P7681 NOZZLE STEAM BENCH

EXPERIMENTAL CAPABILITY

- The variation of pressure along a nozzle profile as a function of back pressure
- The effect of back pressure on the mass rate of flow
- A comparison of theoretical and actual throat pressures on rates of flow
- Determination of critical pressure ratio for choked flow
- Calculation of velocity through length of nozzles of various forms
- Study of the effects of friction in a parallel nozzle
- Study of shock wave formation within nozzle divergence and at nozzle outlet
- Measurement of state at entry to the nozzle and subsequent calculation

FEATURES

- Compact modular design
- Low capital cost
- Easy installation
- Comprehensive instrumentation
- Four interchangeable nozzles
- Pressure test certificates supplied for major components

INTRODUCTION

The purpose of a nozzle is to convert the internal energy of the steam into kinetic energy and this is achieved by expansion from a higher to a lower pressure. The efficiency of this conversion process depends upon the shape (or profile) of the nozzle. Cussons P7681 Nozzle Steam Bench enables students to investigate this process using four different nozzles.

DESCRIPTION

Cussons P7681 Nozzle Steam Bench consists of a sturdy framework and panels of all steel construction, fitted with a student work surface, interconnecting back panel and adjustable feet.

The steam chest consists of an inlet chamber and an exhaust chamber with a test nozzle positioned in the wall common to the two chambers. Steam supply to the inlet chamber first passes through a steam separator to remove excess water content and the chamber is fitted with a throttling facility to enable the dryness of the inlet steam to be determined. Steam passes from the inlet chamber, through the test nozzle, into the exhaust chamber and finally into the surface condenser via a back pressure control valve.

The pressure distribution along the nozzle is measured by a traversing assembly fitted with a calibrated test pressure gauge (-1 to 12 bar) and a pointer moving over a replica profile of the nozzle under test. The replica profile is equipped with a graduated scale (1 mm steps) enabling pressure to be plotted as a function of distance along the axis of the nozzle. The bench includes four different test nozzles and corresponding replica profiles, supplied in a wooden instrument case for damage free storage.

Pressure at the steam header, inlet chamber and exhaust chamber are measured with Bourdon type pressure gauges. Thermocouples are used to measure the throttling, steam inlet chamber and exhaust chamber temperatures with display on an (0-250°C) analogue temperature indicator via a multi-point selection switch.

The apparatus is supplied complete with service facilities relating to water supply, blowdown and drainage together with a set of four stainless steel flexible hoses which enable the bench to be connected to other steam benches to form

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STEAM HEADER ASSEMBLY

Mild steel steam header welded in accordance with BS2633 (1973) incorporating a branch to supply steam to a steam chest. The steam header is enclosed within a header box and fully insulated with mineral wool.

STEAM INLET BRANCH

Mild steel branch fitted with a combined isolating and control valve, a pressure measuring point coupled to a 0-16 bar Bourdon type pressure gauge and steam separator complete with a drain line incorporating a steam trap and a non-return valve. The drain line is connected to the bench drain line.

STEAM CHEST

Comprising an inlet chamber with an interchangeable brass nozzle discharging into an exhaust chamber. The unit is fabricated from mild steel with flanges welded to BS806 (1975) type 6 and branches welded to BS2633 (1973). Each chamber is designed for working pressure of 10.34 bar and a maximum steam temperature of 235°C. All joints are sealed with gaskets and the probe shaft entry is via a brass gland with graphited rope packing. The steam chest is insulated with 100 mm thick fibre glass enclosed with a mild steel cover.

The steam chest is fitted with an inlet chamber drain line connected to the steam separator drain line. An inlet chamber throttling facility incorporating a combined isolating and control valve, a restrictor assembly, a temperature measuring point with a type K thermocouple and a discharge line to atmosphere.

An exhaust chamber exhaust line with a combined isolating and control valve, connected to a surface condenser.

Temperature measuring points to the inlet and exhaust chambers each fitted with a type K thermocouple.

Pressure measuring points to the inlet and exhaust chambers coupled to 0 to 16 bar and -1 to 15 bar Bourdon type pressure gauges respectively.

A traversing nozzle pressure measuring assembly consisting of a stainless steel pressure probe connected to a brass shaft fitted with a calibrated pressure test gauge scaled -1 to 12 bar, a distance indicator and a handwheel for movement of the traversing assembly.

