AN ANALYSIS OF THE PROPERTIES OF TWO-DIMENSIONAL INCOMPRESSIBLE FLUID FLOW IN THE MIXING CHAMBER OF A CONSTANT AREA EJECTOR

MARTIN D. KIEFER
AN ANALYSIS OF THE PROPERTIES
OF TWO-DIMENSIONAL INCOMPRESSIBLE FLUID FLOW
IN THE MIXING CHAMBER OF A CONSTANT AREA EJECTOR

* * * * *

Martin D. Kiefer
AN ANALYSIS OF THE PROPERTIES
OF TWO-DIMENSIONAL INCOMPRESSIBLE FLUID FLOW
IN THE MIXING CHAMBER OF A CONSTANT AREA EJECTOR

by

Martin D. Kiefer

Lieutenant, United States Navy

Submitted in partial fulfillment of
the requirements for the degree of

MASTER OF SCIENCE
IN
MECHANICAL ENGINEERING

United States Naval Postgraduate School
Monterey, California

1963
AN ANALYSIS OF THE PROPERTIES
OF TWO-DIMENSIONAL INCOMPRESSIBLE FLUID FLOW
IN THE MIXING CHAMBER OF A CONSTANT AREA EJECTOR

by

Martin D. Kiefer

This work is accepted as fulfilling
the thesis requirements for the degree of
MASTER OF SCIENCE
IN
MECHANICAL ENGINEERING
from the

United States Naval Postgraduate School
ABSTRACT

The properties of an incompressible fluid in the mixing chamber of a constant area cylindrical ejector are analyzed in a two-dimensional form. The flow field for velocity and temperature is assumed to be made up of regions in which uniform flow of the primary and secondary fluids exist, and which diminish with axial distance from the ejector entrance. The velocity and temperature distributions in the mixed region are assumed to have cosine shaped profiles. The compatible solutions are given an axial distribution by assuming a parabolic spread rate for the secondary fluid jet boundary.

Results are generated in the form of a non-dimensional velocity and pressure, a normalized temperature and a Momentum Factor, as functions of axial distance. Area ratios studied include 100:1, 9:1 and 2.25:1. Velocity ratios studied include 50:1, 10:1, 3:1 and 1.5:1. The Fortran programs employed to generate compatible solutions, titled EJECTMIX I and EJECTMIX II, are included.
ACKNOWLEDGEMENT

The writer wishes to express his appreciation for the assistance and encouragement given him by Professor Paul F. Pucci of the United States Naval Postgraduate School in this investigation.
### TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td></td>
<td>ii</td>
</tr>
<tr>
<td>Acknowledgement</td>
<td></td>
<td>iii</td>
</tr>
<tr>
<td>List of Illustrations</td>
<td></td>
<td>v</td>
</tr>
<tr>
<td>Table of Symbols and Abbreviations</td>
<td></td>
<td>vi</td>
</tr>
<tr>
<td>1. Introduction</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>2. Ejector Analysis</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>3. Method</td>
<td></td>
<td>13</td>
</tr>
<tr>
<td>4. Results</td>
<td></td>
<td>18</td>
</tr>
<tr>
<td>5. Conclusion</td>
<td></td>
<td>21</td>
</tr>
<tr>
<td>Bibliography</td>
<td></td>
<td>22</td>
</tr>
<tr>
<td>Appendix I</td>
<td></td>
<td>23</td>
</tr>
<tr>
<td>Appendix II</td>
<td></td>
<td>52</td>
</tr>
<tr>
<td>Appendix III</td>
<td></td>
<td>74</td>
</tr>
<tr>
<td>Figure</td>
<td>Description</td>
<td>Page</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
<td>------</td>
</tr>
<tr>
<td>1.</td>
<td>Ejector Geometry and Initial Flow Parameters</td>
<td>2</td>
</tr>
<tr>
<td>2.</td>
<td>Typical Velocity and Temperature Profiles</td>
<td>2</td>
</tr>
<tr>
<td>3a.</td>
<td>Possible Spread Rate Configuration</td>
<td>6</td>
</tr>
<tr>
<td>3b.</td>
<td>Typical Profiles for Regions of Fig. 3a</td>
<td>6</td>
</tr>
<tr>
<td>3c.</td>
<td>Possible Spread Rate Configuration</td>
<td>7</td>
</tr>
<tr>
<td>3d.</td>
<td>Typical Profiles for Regions of Fig. 3c</td>
<td>7</td>
</tr>
<tr>
<td>3e.</td>
<td>Typical Profiles with Equation Parameters</td>
<td>8</td>
</tr>
<tr>
<td>4.</td>
<td>Block Diagram for EJECTMIX I</td>
<td>14</td>
</tr>
<tr>
<td>5.</td>
<td>Block Diagram for EJECTMIX II</td>
<td>16</td>
</tr>
<tr>
<td>6.</td>
<td>Profiles and Flow Pattern with Negative Peripheral Velocities</td>
<td>20</td>
</tr>
<tr>
<td>Fortran Symbol</td>
<td>Mathematical Symbol</td>
<td>Definition</td>
</tr>
<tr>
<td>---------------</td>
<td>---------------------</td>
<td>------------</td>
</tr>
<tr>
<td>ALPHA..........</td>
<td>$\frac{m}{\pi \rho V_a^2 r_a^2}$</td>
<td>numerical value of mass rate of flow at the entrance to the mixing chamber</td>
</tr>
<tr>
<td>ANA............</td>
<td>$\frac{r_a - r_{at}}{r_{bt} - r_{at}}$</td>
<td></td>
</tr>
<tr>
<td>ANB............</td>
<td>$\frac{r_b - r_{at}}{r_{bt} - r_{at}}$</td>
<td>function angles for numerical integration of total enthalpy</td>
</tr>
<tr>
<td>ANC............</td>
<td>$0$</td>
<td></td>
</tr>
<tr>
<td>BETA...........</td>
<td>$\frac{\pi \rho V_a^2 r_a^2}{\pi}$</td>
<td>numerical value of the momentum rate at the entrance to the mixing chamber</td>
</tr>
<tr>
<td>CHI............</td>
<td>$\frac{r_b - r_a}{\pi}$</td>
<td>a constant of integration for continuity and momentum equations</td>
</tr>
<tr>
<td>CHIA..........</td>
<td>$\frac{r_{at} - r_a}{\pi}$</td>
<td></td>
</tr>
<tr>
<td>CHIB..........</td>
<td>$\frac{r_{bt} - r_{at}}{\pi}$</td>
<td></td>
</tr>
<tr>
<td>CONST..........</td>
<td>$\frac{(T_p - T)V}{(V_p - V)T}$</td>
<td>proportionality constant between axial fluid temperature and axial fluid velocity after all spreading radii have reached their respective limits</td>
</tr>
<tr>
<td>DA.............</td>
<td>$\frac{(r_b - r_a)\pi}{100r_s}$</td>
<td>incremental changes in the angles during numerical integration of total enthalpy rate</td>
</tr>
<tr>
<td>DB.............</td>
<td>$\frac{(r_b - r_a)}{100(r_b - r_a)}$</td>
<td></td>
</tr>
<tr>
<td>DELTA..........</td>
<td>numerical value of Bernoulli's constant for secondary fluid</td>
<td></td>
</tr>
</tbody>
</table>
DIST(I) \( \frac{X}{r_a} \) \( \) non-dimensional ratio of axial distance from the entrance to the mixing chamber to that of the peripheral diameter of the central jet.

