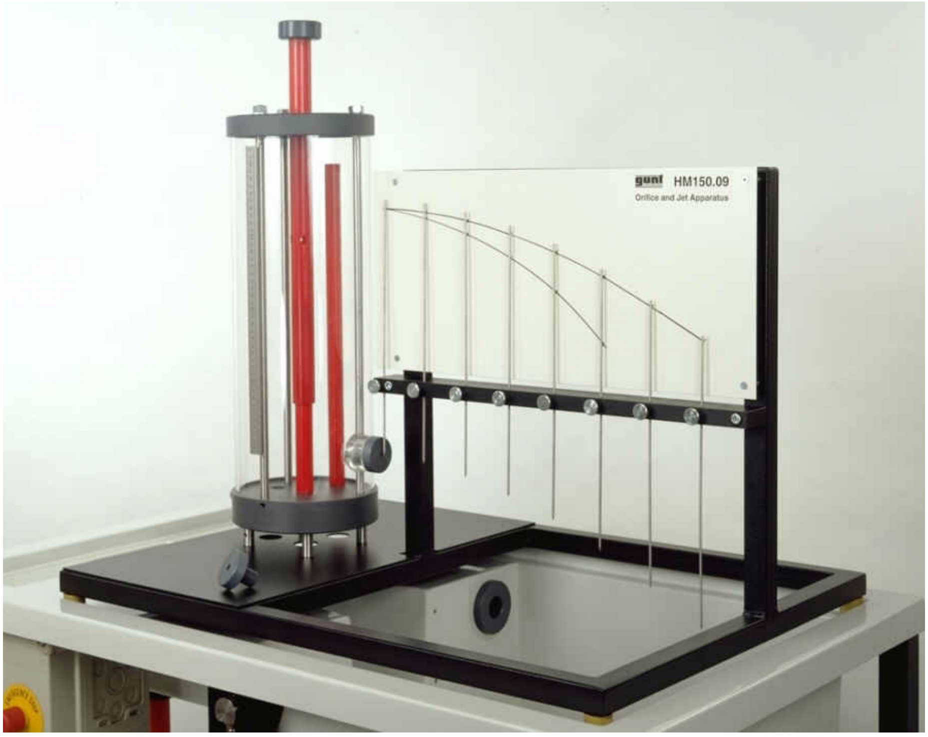
Experiment Instructions

HM 150.09 Orifice and Jet Velocity Apparatus



Experiment Instructions

This manual must be kept by the unit.

Before operating the unit:
- Read this manual.
- All participants must be instructed on handling of the unit and, where appropriate, on the necessary safety precautions.

Table of Contents

1 Introduction

The **HM 150.09 Orifice and Jet Velocity Apparatus** allows the calibration of orifices with different diameters. A clear perspex column serves as a constant head tank. The head is maintained at a constant value by an adjustable overflow and is indicated by a level scale.

The orifices are installed at the base of the column with the help of a special wall fitting. The orifices can be easily interchanged.

A jet trajectory device allows the path followed by the jet to be ascertained. A graph board behind the tracing device supports the student visually.

The unit is suited to be placed on top of the **HM 150 Basic Hydraulics Bench** in order to make use of the water supply and drain facilities of the bench.

The apparatus enables the following instruction capabilities:

- Discharge coefficient from nozzles of varying sizes and shapes
- Trajectory of the water jet for various discharge velocities
- Effect of the height of the water column on discharge velocity

1.1 Intended Use

The unit is to be used only for teaching purposes.

2 Comparison between Theoretical and Calculated Jet Trajectories

2.1 Theoretical Jet Trajectory

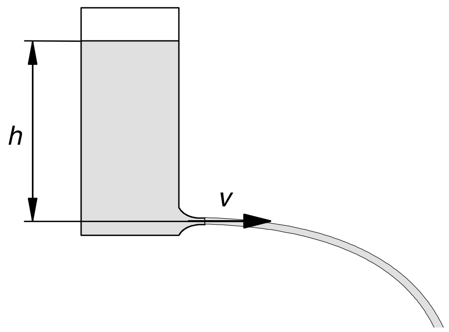


Fig. 2.1

When a water-filled tank is discharged through an orifice, the potential energy of the water head is transformed into kinetic energy of the water jet performed by the orifice.

