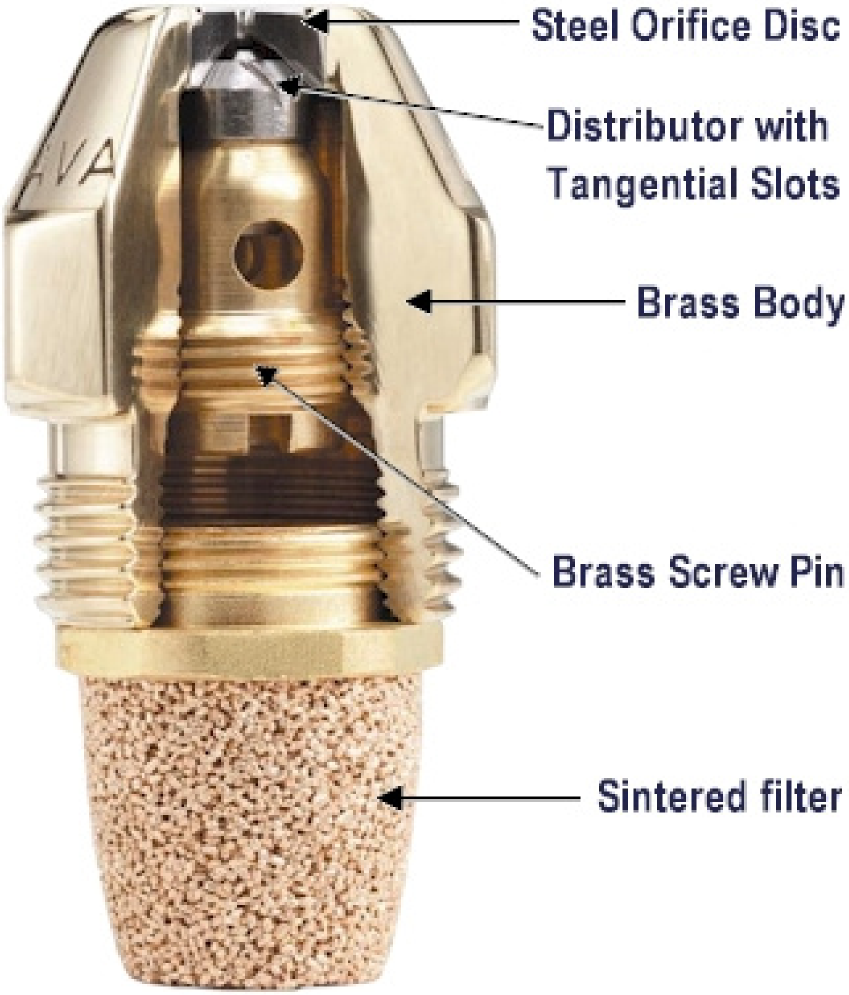
Simple construction

High reliability

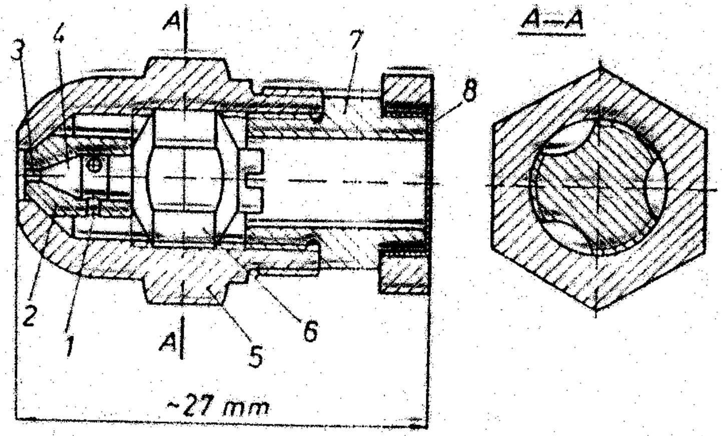
High quality of atomization

Low energy consumption

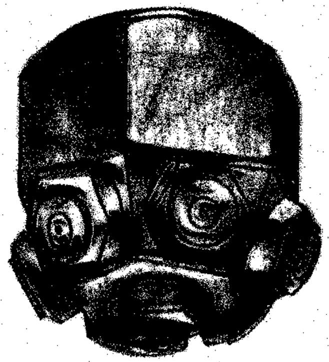
SWIRL NOZZLE: AN EXAMPLE



COMPACT SWIRL ATOMIZER

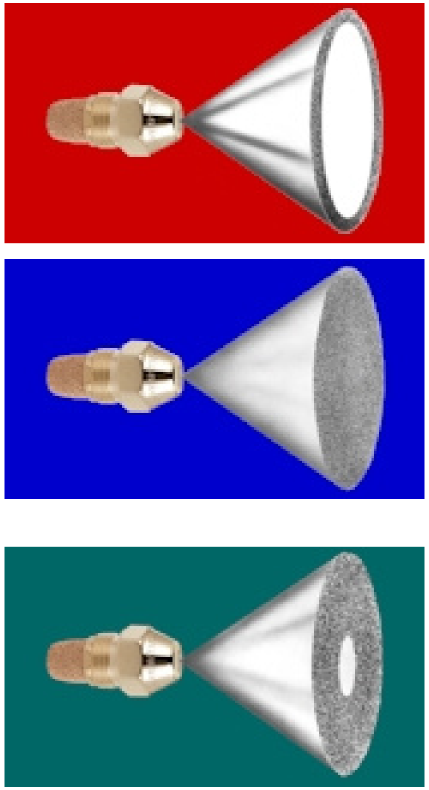


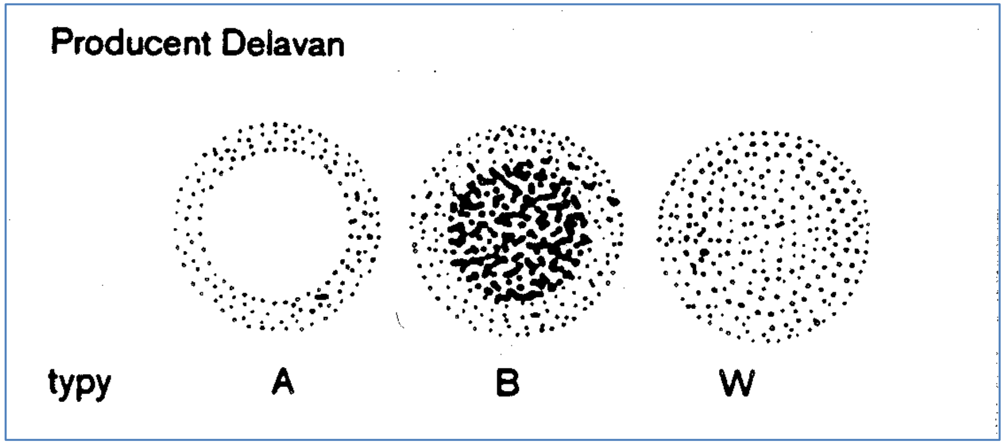
Rys. 3.5. Rozpylacz osiowy ze stycznymi c wlotowymi; 1 - styczn wlotowy, 2 - wkładka, 3 wylotowy, 4 - komora 5 - korpus, 6 - korel towany, 7 - łącznik v 8 - filtr siatkowy



Rys. 3.8. Rozpylacz zespołowy (Spraying Systems)

