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TEST SERIES C 1

EXPERIMENTAL DETERMINATION OF THE
PRESSURE LOSS COEFFICIENT FOR THE
IMPEDANCE RING IN THE
INNER REFLECTOR-OUTER REFLECTOR ANNULUS
(Title Unclassified)

SPECIAL REVIEW
FINAL
DETERMINATION
Class: U

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by

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INTRODUCTION

The inner impedance ring primarily meters the flow in the annulus between the inner and outer reflector and permits the flow in the annulus to be balanced with the rest of the entire reactor system. The impedance ring minimizes the problems of temperature distribution by mixing hydrogen from the various paths.

The purpose of this memo is to summarize the results of test on a 10° inner impedance ring sector.

The areas which were investigated were:

1. The variation in loss coefficient as a function of Reynolds number.
2. The variation in loss coefficient as a function of metering ring configuration for the operating Reynolds number range.
3. The variation in loss coefficient as a function of flow area for the operating Reynolds number range.

Tests were conducted using air at ambient temperature and 100 to 120 psig inlet pressure.

TEST APPARATUS AND INSTRUMENTATION

The flow loop is shown in Figure 1. Air leaves the compressor, passes through the after cooler, the water separator, then the air flows into the receiver. From the receiver, air flows through the pressure reducing valve, the test fixture, the flow control valve and the flow measuring nozzle to atmosphere.

The test fixture shown on Figure 2 was connected to the variable flow air supply capable of 600 scfm at 125 psig. Air was introduced into two inlet ports and then entered the inlet plenum through a series of 10 holes of 3/16 inch diameter, Figure 1. these holes provide for an equal pressure distribution in the inlet plenum. From these holes the flow passes into the inlet plenum, through the simulated inner reflector-outer reflector annulus, over the metering ring, and then into the outlet plenum. This test fixture simulates a 10° sector of the entire inner impedance ring. During the testing of metering ring configurations

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D, E, and F, the spacer was removed from the fixture and a blank plate was inserted in place of the spacer.

Six (6) pressure taps were placed at different locations as indicated and were connected to pressure gauges and manometers. Thermocouples were located in the inlet and exhaust plenums.

The inlet pressure P_1 was read at the inlet plenum. The pressure just upstream of the metering ring was averaged of taps P_{2A} and P_{2B} , and the pressure differential between P_1 and P_{2A} was read. The pressure just downstream of the metering ring was the average of taps P_{3A} and P_{3B} . The differential pressure across the metering ring was read as the difference in pressure of $P_{2A} - P_{3A}$. The differential pressure between the downstream side of the metering ring and the exhaust plenum was read as $P_{3B} - P_4$. Flow through the model was measured by an ASME calibrated orifice. For various tests, in addition to using two (2) design metering ring configurations, four (4) off-design metering ring configurations yielding flow areas larger and smaller than the two design conditions were tested.

These various tests were run with the following parameters:

Inlet Pressure	120, 110 and 100 psig
Inlet Temperature	530°R
Mass Flow	.045 to .352 pps
Outlet Pressure	30 to 120 psig

METERING RING CONFIGURATIONS A, B, C

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METERING RING CONFIGURATIONS D, E, F

The sketches above show the metering ring configurations used in the testing of the impedance ring fixture. Dimension "x" was varied in order to obtain different flow areas. The following table shows the values for Dimension "x".

<u>Metering Ring Type</u>	<u>Dimension (In.)</u>
A and D	1.7435
B and E	2.000
C and F	1.500

METHOD OF DATA REDUCTION

From the above pressure and temperature readings the following calculations were made. Since pressure drops are small compared to the pressure level, incompressible flow concepts are used.

Mass Flow

$$W = 0.1125 \sqrt{\rho P_5}$$

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where W = mass flow (lb/sec)
 P_5 = flow pressure at inlet of the flow measuring nozzle above atmosphere (inches of water)
 ρ = density (lb/cu. ft)

when

$$\rho = 2.6997 \left[\frac{(P_5 \times 0.03613) + (P_a \times 0.4912)}{T} \right]$$

where P_a = barometric pressure (inches of mercury)
 T = air temperature ($^{\circ}R$)

Loss Coefficient

$$C = .4468 \frac{\Delta P_{avg} \rho A^2}{W^2}$$

when

$$\rho = 2.6997 \frac{P_s}{T}$$

where P_s = absolute pressure upstream of the section being considered (psia)
 ΔP_{avg} = pressure drop (psi)
 C = loss coefficient
 A = flow area (square inches)

Reynolds Number

Reynolds number based on channel width is defined as:

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$$Re = \frac{\rho V L}{\mu g}$$

where V = fluid velocity (ft/sec)
 μ = viscosity (lb-sec/ft²)
 L = channel width (3.487 in)
 g = gravitational constant (ft/sec²)

but

$$\rho V = \frac{W}{L \times D}$$

where D = characteristic annulus clearance (ft)

$$\therefore Re = \frac{W}{\mu D}$$

DISCUSSION

Since pressure taps P_{2A} , P_{2B} , P_{3A} and P_{3B} were located in fixed locations while the metering ring geometry was varied, pressure measurements were not taken at the same location relative to the metering ring configuration. This resulted in pressure measurements that varied with metering ring geometry due to varying velocity fields created by the different metering ring configurations.

Figures 3 and 4 present curves of the inlet loss coefficient C_{12} vs Reynolds number. As shown on these figures, the loss coefficient decreases as Reynolds number increases. This decrease in loss coefficient is due to the fact that the flow passage in the inlet area is a rectangular duct and the losses are due to fluid friction. These curves are analogous to curves of friction factor versus Reynolds Number. Figures 3 and 4 also show a variation in loss coefficient which is due to the variation in pressure measurement mentioned above.

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Figures 5 and 6 present typical loss coefficient Reynolds number curves for various test conditions. The two figures show that the loss coefficient across the metering ring C-23 is essentially constant with Reynolds number. Secondly, these figures show that the loss coefficient is a function of flow area. Figures 5 and 6 show that curves for design configurations lie between curves of configurations of greater and less flow area. The increase in loss coefficient is caused by the fact that a decrease in flow area results in a higher pressure drop and a higher value for loss coefficient. The other case has a greater flow area resulting in a lower pressure drop and a lower loss coefficient.

The recovery coefficient C-34 is small on the order of 0.4 or less and reflects the same non-uniformity as C-12.

CONCLUSIONS

1. Over the operating Reynolds number range the loss coefficient across the metering ring is constant.
2. Decreasing the flow area results in a greater loss coefficient and increasing the flow area results in a smaller loss coefficient for the same Reynolds number range.
3. For high flow rates, the loss coefficient is dependent on and increases with increasing Reynolds number due to compressibility effects.

RECOMMENDATIONS

Further investigations should be conducted into the following:

1. The effect of annulus clearance on loss coefficient for the operating Reynolds number range.

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Figure 1 Flow Loop

TYPE A,B,C

TYPE D,E,F

GENERAL CONFIGURATION OF METERING RINGS

Figure 2 Inner Impedance Ring Fixture

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Figure 3
Loss Coefficient C-12 vs Reynolds Number for Metering Ring Configurations A, B, C

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Figure 1. Loss Coefficient C-12 vs Reynolds Number for Metering Ring Configurations D, E, F.

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Figure 5 Loss Coefficient C-23 vs Reynolds Number for Metering Ring Configurations A, B, C.

Figure 6 Loss Coefficient C-23 vs Reynolds Number for
Metering Ring Configurations D, E, F.