DP(I) \( \frac{\Delta p}{\frac{1}{2} \rho V_s^2} \) \( \) the change in the non-dimensional value of \( P(I) \) between a given cross-section and the entrance to the mixing chamber.

DT \( \frac{T_p - T_s}{2} \) \( \) one-half of the difference between the central and peripheral temperature.

DV \( \frac{V_p - V_s}{2} \) \( \) one-half of the difference between the central and peripheral velocity.

DVP \( \frac{V_p - \overline{V}}{} \) \( \) numerical difference between the axial fluid velocity and the final uniform velocity.

DX(I) \( \Delta \left( \frac{X}{r_a} \right) \) \( \) the change in the non-dimensional ratio \( \text{DIST}(I) \) between a given cross-section and the previously computed cross-section.

\( \text{ETA} + \text{ZETA} \). \( \frac{\dot{H}}{X} \) \( \) \( \) numerical value of total enthalpy rate at a given cross-section.

\text{FLAG} \( \) \( \) constant used to ensure that the first correct value of \( \text{CONST} \) is used throughout the program.

\text{GAMMA} \( \) \( \) numerical value of Bernoulli's constant for the central fluid.

\text{HDOT} \( \frac{\dot{H}}{\pi \rho c_p V_s r_a^2} \) \( \) numerical value of the total enthalpy rate at the entrance to the mixing chamber.

\text{PI} \( \frac{\text{Momentum rate}}{\pi \rho V_s^2 r_a^2} \) \( \) numerical value of the momentum rate for uniform flow at exit.

\text{P(I)} \( \frac{p}{\frac{1}{2} \rho V_s^2} \) \( \) non-dimensional ratio of pressure to one-half times the density times the initial secondary fluid velocity squared.
PSI(I) $\frac{\text{Momentum rate}}{K_m}$ numerical multiple of the final momentum rate at any given cross-section

RA(I) $\frac{r_a}{r_{a_o}}$ non-dimensional ratio of the central radius describing velocity core boundary at a given cross-section to that of the central jet radius

RAT(I) $\frac{r_{at}}{r_{a_o}}$ non-dimensional ratio of the central radius describing temperature core boundary at a given cross-section to that of the initial central jet radius

RB(I) $\frac{r_b}{r_{a_o}}$ non-dimensional ratio of the peripheral radius describing velocity jet boundary at a given cross-section to that of the initial central jet radius

RBT(I) $\frac{r_{bt}}{r_{a_o}}$ non-dimensional ratio of the peripheral radius describing temperature jet boundary at a given cross-section to that of the initial jet radius

RS $\frac{r_s}{r_{a_o}}$ ratio of peripheral radius of mixing chamber to the initial jet radius

RX & RY $\frac{r_x}{r_{a_o}}, \frac{r_y}{r_{a_o}}$ limits of integration for the continuity equation and the momentum equation

RZ $\frac{r_z}{r_{a_o}}$ reference radius during numerical integration of the total enthalpy rate

SIG(J) $h \Delta \bar{m}$ incremental numerical segments whose total is ZETA $[ZETA = \Sigma \text{Sig}(J)]$

TAVE $\frac{T_p + T_s}{2} = T_{ave}$ average value of central and peripheral temperature

TBAR $\bar{T}$ final uniform temperature at exit
\[
\text{TAU} + \text{OMEGA.} \quad \frac{\text{Momentum rate}}{\pi \rho V_s r_s^2} = \dot{\mathbf{M}}. \quad \text{numerical value of the momentum rate at a given cross-section}
\]

\[
\text{TAU} + \text{SIGMA.} \quad \frac{\dot{m}_x}{\pi \rho V_s r_s^2} \quad \ldots \quad \text{numerical value of the mass flow rate at a given cross-section}
\]

\[
\text{TP(I)} \quad \ldots \quad T_p \quad \ldots \quad \text{numerical value of the central fluid temperature above the initial secondary fluid temperature at the entrance to the mixing chamber}
\]

\[
\text{TS(I)} \quad \ldots \quad T_s \quad \ldots \quad \text{numerical value of peripheral fluid temperature above the initial secondary fluid temperature at the entrance to the mixing chamber}
\]

\[
\text{VAVE} \quad \ldots \quad \frac{V_p + V_s}{2} = V_{\text{ave}} \quad \text{average value of the central and peripheral velocity}
\]

\[
\text{VBAR} \quad \ldots \quad V \quad \ldots \quad \text{final uniform velocity at exit}
\]

\[
\text{VP(I)} \quad \ldots \quad \frac{V_p}{V_{s_o}} = V_{p^*} \quad \ldots \quad \text{numerical ratio of central fluid velocity to initial secondary fluid velocity at the entrance to the mixing chamber}
\]

\[
\text{VS(I)} \quad \ldots \quad \frac{V_s}{V_{s_o}} = V_{s^*} \quad \ldots \quad \text{numerical ratio of peripheral fluid velocity to initial secondary fluid velocity at the entrance to the mixing chamber}
\]
1. Introduction

The majority of analyses of the physical properties of fluids in ejectors have used a one-dimensional approach in which uniform properties are assumed at the entrance to the mixing chamber which is of sufficient length for the properties to again become uniform at the exit.¹ For example, consider a primary fluid flowing along the central axis of a cylindrical ejector and a secondary fluid flowing parallel to and completely surrounding it, as shown in Fig. 1. These fluids are separated by a circular boundary. At the entrance to the mixing chamber the boundary between the two fluids is removed and, at this initial cross-section, both the primary and the secondary fluids have uniform but different velocities. As the primary and secondary fluids flow axially through the mixing chamber, the fluids mix and the physical properties of each one of them are affected by the physical properties of the adjacent fluid.²

It is the purpose of this investigation, by use of a high speed digital computer and Fortran Programming Language, to predict what the properties in the partially mixed, non-


Fig. 1 Ejector Geometry and Initial Flow Parameters.

Fig. 2 Typical Velocity and Temperature Profiles
uniform sections of the stream will be. Consideration of the fluid flow mechanisms, such as the shear stress within the fluids, leads to the concept of a profile shape for the properties at a given cross-section. A typical profile shape for velocity and temperature is shown in Fig. 2.

The first problem considered is one in which the velocities of the primary and secondary fluids are different but their temperatures and densities are the same. The Fortran Program developed to solve this problem is called EJECTMIX I.

The second problem, considered in the program EJECTMIX II, studies the variations in the velocities and the temperatures of the two fluids.

---

2. Ejector Analysis

In order to analyse the behavior of the physical properties in the mixing chamber of an ejector there are several possible analytic approaches.

The first possible approach is a one-dimensional overall analysis in which uniform properties are assumed at the entrance and uniform properties of the completely mixed fluids are assumed at the exit of the mixing chamber. With this analysis, the region in which mixing of the primary and secondary fluids takes place is not considered. The only regions where the physical properties are studied are at the entrance to the mixing chamber and after the point where uniform flow exists.

A second possible approach is that of an internal analysis which is based on the actual fluid mechanisms. This approach requires the examination of an element of fluid and the forces which are acting upon it. The difficulty here lies in the inability to acquire a usable analytic expression for the shear stress acting upon the element of fluid.

A third approach, the one used in this thesis, is the generation of compatible solutions for the physical properties of the fluids at representative axial cross-sections by means of consideration of Conservation of Mass, Momentum, Bernoulli's Equation and the Energy Equation. In order to apply the above equations to the fluid in the mixing chamber, certain basic assumptions as to the nature of the flow in the
mixing chamber must be made.