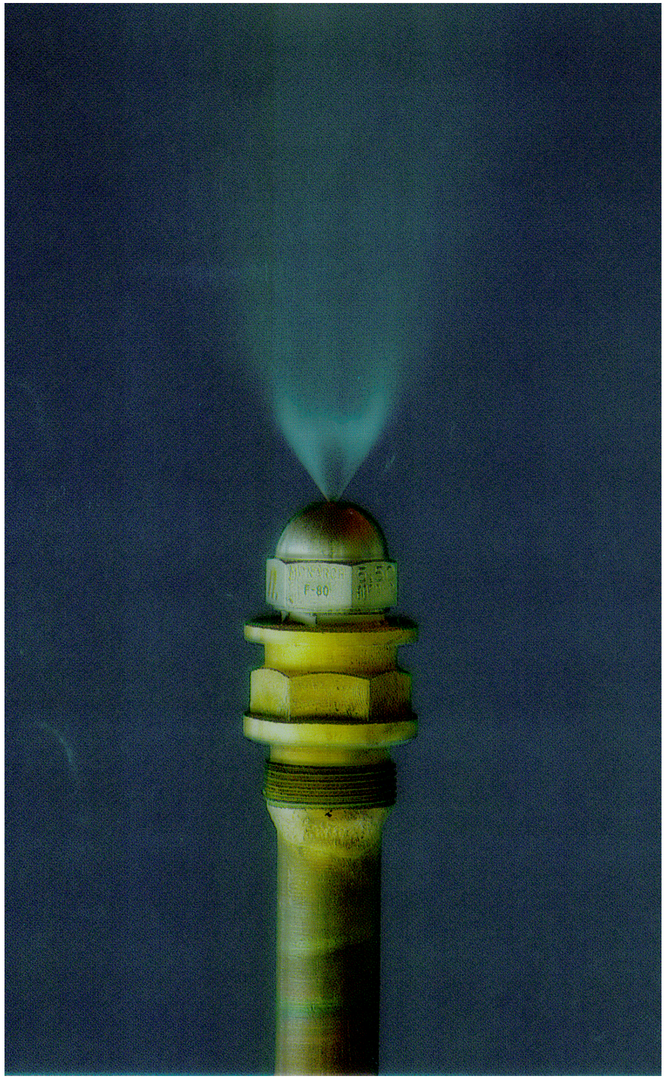
TYPE OF FUEL CONES





Delavan

SWIRL ATOMIZER IN OPERATION



Dispersed oil jet

PNEUMATIC ATOMIZERS

PNEUMATIC ATOMIZER: PRINCIPLE OF OPERATION

liquid fuel

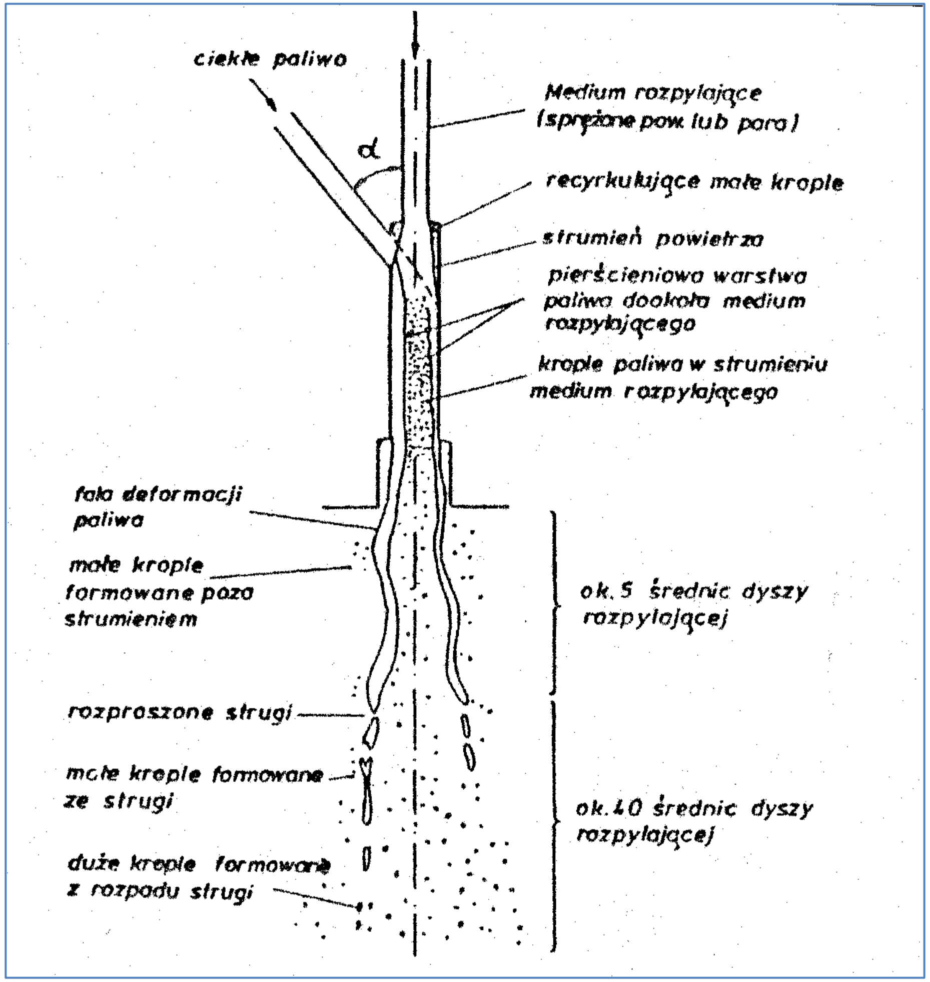
deformation wave of fuel

small droplets formed outside of the stream

dispersion of the stream

small droplets formed from the stream

