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GEOMETRICAL CONSIDERATIONS EFFECT

ON COMBUSTION CHAMBER PERFORMANCE

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ABSTRACT

The performance of a combustion chamber and flame stability
depend mainly on its geometrical design. It is important to
create an anchored flame in a determined position which
could be achieved by the creation of a recirculation zone.
The recirulated flow is obtained utilising the combustor
geometry.

A simplified mathematical model is developped to corrlate
the relation between the geometry and the recirulated flow
in addition to the effect of other parameters such as in8
jection methods and temperature inside the combustion zone.

Using the cold flow simulation and visualization methods
the flow structure at different positions could be traced.
Quantitive visualization measurements are used to estimate
the flow in the recirulated zone.

A comparison between the theoretical results and experi-
mental measurements shows an acceptable coincidence.

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I. INTRODUCTION

In a combustion chamber, expecially in a turbojet combustor, the designer task is to achieve an anchored flame in a de- termined position under all the severe operating conditions That zone into which the fuel would be sent.

That Flame stabililization at the severe conditions, is re- alized by the creation of a recirculation zone which is the center of the intensive change between fresh mixture (or air) and the burned hot gas.

The recirulated flow required for flame stability is created using geometrical methods, i.e utilizing the chamber constru- ction , the create the prementioned zone, which means that the designer is restricted by some considerations related to the combustion process, one of them is the flow distribution between the three zone of the combustion chamber (combustion, dilution and cooling). The second is the flame stability directly related to the flow in the primary (comustion) Zone.

2. STABILITY BY GEOMETRICAL METHODS

2.1. STABILITY BY CONFIINED JETS

That stability mode is related to the jet theory and flow propagation and diffusion between the jet and surroundings depending on the relative velocity (fig.1).

Fig(1)

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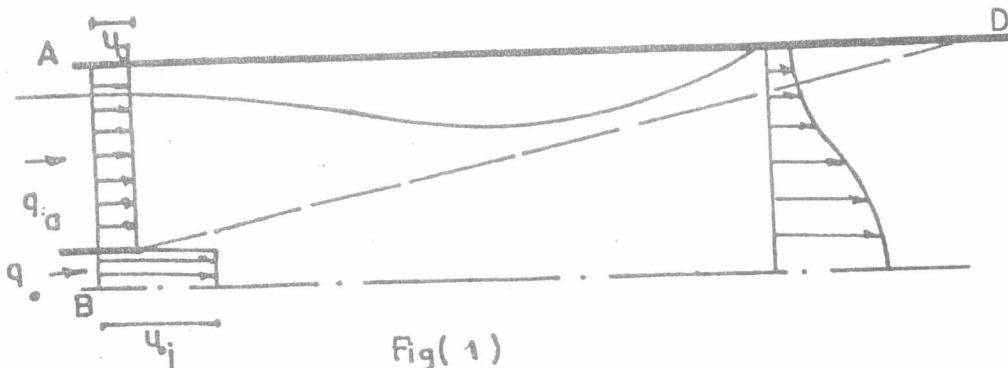
2.2. BLUFF BODY STABILITY

A "bulff body" is a solid object of such a shape that, when
it is suspended in a fluid stream, a re-circulatory flow
is formed in its immediate wake. This recirulation carriés
up-stream and mixes with fresh, unburned gas, the products
of combustion of fuel and oxident which were injected ear-
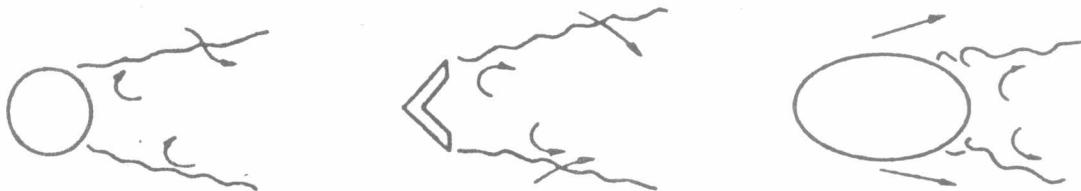lier.

FIG. 2   RECIRCULATING FLOW BEHIND SPHERE, GUTTER
AND STRUT.