First of all, the flow in the mixing chamber is assumed to be divided into regions which are shown in Fig. 3a and Fig. 3c. These regions are defined by the central core boundary and the expanding jet boundary. There are similar velocity and temperature profiles which consist of uniform portions at the central axis and the periphery of the mixing chamber, which are connected by a cosine shaped profile. The assumed profile shapes are shown in Fig. 3b and Fig. 3d. Assuming profile shapes, negligible boundary effects, constant pressure across any given cross-section, and constant temperature until a mixing region is reached, the previously mentioned equations can then be used.

The first equation considered is the Equation of Continuity

\[ \dot{m} = \int_{0}^{r_s} \rho V \, dA = \text{Constant} \]

For a typical profile shape, as shown in Fig. 3e, the Equation of Continuity becomes

\[ \dot{m} = 2\pi \rho \left( \int_{a}^{r_a} V_p r \, dr + \int_{r_a}^{r_b} \left[ \frac{V_{ave} + dV \cos \left( \frac{r-r_a}{r_b-r_a} \pi \right)}{r} \right] \, r \, dr + \int_{r_a}^{r_b} V_s r \, dr \right) \]

Integrating and evaluating the integral gives

\[ \dot{m} = \pi \rho \left( V_p r_a^2 + V_{ave} \left[ r_b^2 - r_a^2 \right] - 4dV \left[ \frac{r_b^2 - r_a^2}{\pi} \right]^2 + V_s \left[ r_s^2 - r_b^2 \right] \right) \]

Dividing through the entire equation by \( \pi \rho V_s r_a^2 \), the
Fig. 3a Possible Spread Rate Configuration

Fig. 3b Typical Profiles for Regions of Fig. 3a
Fig. 3c  Possible Spread Rate Configuration

Fig. 3d  Typical Profiles for Regions of Fig. 3c
Fig. 3e Typical Profiles with Equation Parameters

equation takes on the non-dimensional form

\[
\frac{\dot{m}}{\pi \rho V_s r_a^2} = \frac{V_p^2 r_a^2 V_{ave}}{V_s^2} \left( \frac{r_b^2-r_a^2}{r_a^2} \right) \frac{dV}{V_s} \left( \frac{r_b^2-r_a^2}{r_a^2} \right) + \frac{V_s}{V_s} \left( \frac{r_s^2-r_b^2}{r_a^2} \right)
\]

The next consideration is that of Bernoulli's Equation along a streamline in the uniform velocity portions of the profile. Bernoulli's Equation states that

\[
\frac{p}{\rho} + \frac{v^2}{2} = \text{Constant}
\]

In non-dimensional form the equation becomes

\[
\frac{p}{\pi \rho V_s^2} + \frac{V^2}{V_s^2} = \text{Constant}
\]

The constant associated with Bernoulli's Equation in the primary core is found by evaluating Bernoulli's Equation in
the non-dimensional form along the axis at the entrance to the mixing chamber. Similarly, the constant associated with the secondary cone is determined at the entrance to the mixing chamber. These values will be used in conjunction with the Momentum Equation.

Considering the same profile which was used in the Equation of Continuity and solving for the Momentum rate

\[
\text{Momentum rate} = \int \rho V^2 \, dA
\]

over the entire cross-section the Momentum Rate Equation becomes

\[
\text{Momentum Rate} = 2 \pi \rho \left( \int_{r_a}^{r_b} V_p^2 r \, dr + \int_{r_a}^{r_b} V_{ave} dV \cos \left( \frac{r-r_a \pi}{r_b-r_a} \right) \right)^2 r \, dr + \int_{r_b}^{r_s} V_s^2 r \, dr
\]

Integrating and evaluating the integral

\[
\text{Momentum Rate} = \pi \rho \left( V_p^2 r_a^2 + V_{ave} \left( r_b^2 - r_a^2 \right) - 8 V_{ave} dV \left( \frac{r_b - r_a}{\pi} \right)^2 \right) +
\]

\[
dV^2 \left( \pi r_b \left( \frac{r_b - r_a}{\pi} \right)^2 - \frac{\pi^2}{2} \left( \frac{r_b - r_a}{\pi} \right)^2 \right) v_s^2 \left( r_s^2 - r_b^2 \right)
\]

Dividing through the entire equation by \( \pi \rho V_s^2 r_a^2 \) puts the equation in the non-dimensional form
The Momentum Equation is then applied to the ejector in the axial direction. Neglecting shear stress at the ejector walls,

\[ \Delta p \pi r_s^2 = \Delta (\text{Momentum Rate}) \]

Defining a non-dimensional Momentum Rate by dividing by

\[ \pi \rho V_s^2 r_a^2 \]

we obtain,

\[ \frac{\Delta p}{\rho V_s^2} \frac{r_s^2}{r_a^2} = \Delta \dot{M} \]

Defining a non-dimensional pressure difference, \( \Delta p^* \), as

\[ \Delta p^* = \frac{\Delta p}{\rho \pi V_s^2} \frac{r_s^2}{r_a^2} = \frac{\Delta \dot{M}}{2} \frac{2 r_a^2}{r_s^2} \]

where \( \Delta p = p_x - p_{x=0} \) and \( \Delta \dot{M} = \dot{M}_x - \dot{M}_{x=0} \).

The final equation used is the Energy Equation in which the heat transferred to the surroundings is assumed to be zero. The difference in geo-potential energy is negligible and, lastly, the change in kinetic energy is negligible in comparison with the Enthalpy Rate. Thus the Energy Equation becomes

\[ \dot{H} = \int \dot{H} = \int h d\dot{m} = \pi \rho c_p \int TV r dr = \text{Constant} \]
Using the same profile shapes as before, the Enthalpy Rate for a typical axial cross-section becomes

\[
\dot{H} = 2\pi \rho c_p \left( \int_0^{r_{at}} V_p r \, dr + \int_{r_{at}}^{r_{bt}} \left[ V_{ave} + dV \cos \left( \frac{r-r_a}{r_{bt}-r_{at}} \right) \right] r \, dr + \right.
\]

\[
\int_{r_{at}}^{r_{bt}} \left[ T_{ave} + dT \cos \left( \frac{r-r_a}{r_{bt}-r_{at}} \right) \right] \left[ V_{ave} + dV \cos \left( \frac{r-r_a}{r_{bt}-r_{at}} \right) \right] r \, dr +
\]

\[
\int_{r_{bt}}^{r_{bt}} \left[ V_{ave} + dV \cos \left( \frac{r-r_a}{r_{bt}-r_{at}} \right) \right] r \, dr + \int_{r_{bt}}^{r_s} T_s V_s \, dr
\]

The second term of the Enthalpy Rate Equation, namely,

\[
2\pi \rho c_p \int_{r_{at}}^{r_{bt}} \left[ V_{ave} + dV \cos \left( \frac{r-r_a}{r_{bt}-r_{at}} \right) \right] \left[ T_{ave} + dT \cos \left( \frac{r-r_{at}}{r_{bt}-r_{at}} \right) \right] r \, dr
\]

was solved by numerical integration. The interval between \( r_{at} \) and \( r_{bt} \) was divided into 100 increments and summed.