big droplets formed from the disintegration of the stream



atomizing medium air / steam

recirculating small droplets

air jet

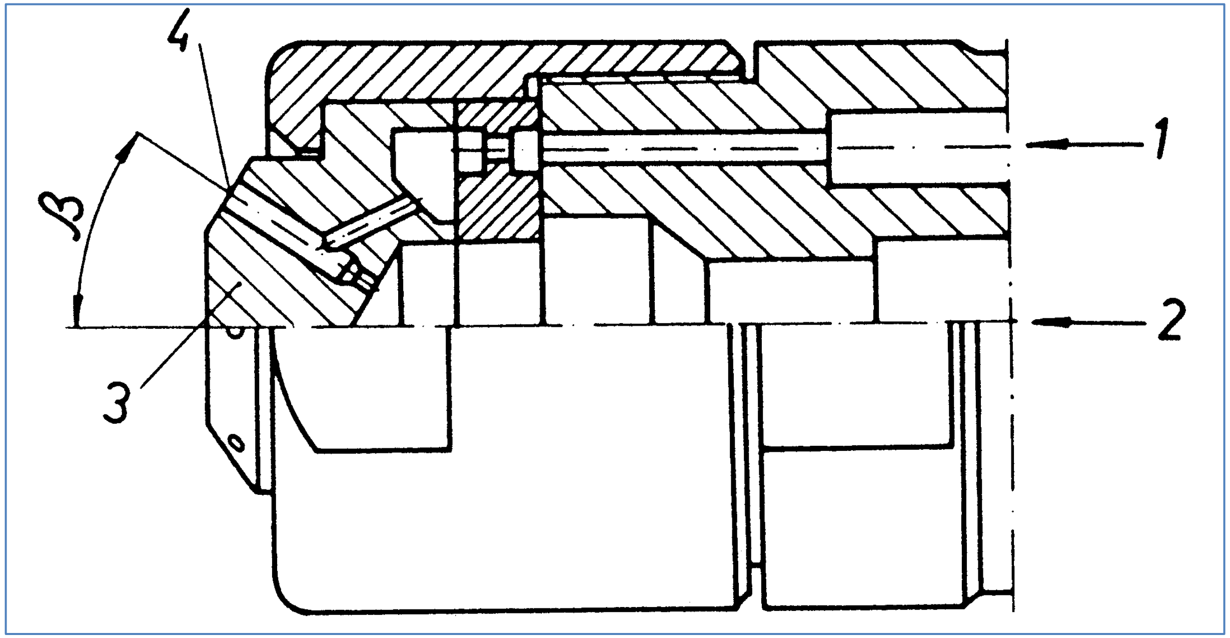
layer of fuel around the atomizing medium

about 5 x diameter of atomizing nozzle

about 40 x diameter of atomizing nozzle

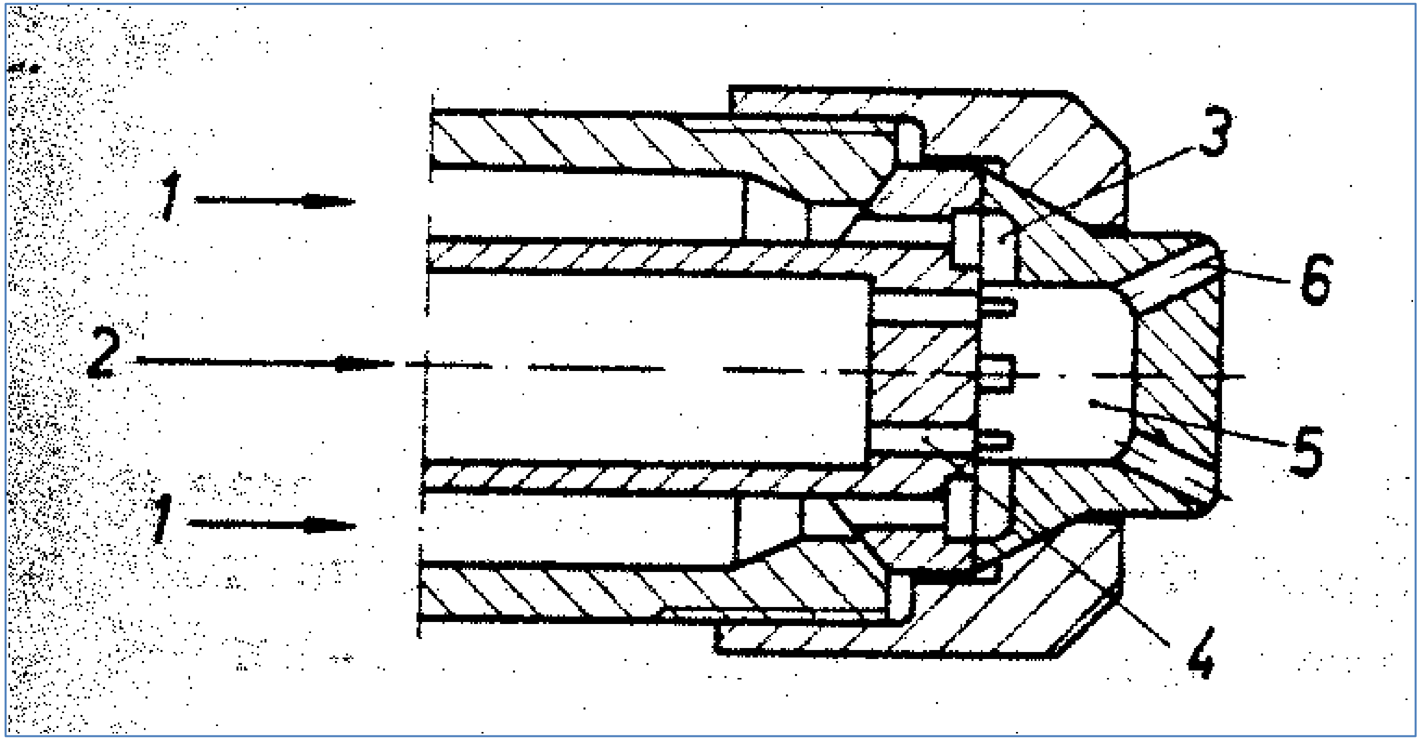
Consumption of atomizing medium: δ =0.06-0,1 kg/kg