Without losses the kinetic energy is equal to the potential energy:

$$\frac{1}{2} \cdot m \cdot v^2 = m \cdot g \cdot h \qquad (2.1)$$

where g is the acceleration due to gravity and h the height of the water. This equation can be rearranged to give an equation for the velocity v.

$$v = \sqrt{2 \cdot g \cdot h} \qquad (2.2)$$

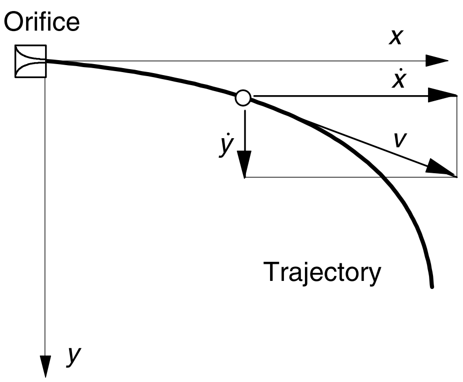


Fig. 2.2

For description of the jet trajectory it is advantageous to introduce cartesian coordinates. The horizontal part of the velocity v is $\dot{x}$ and the vertical $\dot{y}$. The horizontal part of the velocity is constant and equal to the velocity in the orifice. The vertical part depends of the acceleration due to gravity.

$$\dot{x} = \sqrt{2 \cdot g \cdot h} \qquad (2.3)$$

$$\dot{y} = g \cdot t \qquad (2.4)$$

Integration over the time gives the position function of the jet trajectory.

$$x = \dot{x} \cdot t \tag{2.5}$$

$$y = \frac{1}{2} \cdot g \cdot t^2 \tag{2.6}$$

Elimination of time gives the y-position dependence on of the width *x* and the water head *h.*

$$y(x) = \frac{1}{2} \cdot g \cdot \frac{x^2}{\dot{x}^2} = \frac{1}{4} \cdot \frac{x^2}{h} \tag{2.7}$$

2.2 Performing the Experiment

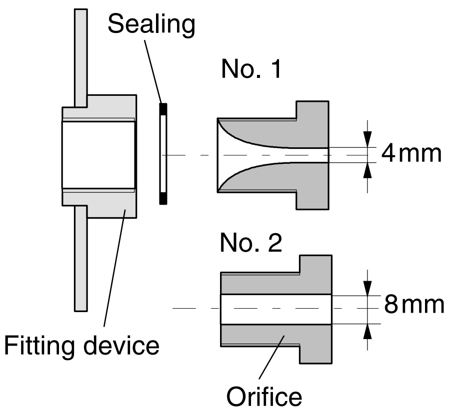


Fig. 2.3

- Insert orifice No.1 (Ø 4mm) into the orifice fitting device.

NOTICE

Don't forget the sealing ring between orifice and fitting.

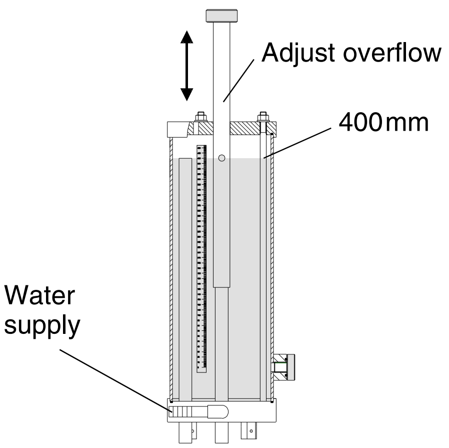


Fig. 2.4

- Connect apparatus to the water supply of the Basic Hydraulic Bench HM 150 and start the pump.
- Adjust the water head to 400mm by means of the adjustable overflow.
  If necessary the overflow to be lubricated.