The other integrals which make up the total value of the Enthalpy Rate are integrated and evaluated giving

\[
\pi \rho c_p \left( V_p T_p r_{at}^2 + V_p T_{ave} \left[ r_a^2 - r_{at}^2 \right] \right) +
\]

\[
2V_p \frac{dT}{\pi} \left[ \frac{r_{bt}-r_{at}}{\pi} \right] \frac{r_a \sin \left( \frac{r_a - r_{at}}{r_{bt}-r_{at}} \right)}{r_{bt}-r_{at}} +
\]

\[
2V_p \frac{dT}{\pi} \left[ \frac{r_{bt}-r_{at}}{\pi} \right]^2 \left[ \cos \left( \frac{r_a - r_{at}}{r_{bt}-r_{at}} \right) \right] +
\]

\[
V_s T_{ave} \left[ r_{bt}^2 - r_b^2 \right] - 2V_s \frac{dT}{\pi} \left[ \frac{r_{bt}-r_{at}}{\pi} \right] r_b \sin \left( \frac{r_b - r_{at}}{r_{bt}-r_{at}} \right) +
\]

\[
2V_s \frac{dT}{\pi} \left[ \frac{r_{bt}-r_{at}}{\pi} \right]^2 \left[ 1 - \cos \left( \frac{r_b - r_{at}}{r_{bt}-r_{at}} \right) \right] + V_s T_s \left[ r_s^2 - r_{bt}^2 \right]
\]
In order to place this in non-dimensional form, the equation was divided by $\pi p c_p V_s b r_a^2$. Thus the integral for numerical integration becomes

$$\int_{R_{bt}}^{R_{at}} \left[ \frac{V_{ave}}{V_s} + \frac{dV}{V_s} \cos \left( \frac{r-r_a x}{r_a x} \pi \right) \right] \left[ T_{ave} + dT \cos \left( \frac{r-r_{at x}}{r_{bt x} r_{at x}} \pi \right) \right] \frac{r}{r_{a o}} \frac{d}{r_a} \left[ \frac{r}{r_{a o}} \right]$$

Non-dimensionalizing the evaluated portion of the Enthalpy Rate gives

\[
\frac{V_s x T_{ave}}{V_{ave}} \frac{r_{at x}^2}{r_{a o}^2} \left[ \frac{V_{ave}}{V_s} \right] + \frac{2 V_{ave} dT_x}{V_{ave}} \left( \frac{r_{bt x} r_{at x}}{\pi r_{a o}} \right) \frac{r_{ax}^2}{r_{a o}^2} \sin \left( \frac{r_{ax} r_{at x}}{r_{bt x} r_{at x}} \pi \right) + \frac{2 V_{ave} dT_x}{V_{ave}} \left( \frac{r_{bt x} r_{at x}}{\pi r_{a o}} \right) \left( \cos \left[ \frac{r_{ax} r_{at x}}{r_{bt x} r_{at x}} \pi \right] -1 \right) + \frac{V_{ave}}{V_s} \frac{r_{bt x}^2}{r_{a o}^2} - \frac{2 V_{ave} dT_x}{V_{ave}} \left( \frac{r_{bt x} r_{at x}}{\pi r_{a o}} \right) \frac{r_{bx}^2}{r_{a o}^2} \sin \left( \frac{r_{bx} r_{at x}}{r_{bt x} r_{at x}} \pi \right) \frac{2 V_{ave} dT_x}{V_{ave}} \left( \frac{r_{bt x} r_{at x}}{\pi r_{a o}} \right) \left( 1 - \cos \left[ \frac{r_{bx} r_{at x}}{r_{bt x} r_{at x}} \pi \right] \right) + \frac{V_{ave} T_{ave}}{V_s} \frac{r_{bt x}^2}{r_{a o}^2} \frac{r_{bt x}^2}{r_{a o}^2}
\]
3. Method

The equations employed in EJECTMIX I and EJECTMIX II were used in the following manner. At a given axial position, a core boundary \( r_a \) is assumed. Primary and secondary velocities \( V_p \) and \( V_s \) are assumed which will be compatible with the Bernoulli Equation for the entrance to the mixing chamber. A jet boundary \( r_b \) is assumed and the conditions are checked for Conservation of Mass by means of the Continuity Equation. The primary and secondary velocities are corrected by an iterative process until a compatible solution is found.

The velocities found by the Continuity Equation are then used to solve for the pressure at the cross-section under consideration. Pressure changes determined from Bernoulli's Equation along streamlines in the uniform flow velocity regions are compared with the pressure change found from the overall Momentum Rate. If the pressure is found to be incompatible, the jet boundary \( r_b \) is corrected and once again the Equation of Continuity is used in order to determine compatible central and peripheral velocities. The values found by the Continuity Equation are then used to find a new value of the Momentum Rate, which, in turn, determines a new pressure change which can be used in Bernoulli's Equation to check the velocities found by Continuity. This process repeats itself until the core and jet boundaries \( r_a \) and \( r_b \), the central and peripheral velocities \( V_p \) and \( V_s \) and the pressure change are all compatible in the three basic equa-
Fig. 4 Block Diagram for EJECTMIX I
tions used. Then the process is repeated for the next cross-section which is displaced axially in the direction of fluid flow.

After several cross-sections have been investigated, the core boundary ($r_a$) or the jet boundary ($r_b$) may reach their limiting value, that is, the central core boundary ($r_a$) may go to zero or the peripheral jet boundary ($r_b$) may reach the mixing chamber boundary ($r_s$).

Considering the case of either one of the boundaries reaching its limiting value while the other boundary remains within its limit, the scheme for finding the compatible solution remains exactly the same as that used when both boundaries were within limits, with the exception of the role of Bernoulli's Equation. Since the flow field will no longer be uniform where the boundary has reached its limit, the streamline along which Bernoulli's Equation was assumed to have a constant value will no longer exist. With this in mind, Bernoulli's Equation will only be taken into account in the uniform flow portion which has not reached its limiting value.

When both boundaries have reached their respective limiting values, no additional restrictions are required other than the overall Momentum Rate. Compatible solutions are then found using fixed increments of the central velocity as the criteria for the particular cross-section.

EJECTMIX II is basically the same program as EJECTMIX I
Fig. 5 Block Diagram for EJECTMIX II
with additional restrictions placed upon the flow field. These additional restrictions take the form of variations in the temperatures of the primary and secondary fluids. The temperature boundaries are assumed to spread more rapidly than the velocity region boundaries. This has been verified by experiments on jets of gases flowing in ejectors.\(^4\) Also, the temperature is assumed to be a constant until the temperature boundaries reach their limiting values. The temperature boundaries are assumed and the value of the energy equation at the cross-section in question is compared with that of the initial cross-section. The central temperature core boundary \(r_{at}\) is corrected until a compatible solution is obtained.

In order to determine the axial position on which each of the representative compatible solutions lie, a spread rate \(\left[ \frac{d}{dx} (r_b) \right]\) is assumed for the peripheral jet boundary. When this boundary reaches its limiting value, it is assumed that the pressure will continue varying as a smooth curve until it reaches its limiting value in the mixing chamber.

4. Results

The data which was obtained using EJECTMIX I and EJECTMIX II is presented in graphical form in Appendix 2 and in tabular form in Appendix 3. The properties obtained are presented in groups according to the ratio of the radius of the peripheral boundary to the central jet radius. The values of this given ratio are 1.5, 3.0 and 10.0.

These graphs may be entered with the known physical dimensions of the ejector mixing chamber and the velocity ratio. The ratio of the initial peripheral radius to the central jet radius of ten to one gives an actual area ratio of 100 to one and thus approaches the condition whereby the peripheral fluid actually would be unbounded.

The graphical solutions shown are those in which the fluid was assumed to return to a uniform flow after it had passed down an axial distance equal to ten times the peripheral diameter. The data and graphs are presented as functions of axial distance divided by initial central jet radius \( \frac{X}{r_a} \). Tabulated data shown in Appendix 3 is the computer output which was used to produce these graphs.