PNEUMATIC ATOMIZER OF Y TYPE



Pneumatic atomizer of Y type:
1 – oil, 2 – gas, 3 – atomizing head, 4 – nozzles

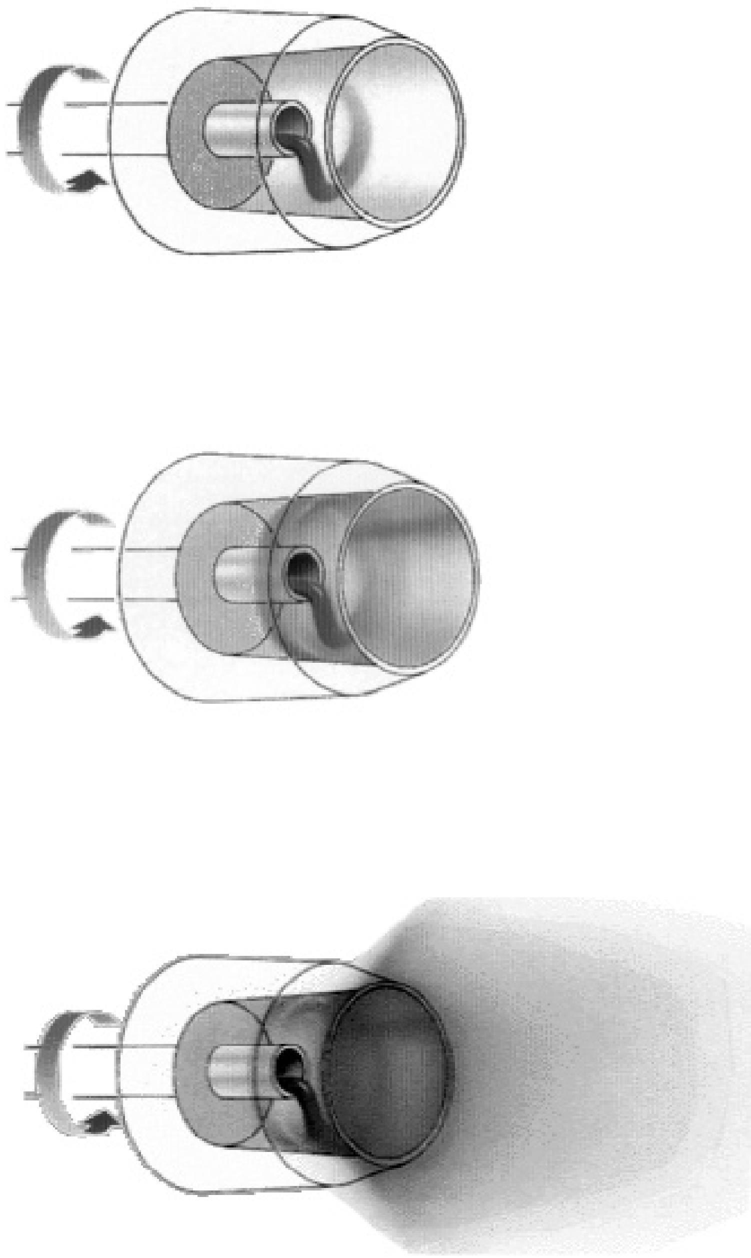
PNEUMATIC ATOMIZER OF CROSS-SHAPE FLOW TYPE



