3.7. QUEOS - QUEnching Of Spheres

Simulation of the Premixing-phase of a Steam Explosion with Hot Spheres in Water

Objective of the facility

The QUEOS facility serves to study premixing phenomena with solid spheres, i.e. without the danger of a steam explosion and the complication of melt fragmentation. Emphasis was put on high sphere temperatures (up to 2600 K) and the use of large numbers of comparatively small spheres so that intensive multiphase interactions with strong coupling of the phases (collective motion of the spheres) are observed. In order to simulate melt jets as closely as possible, the spheres are released as a cylindrical jet into a three-dimensional test vessel.

Parameters of the facility

The QUEOS facility consists of the test vessel, the furnace and the valve system separating the two. The spheres are heated in an electric radiation furnace in an argon atmosphere. The spheres are discharged into the water with a drop height of 130 cm. The diameter of the sphere stream is 100 mm or 180 mm after the discharge from the middle valve and the spheres fall freely without touching any walls.

The water vessel is made of stainless steel frames and glass and has a square cross section of 0.7 m side length and is 1.38 m high. Three walls have glass windows, with a field of view of 50 by 113.5 cm. A reference grid of 10x10 cm is mounted close to the inside of each of the windows, consisting of steel wire with 2 mm diameter. The fourth wall is the instrumentation wall made of steel. At its upper end there is an opening of 100 mm diameter, connected to the steam venting pipe. This pipe is guard-heated and insulated to prevent condensation. The test vessel is filled with water (0.5m3) to a level of 1 m.

Instrumentation and measurements

The release temperature of the spheres is monitored by high temperature thermocouples and pyrometers. The temperature just before the entry into the water is measured by a pyrometer with a response time of 1 ms. The temperatures of the water and steam are measured by Ni-CrNi-thermocouples. Six piezoresistive pressure transducers measure the vessel pressure. The steaming rate is measured by a vortex flowmeter which works on the principle of vortex shedding. The range for saturated steam at 1 bar is 80-700 dm^3/s. The water level is measured by two impedance level meters positioned in opposite corners of the test vessel. In a two phase mixture they measure the collapsed height of the water.

Pictures from the experiment are taken from two sides (90 degree) by two high speed film cameras (500 frames/s) and two video cameras (50 frames/s). The main direction with a lighted background has a long focal distance to reduce the perspective distortion. The second position of picture taking is directed against the black background of the instrumentation panel. Because the windows are only 50 cm wide there is a 10 cm wide space on both sides which cannot fully be seen, depending on the camera position. Also the bottom cannot be seen, it is 12 cm below the lower edge of the windows.

Remarks

The standard tests were chosen from a total of 62 tests performed in the QUEOS facility. The first 12 experiments are documented in [1]; up to experiment number 39 the data are presented in [2]. A comparison between experiments with cold and hot spheres, respectively,

employing three different sphere types each, in a wide (180 mm) short jet, was presented in [3] (Tests Q5 – Q18). The data of an experimental series with a smaller jet diameter (100 mm) and longer pours, with sphere temperatures of 1800 K, were published in [4] (Tests Q30 - Q36 and Q20 - Q22). Tests with a closed vessel were compared with tests with an open vessel in [5] (Tests Q54 – Q59).