In the course of finding compatible solutions, a temperature difference of 100 degrees was used. By varying only the temperature, the solutions obtained for temperature were directly proportional to each other. With this in mind, the temperature difference for any case can be determined by using a proportionality constant and a 100 degree temperature
difference. Temperatures are measured above a reference temperature which is the secondary fluid temperature at the initial cross-section.

The pressure term as used in Bernoulli's Equation is not significant in its absolute value since it cancels out of the equation when used in these programs. Its significance lies in the change of the non-dimensional pressure term. With each specific case an initial non-dimensional pressure can be determined. This non-dimensional pressure will be a function of the absolute velocities, the pressure and the fluid flowing in the ejector.

Since the initial peripheral velocity ratio is equal to one, a change in the non-dimensional pressure of one, before the velocity jet boundary reaches its limiting value, leads to a zero velocity ratio through the Bernoulli Equation. Any increase in the non-dimensional pressure beyond the value of one leads to compatible solutions in which the peripheral velocity becomes negative. This phenomenon is dependent upon the velocity ratio and the cross-sectional area of the central and peripheral jets.

Negative peripheral velocity ratios first appeared in the range of the values studied at an initial central velocity ratio of ten and an area ratio less than 100 to one. The flow pattern which exists when negative peripheral velocity ratios are generated in the compatible solution is shown in Fig. 6.
Fig. 6 Profiles and Flow Pattern with Negative Peripheral Velocities

Throughout most of the program accuracy of one-half of one percent is required in order for the solution to be considered acceptable. This criterion fails during the transition of the peripheral velocity ratio term through its zero values. For this portion of the program accuracy of plus or minus one one-hundredth for the non-dimensional velocity term is required. This change in the criterion ensures that a finite and acceptable error can be established for any value of the peripheral velocity ratio.

The final piece of data presented by the program is the Momentum Factor. This term gives that multiple of the final momentum that exists at any point.
5. Conclusions

The programs presented here represent the first step in a series of programs which would eventually describe the physical properties of any fluid flowing in an ejector. This logical continuation would require that work be done on the compressible fluid problem at both subsonic and supersonic velocities.

The programs contained in this work solve the ejector problem for two incompressible fluids of the same density whose physical properties are initially different. The data obtained is presented here in graphical and tabular form.
BIBLIOGRAPHY