2.3. STABILITY BY OPPOSITE INJECTION

Which creates a zone of recirulation similar to that
created in the wake of a bluff body. The caracteristics
of that zone depend mainly on the relative velocity be-
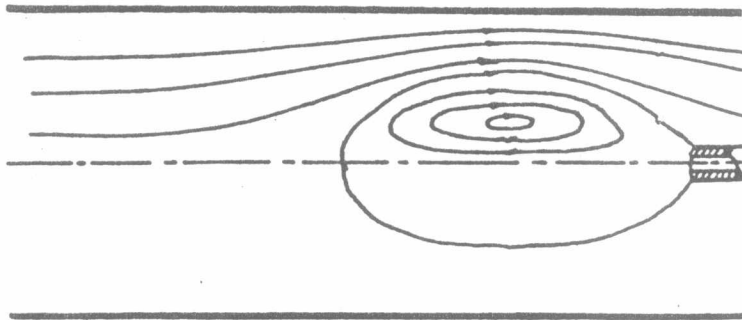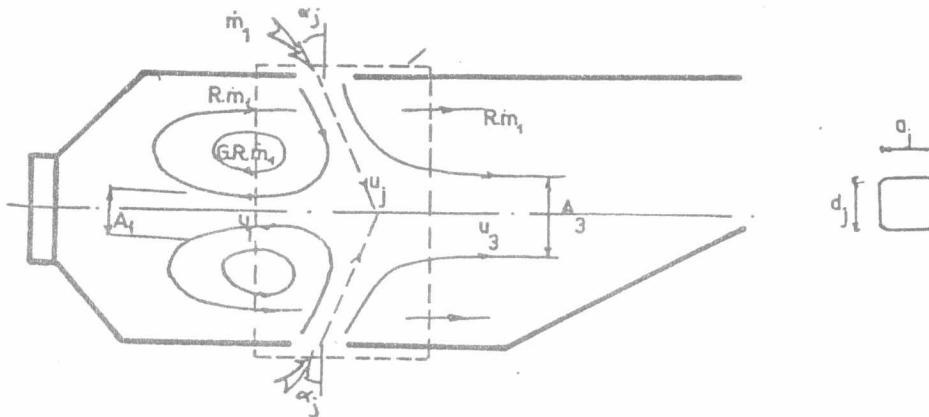tween the jet and the opposite.

Fig 3

2.4. STABILIZATION BY LATERAL ORIFICES

Which create a set of inclined jets, when meet, form a
zone of recirculation will be the center of fuel injection,
and consequently, center of combustion. That form of flow
and the effect of geometrical considerations on it. is the
intererst of the present paper.

Fig(4)

3 . THEORPETICAL STUDY

A simplified mathematical model is developped to correlate
the relation between the geometry of both the chamber and
orifices and the flow distribution inside the combustor.
Simplification of the model appears in the following
assumptions:

- Similarity of cold and hot flows.
- Incompressible flow.
- Steady flow.
- Similarity of the combustor geometry allow to
  treat only a sector as two dimensional flow.