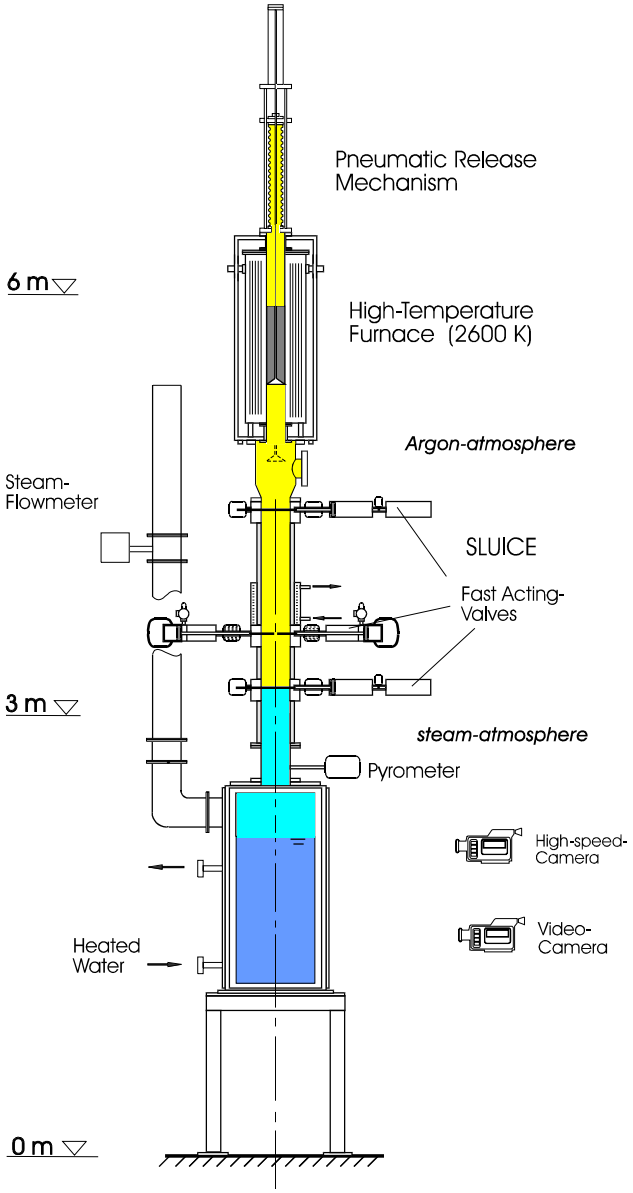

Fig. 7-1 Scheme of the QUEOS test facility

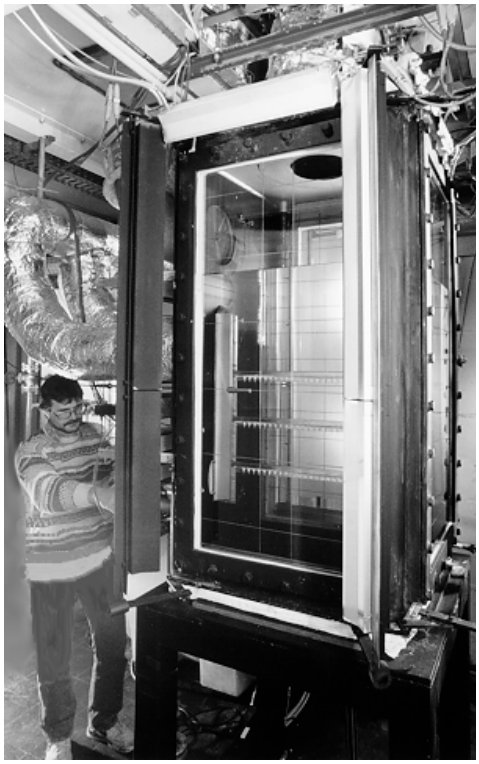

Fig. 7-2 View of QUEOS

Table 7.1 QUEOS Test Matrix

Exp. I.D.	Date	Type (Characteristics)
Q-8a	10/97	10 kg of Molybdenum spheres, 4.3 mm diam., jet diam. 180 mm, at 20°C in water at 20°C, with open vessel
Q-48	11/97	10 kg of Molybdenum spheres, 4.3 mm diam., jet diam. 100 mm, at 1730°C in saturated water, with open vessel
Q-47	7/97	10 kg of Zirconia spheres, 5.0 mm diam., jet diam. 100 mm, at 1530°C in 2°C subcooled water, with open vessel
Q-44	10/97	11.9 kg of Zirconia spheres, 10.0 mm diam., jet diam. 100 mm, at 2000°C in saturated water, with open vessel
Q-56	1/98	13.9 kg of Zirconia spheres, 5.0 mm diam., jet diam. 180 mm, at 1860°C in saturated water, with closed vessel
Q-58	2/98	10.8 kg of Zirconia spheres, 5.0 mm diam., jet diam. 180 mm, at 1850°C in 2°C subcooled water, with closed vessel
Q-53	12/97	20.0 kg of Tungsten spheres, 10.0 mm diam., jet diam. 180 mm, at 2350°C in saturated water, with open vessel
Q-8b	9/97	10 kg of Molybdenum spheres, 4.3 mm diam., jet diam. 180 mm, at 115°C in 2°C subcooled water, with open vessel
Q-17	1/96	10 kg of Molybdenum spheres, 4.3 mm diam., jet diam. 180 mm, at 1930°C in saturated water, with open vessel
Q-45	4/97	7.9 kg of Molybdenum spheres, 4.3 mm diam., jet diam. 100 mm, at 2280°C in saturated water, with open vessel
Q-59	11/98	12 kg of Zirconia spheres, 5.0 mm diam., jet diam. 180 mm, at 1730°C in 3°C subcooled water, with open vessel
Q-07	2/95	7.0 kg of Zirconia spheres, 10.0 mm diam., jet diam. 180 mm, at 1030°C in 1°C subcooled water, with open vessel
Q-61	4/98	5.0 kg of Zirconia spheres, 5.0 mm diam., 3 jets each with diam. of 36 mm, at 1550°C in saturated water, with open vessel
Q-62	6/98	8.6 kg of Zirconia spheres, 5.0 mm diam., 3 jets each with diam. of 36 mm, at 1750°C in saturated water, with open vessel

Status of Documentation

Is already in parts integrated in the STRESA databank.