APPENDIX I

Appendix I contains a listing, in FORTRAN language, of the programs EJECTMIX I and EJECTMIX II.
PROGRAM EJECTMIX
DIMENSION RA(500), RB(500), VP(500), VS(500), P(500), PSI(500), CP(500)
READ 101 (VP(1), RS)
101 FORMAT (2F15.0)
VS(1) = 1.0
P(1) = 10.0
DP(1) = 0.0
RA(1) = 1.0
RB(1) = 1.0
RB(2) = 1.03
I = 1
ALPHA = VP(1)*RB(1)**2 + (RS**2 - RB(1)**2)
BETA = VP(1)**2*RB(1)**2 + (RS**2 - RB(1)**2)
GAMMA = P(1) + VP(1)**2
DELTA = P(1) + 1.0
THETA = GAMMA - DELTA
PI = ALPHA**2/RS**2
PSI(1) = BETA/PI
WRITE OUTPUT TAPE 4,102
WRITE OUTPUT TAPE 4,103
PRINT 133, RA(I),RB(I),DP(I),VP(I),VS(I),PSI(I)
102 FORMAT (11X,7HCENTRAL,8X,10HPERIPHERAL,7X,8HPRESSURE,8X,
17HCENTRAL,8X,1CHPERIPHERAL,7X,8HMOMENTUM)
103 FORMAT (12X,6HRADIUS,10X,6HRADIUS,10X,6HCHANGE,9X,
18HVELOCITY,8X,8HVELOCITY,9X,6HFACOR//)
104 RA(I + 1) = RA(I) - 0.01
VP(I + 1) = VP(I)
VS(I + 1) = VS(I)
I = I + 1
IF (RS - RB(I)) 122,122,105
105 IF (RA(I)) 137,106,106
106 CHI = (RB(I) - RA(I))/3.1415926
107 TAU = VP(I)*RA(I)**2 + VS(I)*(RS**2 - RB(I)**2)
RX = RA(I)
RY =RB(I)
}
108 DV = (VP(I) - VS(I))/2.0
    VAVE = VS(I) + DV
    OMEGA = VAVE*(RY**2 - RX**2) - 4.0*DV*CHI**2
    IF (ALPHA - OMEGA - TAU + C.001) 109,110,110
109 VP(I) = VP(I) - 0.000007
    VS(I) = SQRTF(VP(I)**2 - THETA)
    GO TO 107
110 IF(ALPHA - OMEGA - TAU - C.001) 112,112,111
111 VP(I) = VP(I) + 0.00001
    VS(I) = SQRTF(VP(I)**2 - THETA)
    GO TO 107
112 TAU = VP(I)**2*RA(I)**2 + VS(I)**2*(RS**2 - RB(I)**2)
    RY = RB(I)
113 SIGMA = VAVE**2*(RY**2 - RX**2) - 8.0*VAVE*DV*CHI**2 +
           1DV**2*CHI*RY*3.1415926 - 4.9340C22*CHI**2*DV**2
    DP(I) = (BETA - SIGMA - TAU)/(0.5*RS**2)
    P(I) = P(1) + DP(I)
    IF (1.005*(DELT(A - P(I)) - VS(I)**2)) 115,136,114
114 IF (0.995*(DELTA - P(I)) - VS(I)*2) 136, 136, 116
136 RP(I + 1) = 2.0*RP(I) - RP(I - 1)
  GO TO 132
115 RP(I) = RP(I) + C.CCC1
  GO TO 117
116 RP(I) = RP(I) - 0.CCC1
117 GO TO 106
122 IF(RA(I)) 147, 123, 123
123 RB(I) = RS
  RX = RA(I)
  RY = RS
124 DV = (VP(I) - VS(I))/2.0
  TAU = VP(I)*RA(I)*2
  VAVE = VS(I) + DV
  CHI = (RS - RA(I))/3.1415926
  OMEGA = VAVE*(RY**2 - RX**2) - 4.0*DV*CHI**2
  IF (ALPHA - OMEGA - TAU + C.001) 125, 126, 126
125 VS(I) = VS(I) - C.CC007
  GO TO 124
126 IF (ALPHA - CMECA - TAU - C.001) 128, 128, 127
127 VS(I) = VS(I) + 0.0001
GO TO 124
128 TAU = VP(I)**2*RA(I)**2
129 SIGMA = VAVE**2*(RY**2 - RX**2) - 8.0*VAVE*DV*CHI**2 +
10*VAVE*2*CHI*RY**2 * 1.415926 - 4.9348022*CHI**2*DV**2
DP(I) =(BETA - SIGMA - TAU)/(C.5*RS**2)
P(I) = P(I) + DP(I)
IF (1.005*(GAMMA - P(I)) - VP(I)**2) 131, 132, 130
130 IF (0.995*(GAMMA - P(I)) - VP(I)**2) 132, 132, 135
131 VP(I) = VP(I) - 0.0001
GO TO 124
132 PSI(I) = (SIGMA + TAU)/PI
RB(I + 1) = 2.0*RB(I) - RB(I - 1)
PRINT 133, RA(I), RB(I), DP(I), VP(I), VS(I), PSI(I)
133 FORMAT (5X,6E16.7)
, GO TO 104
135 VP(I) = VP(I) + 0.0001
GO TO 124
137 TAU = VS(I) * (RS**2 - RB(I)**2)
RA(I) = 0.0
RX = 0.0
RY = RB(I)
CHI = RB(I)/3.1415926
138 DV = (VP(I) - VS(I))/2.0
VAVE = VS(I) + LV
OMEGA = VAVE*(RY**2 - RX**2) - 4.0*DV*CHI**2
IF (ALPHA - OMEGA - TAU + C.001) 140,142,139
139 IF (ALPHA - OMEGA - TAU - C.001) 142,142,141
140 VP(I) = VP(I) - C.C0007
GO TO 138
141 VP(I) = VP(I) + 0.0001
GO TO 138
142 TAU = VS(I)**2 *(RS**2 - RB(I)**2)
SIGMA = VAVE**2 *(RY**2 - RX**2) - 8.0*VAVE*DV*CHI**2 +
1DV**2*CHI*RY**3.1415926 - 4.939022*CHI**2*DV**2
DP(I) = (PETA - SIGMA - TAU)/(0.5*RS**2)
\begin{verbatim}
P(I) = P(I) + DP(I)
IF (1.005*(DELTA - P(I)) - VS(I)**2) 145, 144, 143
143 IF (0.995*(DELTA - P(I)) - VS(I)**2) 144, 144, 146
144 RE(I + 1) = RE(I) + 0.01
GO TO 132
145 VS(I) = VS(I) - 0.0001
GO TO 137
146 VS(I) = VS(I) + 0.0001
GO TO 137
147 RA(I) = 0.0
RX = 0.0
RE(I) = RS
RY = RS
TAU = 0.0
CHI = RS/3.1415926
148 DV = (VP(I) - VS(I))/2.0
VAVE = VS(I) + DV
OMEGA = VAVE*(RY**2 - RX**2) - 4.0*DVs*CHI**2
\end{verbatim}
IF (ALPHA - CMega + 0.001) 150, 149, 151
149 IF (ALPHA - CMega - 0.001) 152, 152, 151
150 VS(I) = VS(I) - 0.00007
   GO TO 148
151 VS(I) = VS(I) + 0.0001
   GO TO 148
152 SIGMA = VAIVE*2*(RY**2 - RX**2) - 0.0*VAIVE*DV*CHI**2 +
         1DV**2*CHI*RY*3.1415926 - 4.9348022*CHI**2*DV**2
   DP(I) = (BETA - SIGMA - TAU)/(0.5*RS**2)
   P(I) = P(I) + DP(I)
   PSI(I) = (SIGMA + TAU)/PI
   PRINT 153, RA(I), RB(I), DP(I), VP(I), VS(I), PSI(I)
153 FORMAT (5X,6E16.7)
   VP(I + 1) = VP(I) - 0.01
   VS(I + 1) = VS(I) + 0.0001
   IF (VP(I) - VS(I)) 134, 154, 154
154 I = I + 1
   GO TO 147
134 STOP
   END
   END
PROGRAM EJECTMIX II
DIMENSION RA(500),RB(500),VP(500),VS(500),P(500),PSI(500),
1DP(500),TP(500),TS(500),DIST(500),DX(500),RAT(500),
2RBT(500),SIG(500)
READ 101 (VP(1), RS, TP(1))
101 FORMAT (3F10.0)
    PARAB1 = 0.0C2
70 P(1) = 10.0
    DP(1) = 0.0
    TS(1) = 0.0
    VS(1) = 1.0
    RA(1) = 1.0
    RB(1) = 1.0
    RB(2) = 1.1
    RAT(1) = 1.0
    RBT(1) = 1.0
    RBT(0) = 1.0
    DIST(1) = 0.0
FLAG = 0.0
PARAB2 = 1.3*PARAB1
I = 1
ALPHA = VP(1)*RB(1)*2 + (RS*2 - RB(1)*2)
BETA = VP(1)*2*RB(1)*2 + (RS*2 - RB(1)*2)
GAMMA = P(1) + VP(1)*2
DELTA = P(1) + 1.0
THETA = GAMMA - DELTA
P1 = ALPHA*2/RS*2
PSI(1) = BETA/P1
HDOT = VP(1)*TP(1)*RA(1)*2
VBAR = ALPHA/RS*2
TBAR = HDOT/(VBAR*RS*2)
WRITE OUTPUT TAPE 4, 190
190 FORMAT (1H1)
WRITE OUTPUT TAPE 4,102
102 FORMAT (6X,3F-X/0,7X,2HRA,8X,2HRP,8X,2HVP,8X,2HVS,8X,3HRAT,
17X, 3HRBT, 6X, 2HTP, 9X, 2HTS, 9X, 2HDP, 5X, 8HMOMENTUM//)
PRINT 133, DIST(I), RA(I), RB(I), VP(I), VS(I), RAT(I), RBT(I),
1TP(I), TS(I), CP(I), PSI(I)
104 RA(I + 1) = RA(I) - 0.1
VP(I + 1) = VP(I)
VS(I + 1) = VS(I)
I = I + 1
199 IF (RS - RB(I)) 122, 122, 105
105 IF (RA(I)) 137, 106, 106
106 CHI = (RB(I) - RA(I))/3.1415926
DIST(I) = SQRTF((RB(I) - 1.0)/PARAB1)
DX(I) = DIST(I) - DIST(I - 1)
107 TAU = VP(I)*RA(I)**2 + VS(I)*(RS**2 - RB(I)**2)
RX = RA(I)
RY = RB(I)
108 DV = (VP(I) - VS(I))/2.0
VAVE = VS(I) + DV
OMEGA = VAVE*(RY**2 - RX**2) - 4.0*DVS*CHI**2
IF (1.005*ALPHA - OMEGA - TAU) 109, 110, 110
109 VS(I) = VS(I) + (ALPHA - OMEGA - TAU)/(15.0*RB(I)**2)
   IF (VS(I)) 193, 192, 192
192 VP(I) = SQRTF(VS(I)**2 + THETA)
   GO TO 107
   LONG = ABSF(THETA - VS**2)
193 VP(I) = SQRTF(LONG)
   GO TO 107
110 IF (0.995*ALPHA - OMEGA - TAU) 112, 112, 109
112 TAU = VP(I)**2*RA(I)**2 + VS(I)**2*(RS**2 - RB(I)**2)
   RY = RB(I)
113 SIGMA = VAVE**2*(RY**2 - RX**2) - 8.0*VAVE*DV*CHI**2 +
   1DV**2*CHI*RY*3.1415926 - 4.934822*CHI**2*DV**2
   DP(I) = (BETA - SIGMA - TAU)/(0.5*RS**2)
   P(I) = P(I) + DP(I)
   IF (1.005*(GAMMA - P(I)) - VP(I)**2) 115, 136, 114
114 IF (0.995*(GAMMA - P(I)) - VP(I)**2) 136, 136, 116
136 RB(I + 1) = 2.0*RB(I) - RB(I - 1)
   GO TO 132
115 RB(I) = RB(I) + 0.001
    GO TO 199
116 RB(I) = RB(I) - 0.001
117 GO TO 199
122 IF(RA(I)) 147,123,123
123 RB(I) = RS
    RX = RA(I)
    RY = RS
    DX(I) = DX(I - 1)*(RA(I)-RA(I-1))/(RA(I-1)-RA(I-2))
    DIST(I) = DIST(I-1) + DX(I)
124 DV = (VP(I) - VS(I))/2.0
    TAU = VP(I)*RA(I)**2
    VAVE = VS(I) + DV
    CHI = (RS - RA(I))/3.1415926
    OMEGA = VAVE*(RY**2 - RX**2) - 4.0*DVECHI**2
    IF (1.005*ALPHA - OMEGA - TAU) 125,126,126
125 VS(I) = VS(I) + (ALPHA - OMEGA - TAU)/150.0*RS**2
    GO TO 124
126 IF (0.995*ALPHA - OMEGA - TAU) 123,128,125
DE = (RB(I) - RA(I)) * 3.1415926/(100.0*(RB(I) - RA(I)))
DT = (TP(I) - TS(I))/2.0
RZ = RA(I) + 0.05*(RB(I) - RA(I))
CHIA = (RAT(I) - RA(I))/3.1415926
ANA = (RA(I) - RAT(I)) * 3.1415926/(RBT(I) - RAT(I))
CHIB = (RBT(I) - RAT(I))/3.1415926
ANB = (RB(I) - RAT(I)) * 3.1415926/(RBT(I) - RAT(I))
ANC = 0.0
TAVE = 0.5*(TP(I) + TS(I))
ETA = VP(I)*TP(I)*RAT(I)*vs2+VP(I)*TAVE*(RA(I)*vs2-RAT(I)*vs2)+
12.0*VP(I)*DT*CHID*RA(I)*SINF(ANA)+2.0*VP(I)*DT*CHIB*vs2+
2*(COSF(ANA)-1.0)+VS(I)*TAVE*(RBT(I)*vs2-RB(I)*vs2)+
32.0*VS(I)*DT*CHIE*RB(I)*SINF(ANB)+2.0*VS(I)*DT*CHIB*vs2+
4*(1.0-COSF(ANB)) + VS(I)*TS(I)*(RS*vs2-RBT(I)*vs2)
DO 303 J = 1,100
SIG(J) = (VAVE+DV*COSF(ANC))*(TAVE+DT*COSF(ANA))*
1((RZ+0.01*(RB(I)-RA(I)))*vs2-RZ*vs2)
ANA = ANA + DA
ANC = ANC + CB
RZ = RZ + 0.01*(RP(I) - RA(I))
ZETA = ZETA + SIG(J)