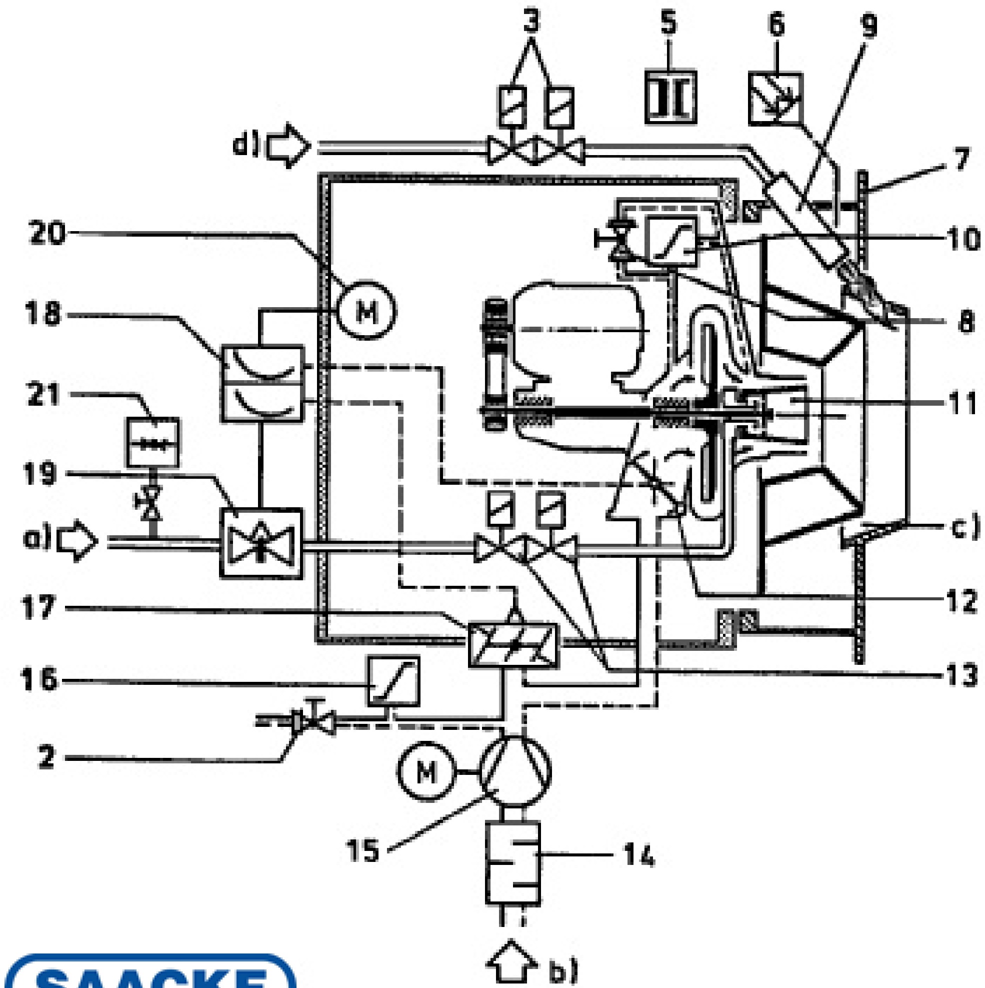
Pneumatic atomizer of the cross-shape flow type:
1 – oil, 2 – gas, 3 – oil injection, 4 – gas injection,
5 – mixing chamber, 6 - nozzles

ROTATING ATOMIZERS

How does rotating atomizer operate?



OIL BURNER WITH ROTATING ATOMIZER



2 Self-closing valve
3 Electromagetic valves for ignition gas 1)
5 Ignition transformer
6 Flame scanner 2)
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