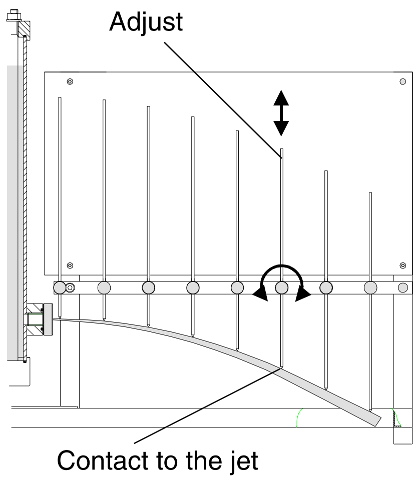


Fig. 2.5

- Beginning at the right side, adjust the trajectory probes until they get in contact with the jet.
- Read off the measured y-positions of the jet and note them down in tabular form.

x-position in m	y-position in m (measured)	y-position in m (calculated)
0	0,000	0,000
0,07	0,006	0,003
0,14	0,022	0,012
0,21	0,047	0,028
0,28	0,079	0,049
0,35	0,118	0,077
0,42	0,168	0,110
0,49	0,223	0,150

Tab. 2.1 Measured and calculated jet trajectory (Water head 0,4 m)

For comparison, both results are plotted in the following diagram:

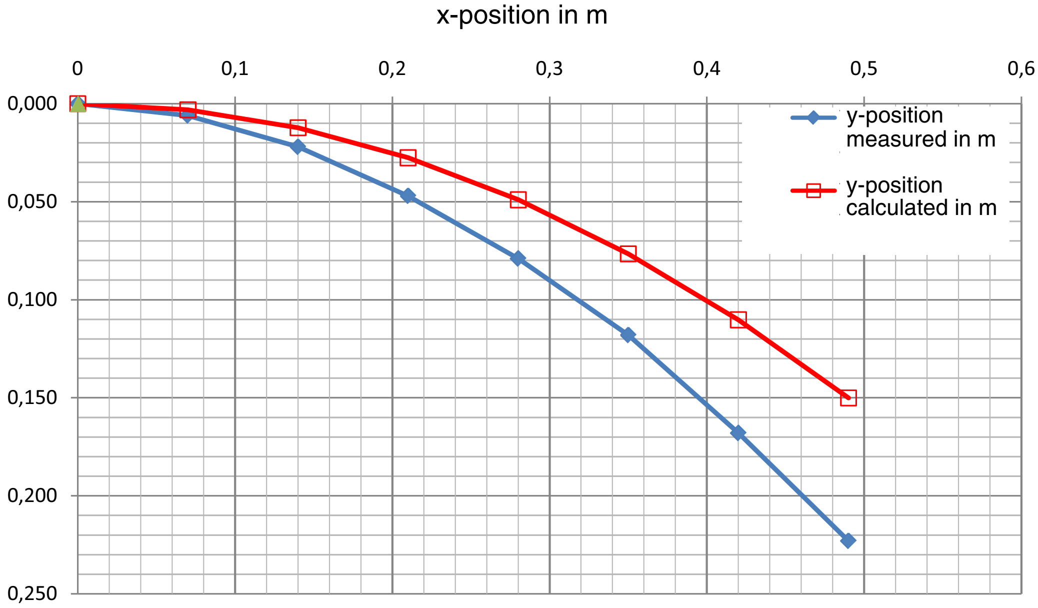


Fig. 2.6 Measured and calculated jet trajectory

The measured trajectory is below the calculated one. This is due to friction losses in the orifice and air resistance to the free jet.

3 Technical Data

Dimensions

Lenght x width x height:	865 x 640 x 590 mm
Weight:	approx. 27 kg

Connections

Water supply from HM 150 or from the labaratory mains

Perspex cylinder

Height:	510 mm
Diameter:	190 mm
Capacity:	approx. 13,5 ltr

Orifice

1 pce. contour round	diameter 4 mm
1 pce. contour angular	diameter 4 mm
1 pce. contour round	diameter 8 mm
1 pce. contour angular	diameter 8 mm

Sensing device

Eight flexible tracers

Length:	350 mm