303 CONTINUE
  IF (1.005*HDCT - ETA - ZETA) 305,328,304
304 IF (0.995*HDCT - ETA - ZETA) 328,328,305
305 RAT(I) = RAT(I) + (HDCT-ETA-ZETA)/(100.0*TP(I))
  IF (RAT(I)) 170,202,302
170 RAT(I) = 0.0
  GC TC 316
307 BRT(I) = RS
  RAT(I) = RAT(I-1)*2/RAT(I-2)
  IF (RAT(I)) 321,90,90
90 DA = (RS - RA(I))**2.1415926/(100.0*(BRT(I) - RAT(I)))
  DB = (RS - RA(I))**2.1415926/(100.0*(ER(I) - RA(I)))
  TS(I) = TS(I-1)**2/TS(I-2)
308 DT = (TP(I) - TS(I))/2.0
  83 ZETA = 0.0
          RZ = RA(I) + 0.005*(RR(I) - RA(I))
CHIA = (RAT(1) - RA(I))/3.1415926
ANA = (RA(I) - RAT(I))*3.1415926/(RBT(I) - RAT(I))
CHIB = (RBT(I) - RAT(I))/3.1415926
ANB = (RB(I) - RAT(I))*3.1415926/(RBT(I) - RAT(I))
ANC = 0.0
TAVE = 0.5*(TP(I) + TS(I))
ETA = VP(I)*TP(I)*RAT(I)*2+VP(I)*TAVE*(RA(I)*2-RAT(I)*2)+
12.0*VP(I)*DT*CHIB*RA(I)*SINF(ANA)+2.0*VP(I)*DT*CHIB*2*
2(COSF(ANA)-1.0)*VS(I)*TAVE*(RBT(I)*2-RB(I)*2)-
32.0*VS(I)*DT*CHIB*RB(I)*SINF(ANB)+2.0*VS(I)*DT*CHIB*2*
4(1.0-COSF(ANA))*VS(I)*TS(I)*(RS*2-RBT(I)*2)
DO 309 J = 1,100
SIG(J) = (VAVE+DV*COSF(ANA))*(TAVE+DT*COSF(ANA))*
1((RZ+0.01*(RB(I)-RA(I)))*2-RZ*2)
ANA = ANA + DA
ANC = ANC + DP
RZ = RZ + 0.01*(RB(I) - RA(I))
ZETA = ZETA + SIG(J)
309 CONTINUE
IF (1.005*HDCT - ETA - ZETA) 311,328,310
310 IF (0.995*HDCT - ETA - ZETA) 328,328,311
311 TS(I) = TS(I) + (HDCT - ETA - ZETA)/(20.0*RS**2)
   GO TO 308
313 RBT(I) = 1.0 + PARAD2*DIST(I)**2
   TP(I) = TP(I - 1)**2/TP(I - 2)
314 IF (RS - RBT(I)) 321,321,315
315 TS(I) = TS(I)
   RAT(I) = 0.0
316 ZETA = 0.0
   DA = (RB(I) - RA(I))*3.1415926/(100.0*RBT(I))
   DB = (RB(I) - RA(I))*3.1415926/(100.0*(RB(I) - RA(I)))
   DT = (TP(I) - TS(I))/2.0
   RZ = RA(I) + 0.005*(RB(I) - RA(I))
   CHIA = (RAT(I) - RA(I))/3.1415926
   ANA = (RA(I) - RAT(I))*3.1415926/(RBT(I) - RAT(I))
   CHIB = (RBT(I) - RAT(I))/3.1415926
   ANB = (RB(I) - RAT(I))*3.1415926/(RBT(I) - RAT(I))
IF (TP(I) - TP(I)) 316,316,320

320 TP(I) = TP(I)
GO TO 302

321 RAT(I) = 0.0
RBT(I) = RS
TS(I) = 2.0*TS(I - 1) - TS(I - 2)
DVP = VP(I) - VBAR
DA = (RB(I) - RA(I))*3.1415926/(100.0*RS)
DB = (RB(I) - RA(I))*3.1415926/(100.0*(RB(I) - RA(I)))
IF (FLAG) 322,322,378

322 STAR = (TP(I-1)-TBAR)*VBAR/((VP(I-1)-VBAR)*TBAR)
TP(I) = TBAR + STAR*DVP*TBAR/VBAR
CONST = (TP(I) - TBAR)*VBAR/((VP(I) - VBAR)*TBAR)
GO TO 323