3.1. GEOMETRICAL FFFFCT ON THE FLOW DISTRIBUTION:

The results show the direct relation between the flow pass-
ing to the primary flow through the orifices and the relative
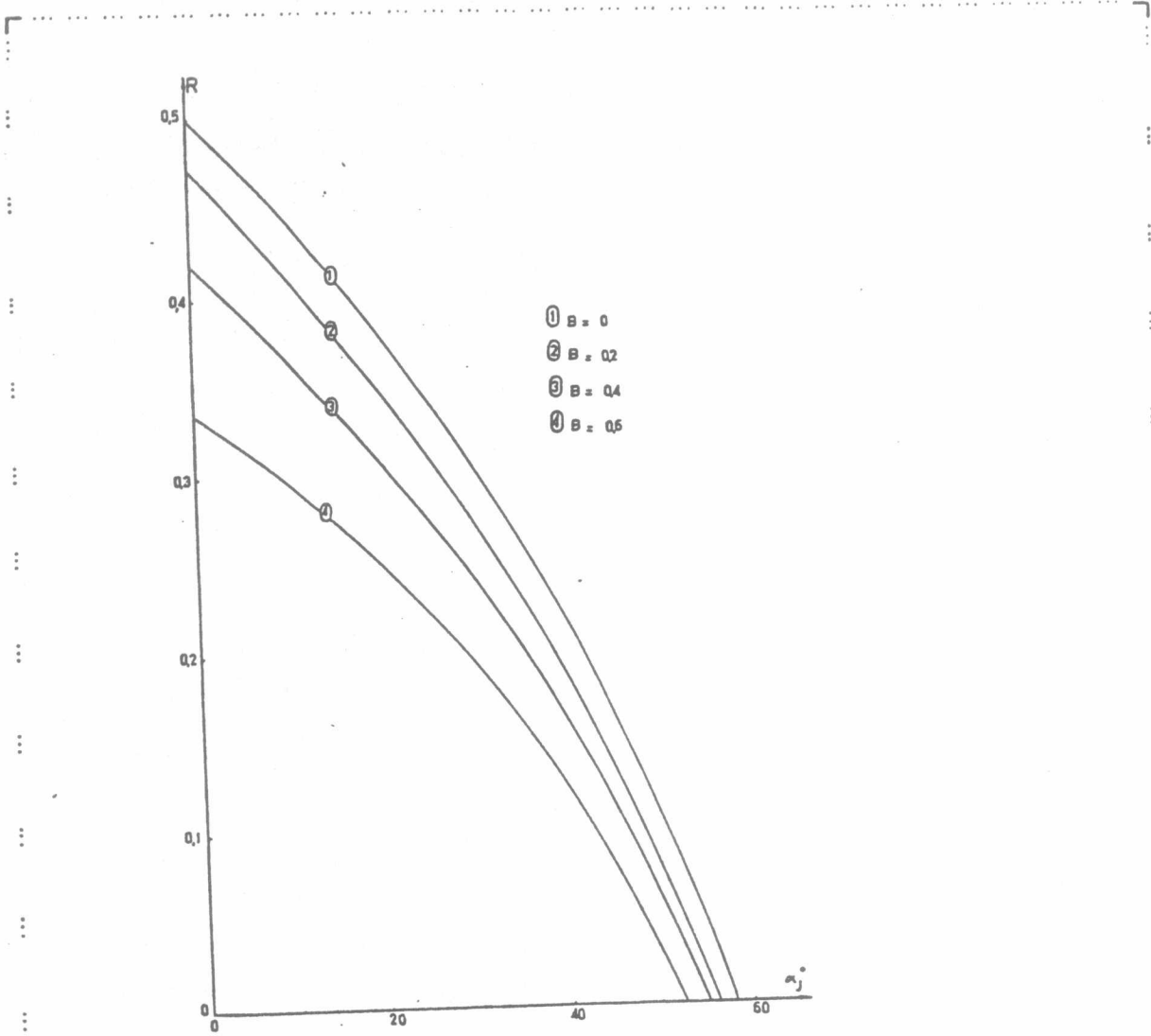area of the orifices.

Fig.5

3.2. RECIRCULATED FLOW CALCULATION;

3.2.1. With no premixed flow;

The model understands different fuel injection modes, and the first case with no permixed flow, shows how changes the recirulated flow with the combustor geometry (blockage) at different jet angles.

3.3.2. Permixed flow injected through swirlers;

One of the injection modes in the combustion chamber is the swirler which has an interference effect on the flow inside the combustion zone.