SAACKE

CONTROL OF OIL FLOW RATE

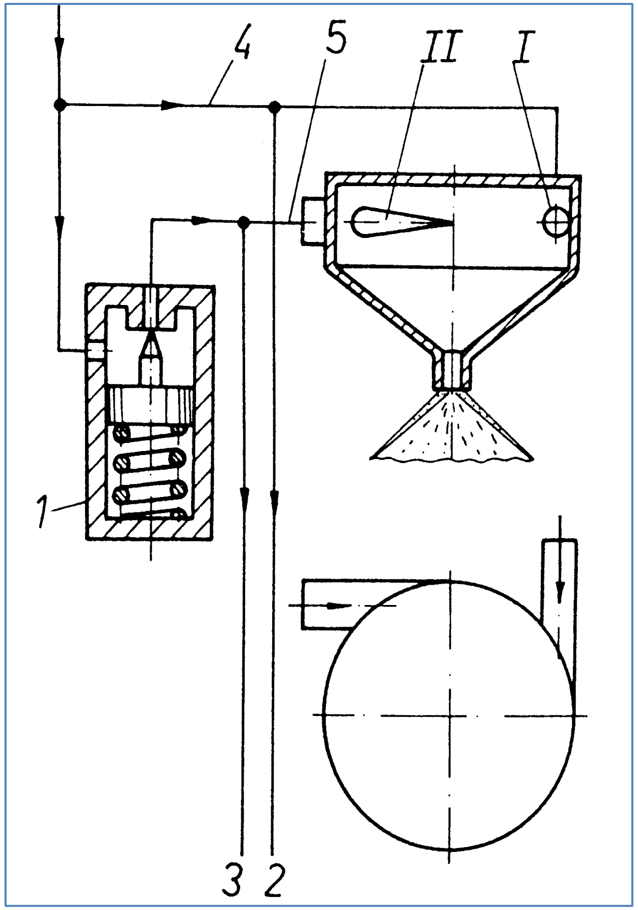
ATOMIZATION PRESSURE VARIATION

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

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

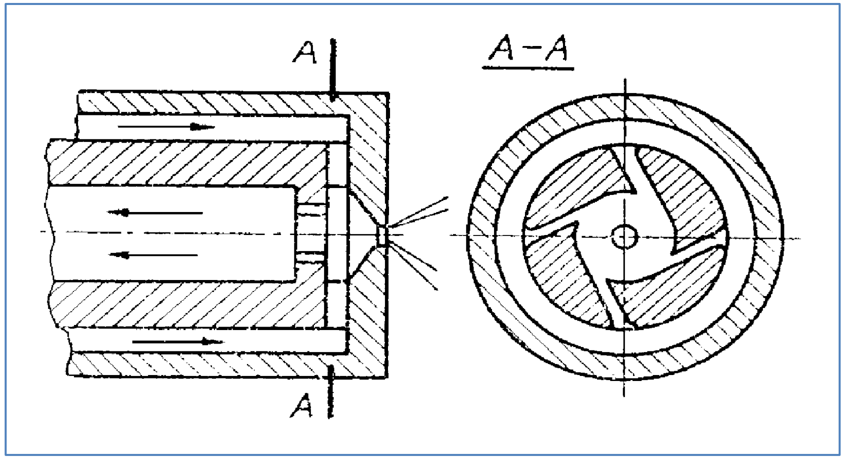
Rate of oil output ~ $(\Delta p)^{0.5}$

Two-step control of oil flow rate

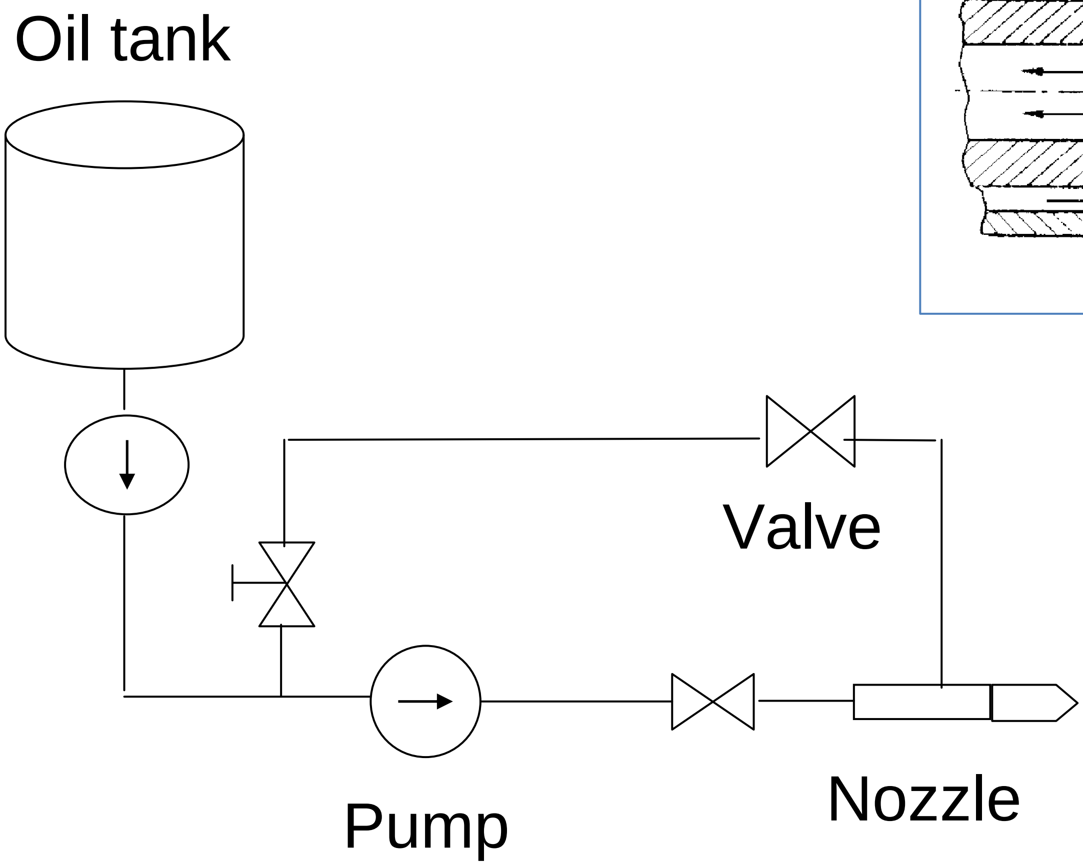


Scheme of single chamber two-step oil atomizer:
1 – valve, 2, 3 – recalculating pipes