A replica nozzle profile plate with an associated graduated scale marked -10 to 85 mm in 1 mm steps, for use in conjunction with the traversing assembly distance indicator.

CONDENSER

Water cooled surface condenser designed for a working pressure of 3 bar and capable of condensing steam at a rate of 31 kg/hr at atmospheric pressure. The condenser is fitted with a pressure relief valve set at one bar venting to atmosphere, a cooling water inlet line with a control valve and a flow indicator and a cooling water discharge line with a control valve. A 5 litre glass beaker and a 250 ml glass measuring cylinder are supplied for condensate collection/ measurement respectively.

TEMPERATURE DISPLAY

The type K thermocouples are each connected to a 0-250°C analogue temperature indicator through a multipoint selection switch.

CERTIFICATION

The steam header and steam chest are pressure tested at 21 bar and the steam system pipe work is pressure tested at 16 bar. Test certificates are supplied with the equipment.

INTER-CHANGEABLE NOZZLES

A set of four interchangeable brass nozzles is supplied complete with 'O' ring seals, replica nozzle profile plates, a special box spanner for insertion/withdrawal of nozzles and a spanner for removal of inlet chamber access plate. The foregoing are supplied in a varnished wooden instrument case for damage free storage. The profiles of the nozzles supplied are respectively, convergent, convergent/1° divergent, convergent/3° divergent and convergent/parallel.

CONSUMABLE SPARES

The bench is supplied with a pack of 10 inlet chamber flange gaskets, a 2m length of probe shaft gland packing rope and a pack of 2 'O' nozzle sealing rings.

SERVICE SYSTEMS

The bench is equipped with independent service lines relating to water supply (untreated), blowdown and drainage. These lines interconnect with similar facilities on other steam benches to provide a common service facility.

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INTERCONNECTION OF STEAM BENCHES

To enable steam benches to be linked to form a system utilising a common steam supply and service system, the steam bench is supplied complete with:

- An interconnecting back panel and student work surface.
- A set of 4 stainless steel flexible hoses for the steam and service connections.
- A section of aluminium clad lagging for the flexible steam hose.

PIPE CLOSURE KIT

If this steam bench is to be installed on a stand-alone basis **or** is the last unit in a run of steam benches a P7682 Pipe Closure Kit will be required.

TENDER SPECIFICATION

To comprise a sturdy framework and panels of all steel construction including student work surface and fitted with a steam chest constructed of mild steel. The chest will include an inlet chamber fitted with a drain line, a throttling restrictor assembly and type K thermocouple, a temperature measuring point with type K thermocouple and a pressure measuring point coupled to 0-16 bar Bourdon type pressure gauge; an exhaust chamber fitted with a type K thermocouple, a pressure measuring point coupled to a -1 to 15 bar Bourdon type pressure gauge and an exhaust line, a water cooled surface condenser with a capacity of 31 kg/hr, a traversing nozzle pressure measuring assembly including a stainless steel measuring probe, a -1 to 12 bar calibrated pressure test gauge and a nozzle distance indicator.

The inlet exhaust chambers are to be designed for a working pressure of 10.34 bar and a maximum steam temperature of 234°C and the steam chest is to be fully insulated.
Steam supply will be from a fully insulated steam header unit, a pressure measuring point coupled to a 0-16 bar Bourdon type pressure gauge and a steam separator with a drain line including a steam trap and non-return valve. The type K thermocouples are to be connected to a 0-250°C analogue temperature indicator via a multipoint selection switch.
The bench shall be supplied complete with a set of four stainless steel flexible hoses for service connection, a set of four different brass nozzles with replica nozzle profiles and insertion tools housed in a wooded case.

P7682 Pipe closure Kit

A complete assembly of pipework, comprising connections, valves and steam trap to enable the steam header to be discharged of condensate into the blowdown line.

INSTALLATION REQUIREMENTS

Steam supply: Maximum working pressure of 10.34 bar and maximum temperature of 235°C, which can be supplied by Cussons P7670 Steam Boiler Bench, a Cussons Steam Plant, or clients own steam line.
Water supply: From bench water service line.

DIMENSIONS AND WEIGHTS

Case size: 2.32m³
Length: 158cm
Width: 80cm
Height: 200cm
Gross weight: 315kg
Nett weight: 190 kg

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