Fig.6
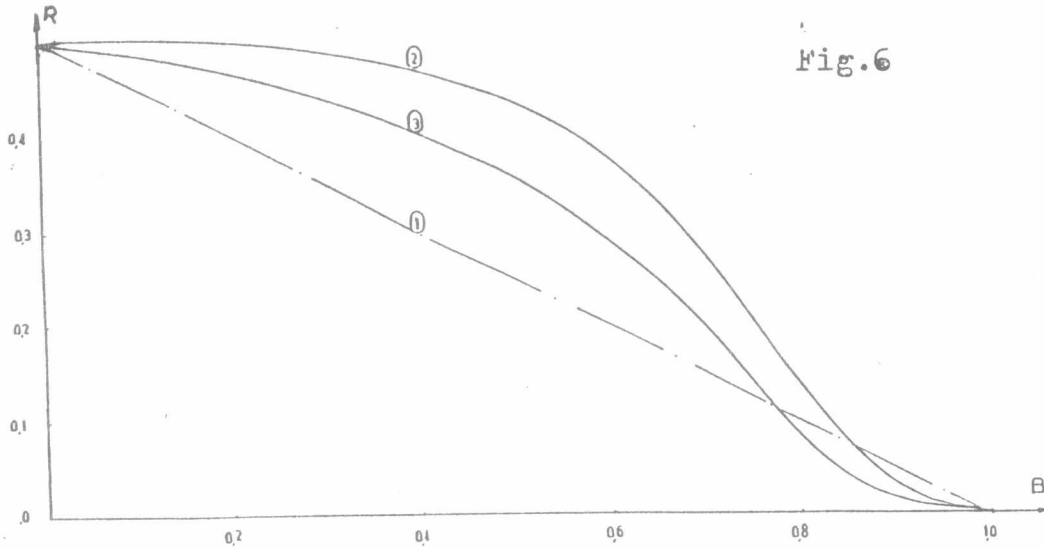
3.3.3. Permixed flow injected through prevaporization can:-

Another injection mode where a fuel / air mixture is injected in the opposite direction of the main flow inside the recirculation zone and intefering with. The prevaporization flow has an effect on both quantitive and qualititive feature of the recirculation zone. fig 7
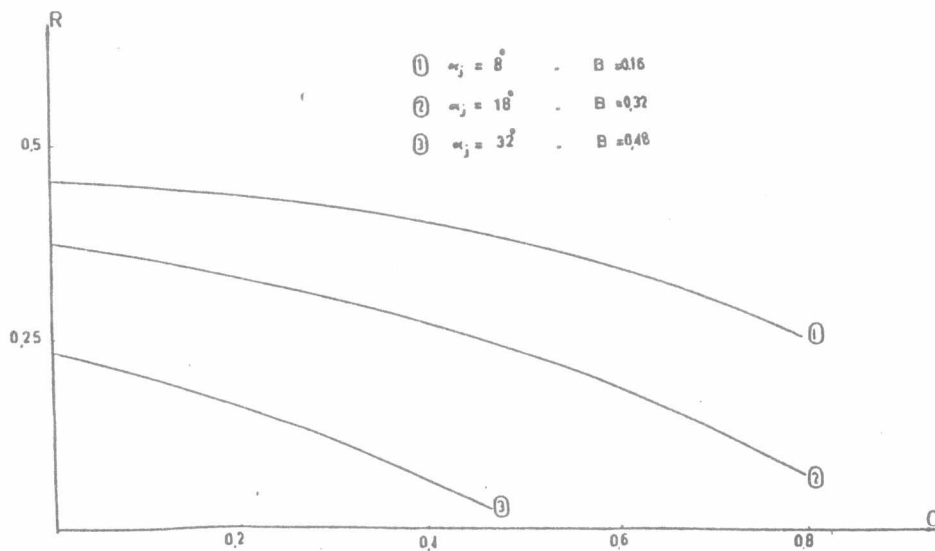

(1)	$\alpha_j = 8^\circ$	B = 0.16
(2)	$\alpha_j = 18^\circ$	B = 0.32
(3)	$\alpha_j = 32^\circ$	B = 0.48

Fig.7

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3.4. GEOMETRICAL EFFECT ON THE ENTRAINED FLOW:

This flow is the vortex formed inside the recirculation
zone and represent an important factor of flame stability,
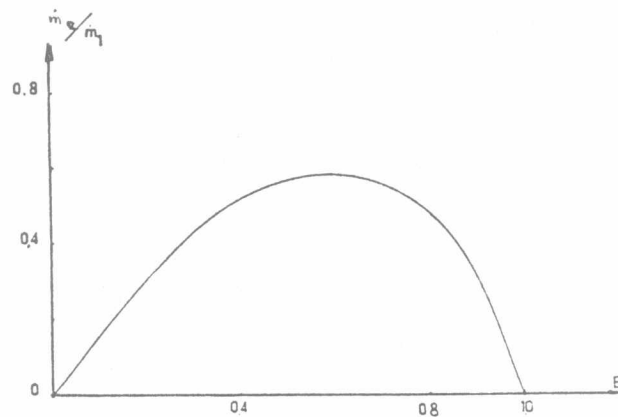the figure shows the effect of orifices geometry on that
flow.