CIRCLE MECHANICAL (RETURN- FLOW) ATOMIZER



Fuel nozzle



RETURN OIL INNER CIRCLE ATOMIZER

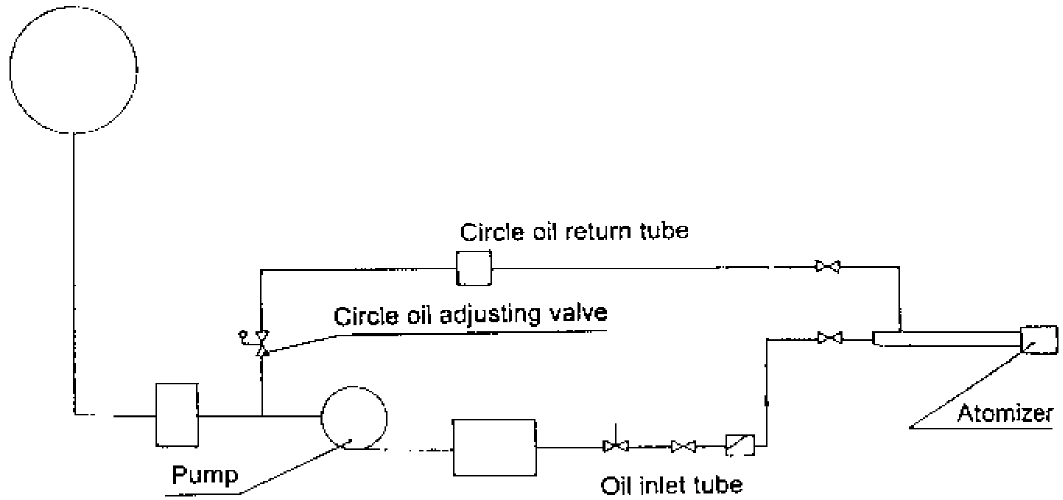


FIGURE 5-5. The oil pipe arrangement for a return oil or circle oil atomizer

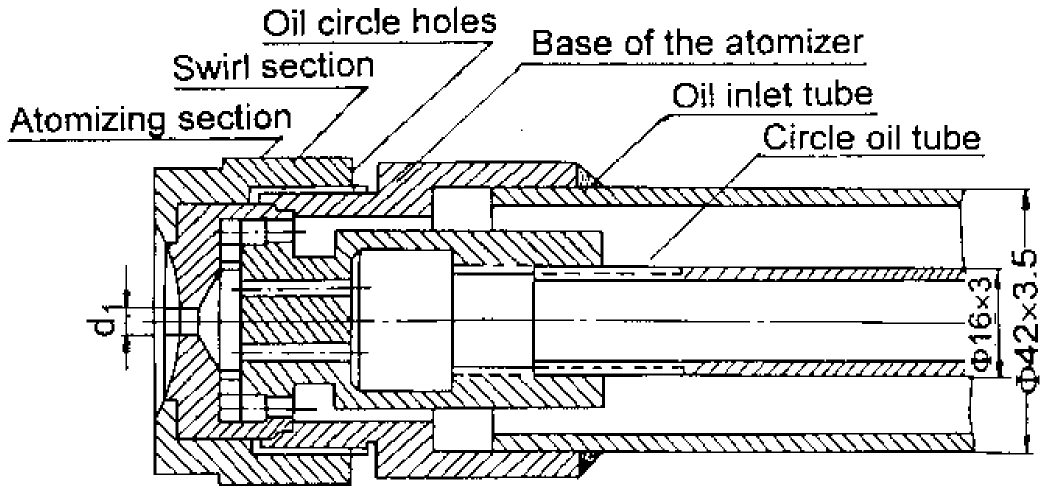
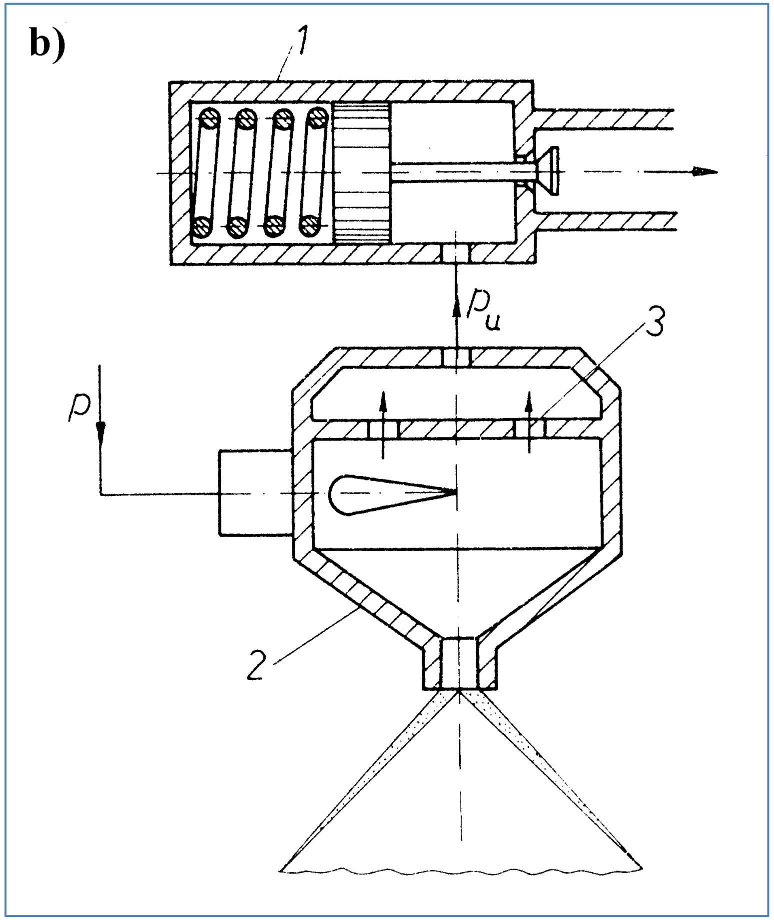


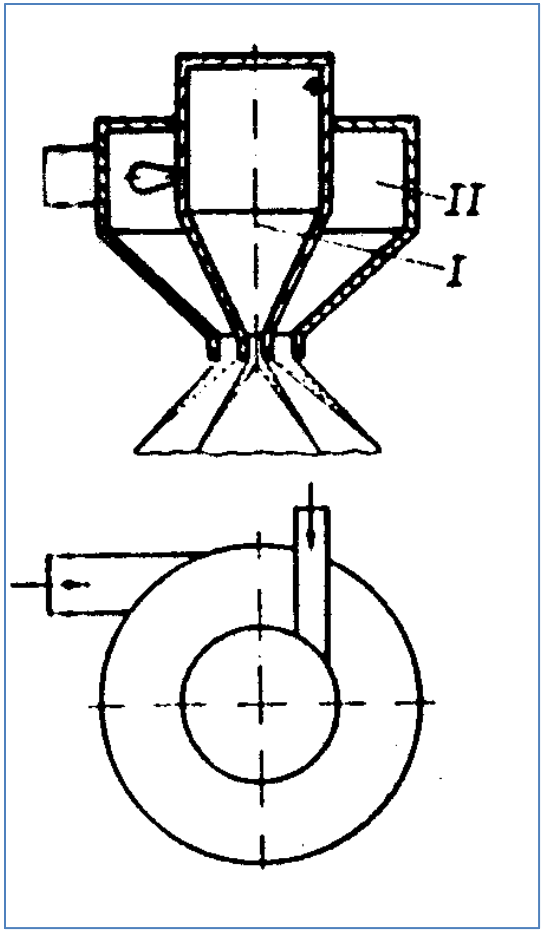
FIGURE 5-6. Cross section view of a return oil inner circle type atomizer