Fig.8

3.5. INTERFERNCE OF TEMPERATURE EFFECT:

The temperature effect interfers with the geometrical
effect on both recirulated and entrained flow, some re-
sults are shown in figures (9 , 10) which show that the
blockage has rapid effect on the recirulated flow at high
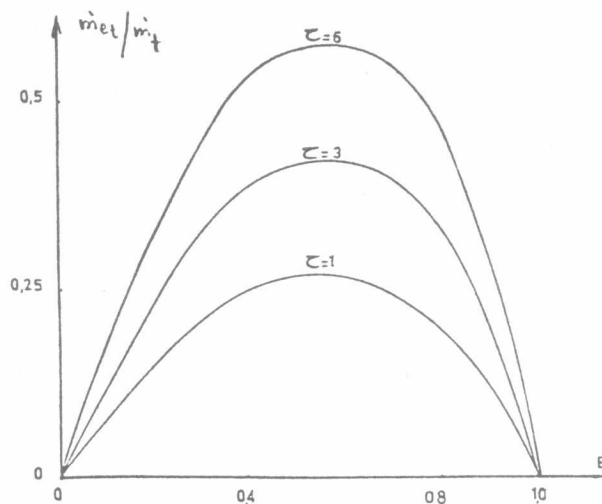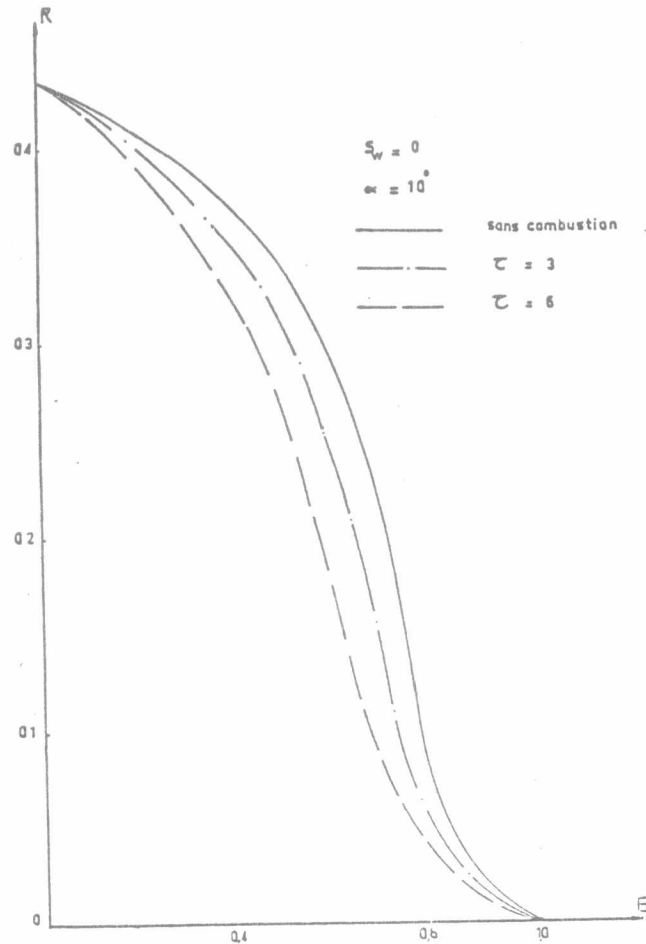temperature of combustion.