CIRCLE OIL ADJUSTING VALVE



1 – VALVE, 2 – SWIRL CHAMBER,
3 – OIL CIRCLE HOLES

TWO-NOZZLES ATOMIZER



I – nozzle

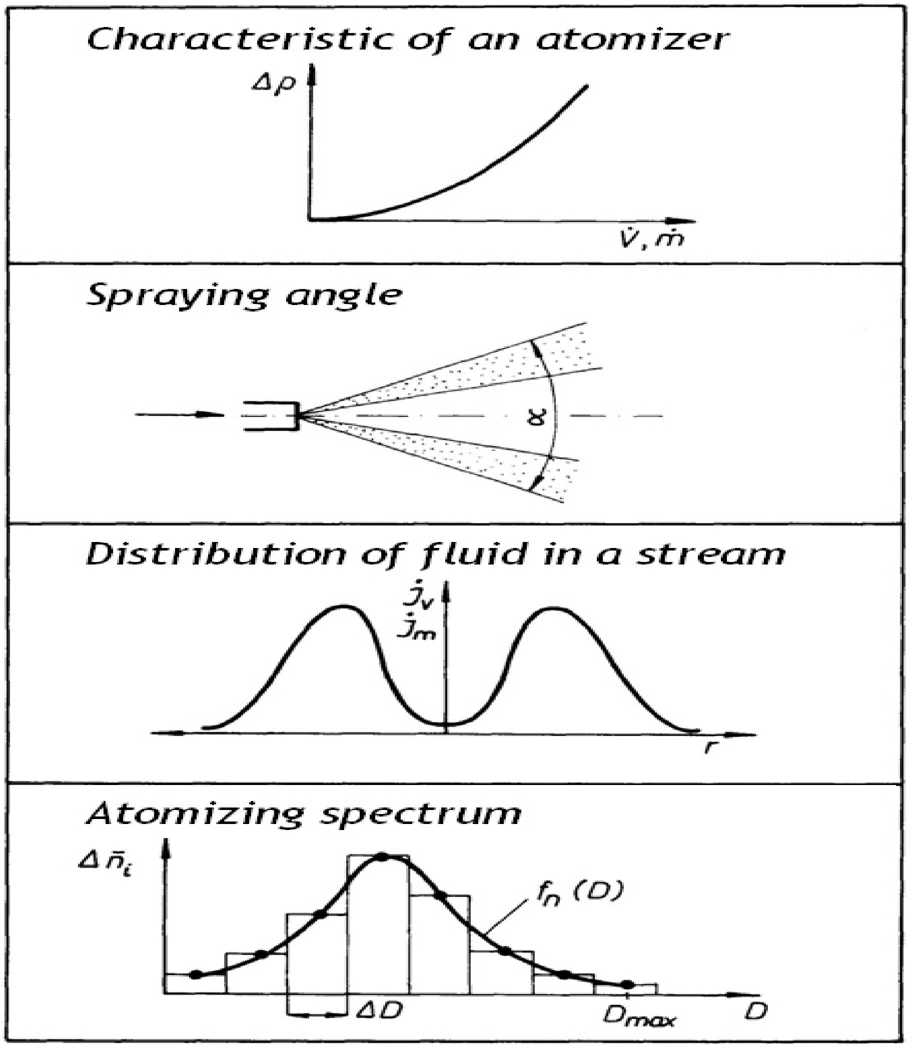
II - nozzle

QUALITY OF ATOMIZATION

PARAMETERS OF ATOMIZATION

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

CHARACTERISTICS OF ATOMIZING NOZZLE



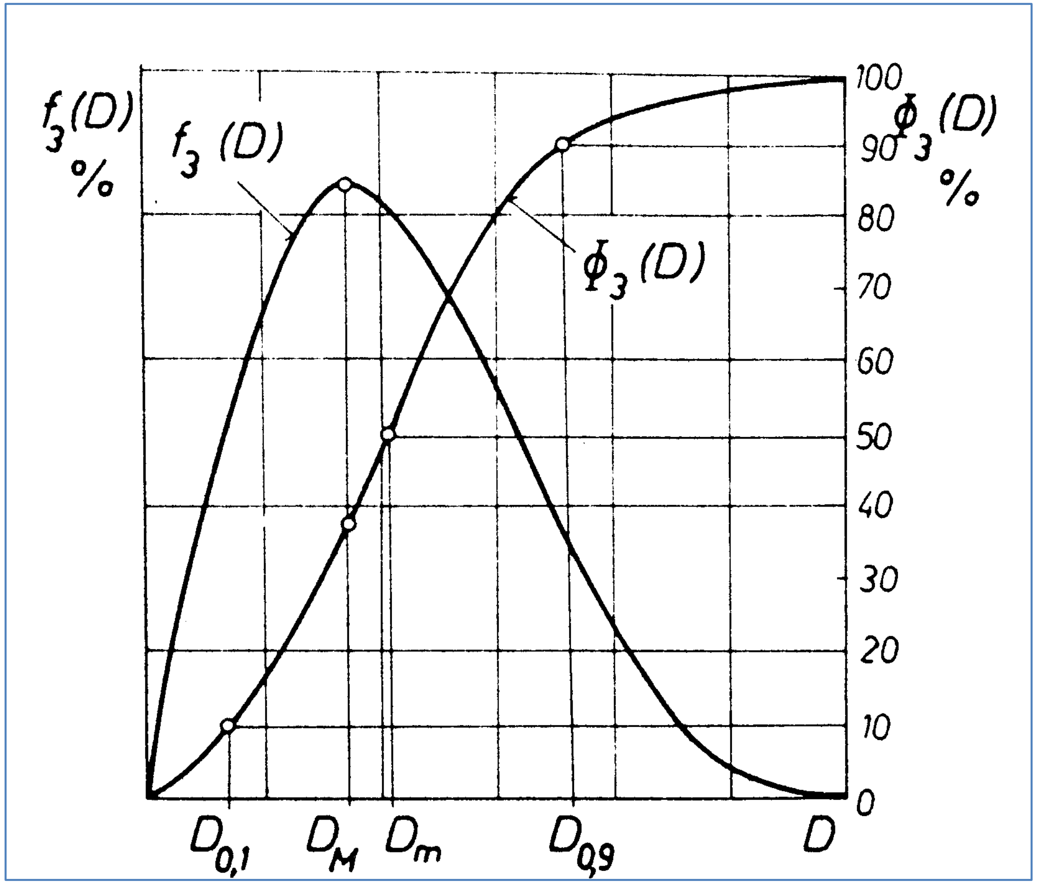
OUTPUT of PRESSURE ATOMIZERS

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 the nozzle output, p is pressure and μ is the outflow coefficient.

DROP SIZE DISTRIBUTION



Drop size distribution curves

CHARACTERISTIC OF DROPLETS SIZE

Mean drop size:

mean drop size

$$MDS = [(\Sigma nD^3/\Sigma nD)]^{0,5},$$

Sauter mean drop size

$$SMDS = \Sigma\, nD^3/\Sigma\, nD^2.$$