Fig.9

Fig.10

4. EXPERIMENTAL STUDY :

Using a hydromechanical model , the flow inside one sector of the combustion chamber is studied after the adjusting of the similarity with the actual flow. Examples of the results and their comparison with the theoritical results are shown in figures.
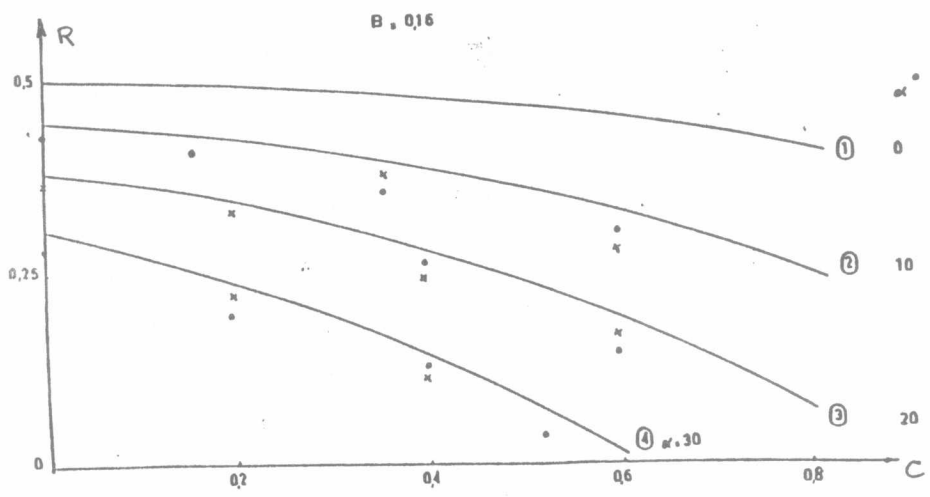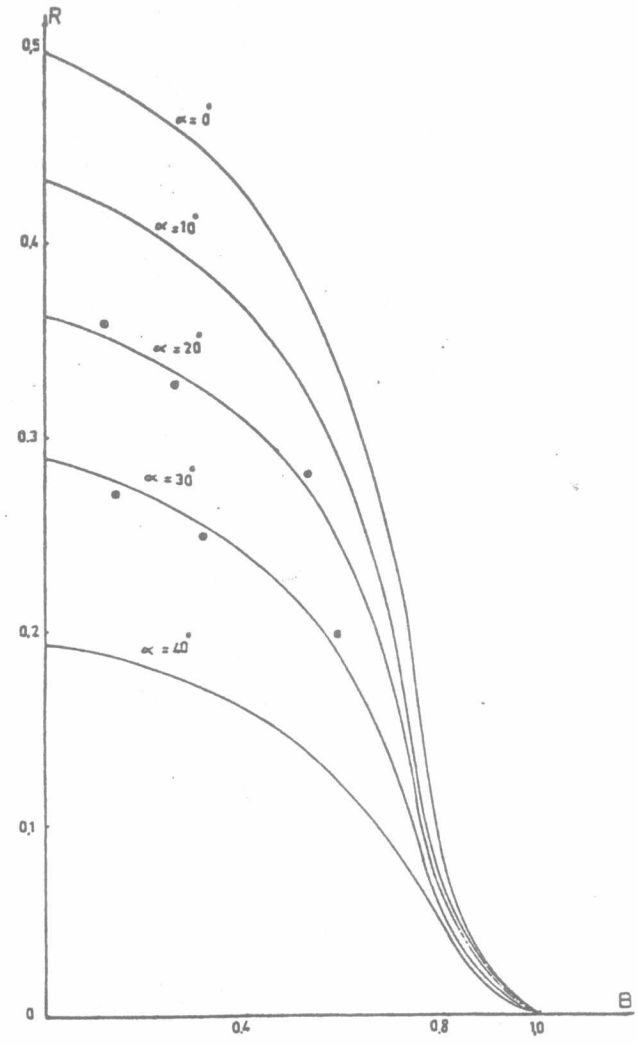
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Fig.11

Fig.12

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Nomenclature

$\dot{m}_t$ Total flow (Compressor exit).

$\dot{m}_1$ Primary flow.

$\dot{m}_R$ Recirculated flow = R. $\dot{m}_1$

$\dot{m}_c$ Can flow = C. $\dot{m}_1$

$\dot{m}_{sw}$ Swirl flow = Sw. $\dot{m}_1$

$\dot{m}_e$ Entrained flow

α_j Jet angle

B   blockage