378 TP(I) = TBAR + CONST*DVP*TBAR/VBAR

323 ZETA = 0.0

365 DT = (TP(I) - TS(I))/2.0
RZ = RA(I) + 0.005*(RB(I) - RA(I))
CHIA = (RAT(I) - RA(I))/3.1415926
ANA = (RA(I) - RAT(I))/3.1415926/(RBT(I) - RAT(I))
CHIB = (RBT(I) - RAT(I))/3.1415926
ANB = (RB(I) - RAT(I))/3.1415926/(RB(I) - RAT(I))
ANC = 0.0
TAVE = 0.5*(TP(I) + TS(I))
ETA = VP(I)*TP(I)*RAT(I)**2 + VP(I)*TAVE*(RA(I)**2 - RAT(I)**2) +
12.0*VP(I)*DT*CHIB*RA(I)*SINF(ANA)+2.0*VP(I)*DT*CHIB**2*
2*(COSF(ANA)-1.0)+VS(I)*TAVE*(RBT(I)**2-RB(I)**2)-
32.0*VS(I)*DT*CHIB*RB(I)*SINF(ANB)+2.0*VS(I)*DT*CHIB**2*
4(1.0-COSF(ANB))+VS(I)*TS(I)*RS**2-RBT(I)**2)
DO 324 J = 1,100
SIG(J) = (VAVE+DV*COSF(ANC))*(TAVE+DT*COSF(ANA))*
((RZ+0.01)*(RB(I)-RA(I))**2-RZ**2)
ANA = ANA + CA
ANC = ANC + CB
RZ = RZ + 0.01*(RB(I) - RA(I))
ZETA = ZETA + SIG(J)
324 CONTINUE
IF (1.005*HDCT - ETA - ZETA) 326, 366, 325
325 IF (0.995*HDCT - ETA - ZETA) 366, 366, 326
326 TS(I) = TS(I) + (HDCT - ETA - ZETA)/(0.5*(VP(I) + VS(I))*RS**2)
GO TO 323
366 FLAG = FLAG + 1.0
328 RB(I + 1) = 2.0*RB(I) - RB(I - 1)
PRINT 133, DIST(I), RA(I), RB(I), VP(I), VS(I), RAT(I), RBT(I),
1TP(I), TS(I), DP(I), PSI(I)
133 FORMAT (11F10.4/)
GO TO 104
135 VP(I) = VP(I) + 0.0001
GO TO 124
137 TAU = VS(I)*(RS**2 - RB(I)**2)
RA(I) = 0.0
RX = 0.0
RY = RB(I)
CHI = RB(I)/2.1415926
DIST(I) = SQRTF((RB(I) - 1.0)/PARAB1)
\[
\begin{align*}
\text{DX}(I) &= \text{DIST}(I) - \text{DIST}(I - 1) \\
138 \text{ DV} &= (\text{VP}(I) - \text{VS}(I))/2.0 \\
\text{VAVE} &= \text{VS}(I) + \text{DV} \\
\text{OMEGA} &= \text{VAVE}*(\text{RY}**2 - \text{RX}**2) - 4.0*\text{DV}^*\text{CHI}**2 \\
\text{IF} (1.005*\text{ALPHA} - \text{OMEGA} - \text{TAU}) &= 140, 142, 139 \\
139 \text{ IF} (0.995*\text{ALPHA} - \text{OMEGA} - \text{TAU}) &= 142, 142, 140 \\
140 \text{ VP}(I) &= \text{VP}(I) + (\text{ALPHA} - \text{OMEGA} - \text{TAU})/(10.0*\text{RS}**2) \\
\text{GO TO} 138 \\
142 \text{ TAU} &= \text{VS}(I)**2*(\text{RS}**2 - \text{RR}(I)**2) \\
\text{SIGMA} &= \text{VAVE}**2*(\text{RY}**2 - \text{RX}**2) - 8.0*\text{VAVE}^*\text{DV}^*\text{CHI}**2 + \\
&1\text{DV}**2*\text{CHI}^*\text{RY}^*3.1415926 - 4.9348022*\text{CHI}**2*\text{DV}**2 \\
\text{DP}(I) &= (\text{BETA} - \text{SIGMA} - \text{TAU})/(0.5*\text{RS}**2) \\
\text{P}(I) &= \text{P}(I) + \text{DP}(I) \\
50 \text{ IF} (\text{VS}(I) - 0.2) &= 51, 196, 196 \\
51 \text{ VEL} &= \text{ABSF} (\text{CELT}A - \text{P}(I)) \\
\text{IF} (\text{DELTA} - \text{P}(I)) &= 52, 53, 53 \\
52 \text{ VSB} &= -\text{SQRTF}(\text{VEL}) \\
\text{GO TO} 54 \\
53 \text{ VSB} &= \text{SQRTF}(\text{VEL})
\end{align*}
\]
54 IF (VS8 - VS(I) + 0.01) 145, 55, 55
55 IF (VS8 - VS(I) - 0.01) 144, 144, 146
196 IF (1.005*(DELTA - P(I)) - VS(I)**2) 145, 144, 143
143 IF (0.995*(DELTA - P(I)) - VS(I)**2) 144, 144, 146
144 RB(I + 1) = RB(I) + 0.01
   GO TO 132
145 VS(I) = VS(I) - 0.001
   GO TO 137
146 VS(I) = VS(I) + 0.009
   GO TO 137
147 RA(I) = 0.0
   RX = 0.0
   RB(I) = RS
   RY = RS
   TAU = 0.0
   CHI = RS/3.1415926
   VP(I) = VP(I - 1) - 2.0
148 DV = (VP(I) - VS(I))/2.0
VAVE = VS(I) + DV

OMEGA = VAVE*(RY**2 - RX**2) - 4.0*DVA*CHI**2

IF (ALPHA - OMEGA + 0.001) 150, 149

149 IF (ALPHA - OMEGA - 0.001) 152, 152, 151

150 VS(I) = VS(I) - 0.00007
GO TO 148

151 VS(I) = VS(I) + 0.0001
GO TO 148

152 SIGMA = VAVE**2*(RY**2 - RX**2) - 8.0*VAVE*DVA*CHI**2 +

1DVA**2*CHI*RY*3.1415926 - 4.9348022*CHI**2*DVA**2

DP(I) = (BETA - SIGMA - TAU)/(0.5*RS**2)
P(I) = P(I) + DP(I)

DX(I) = DP(I)*CP(I - 2)*DX(I - 1)**2/(DX(I - 2)*CP(I - 1)**2)

DIST(I) = DIST(I - 1) + DX(I)

PSI(I) = (SIGMA + TAU)/PI

371 RAT(I) = 0.0

RBT(I) = RS

TS(I) = TS(I - 1)**2/TS(I - 2)

DVP = VP(I) - VBAR
DA = (RB(I)) - RA(I) * 3.1415926 / (100.0 / 0.05
DB = (RB(I)) - RA(I) * 3.1415926 / (100.0 / (RB(I)) - RA(I))

IF (FLAG) 372, 372, 379

372 STAR = (TP(I) - T(BAR) * VBAR / (VP(I) - VBAR)

TP(I) = T(BAR) + STARDVP * T(BAR) / V(BAR)

CONST = (TP(I) - T(BAR) * V(BAR) / (VP(I) - VBAR))

373 ZETA = 0.0

GO TO 373

373 ZETA = 0.0

360 DT = (TP(I) - TS(I)/1.82

RH = (RA(I)) + 0.005 / (RB(I)) - RA(I)

CHIA = (RA(I)) - RAT(I) * 3.1415926

CHIB = (RB(I)) - RAT(I) * 3.1415926

B(CH) = (RB(I)) - RAT(I) * 3.1415926

ANC = 0.0

TAVE = 0.05 * (TP(I) + TS(I))

ETA = VP(I) * (TP(I) - TA(I)) * 0.05 / 2.0 + TAVE * (RA(I)) ** 2 - RAT(I) ** 2 +
12.0*VP(I)*DT*CHIB*RA(I)*SINF(ANA)+2.0*VP(I)*DT*CHIB*RS**2*
2(COSF(ANA)-1.0)+VS(I)*TAVE*(RBT(I)**2-RB(I)**2)-
32.0*VS(I)*DT*CHIB*RB(I)*SINF(ANB)+2.0*VS(I)*DT*CHIB*RS**2*
4(1.0-COSF(ANB))+VS(I)*TS(I)*(RS**2-RBT(I)**2)
DO 374 J = 1,100
SIG(J) = (VAVE*DV*COSF(ANC))*(TAVE+DT*COSF(ANA))*
1((RZ+0.01*(RB(I)-RA(I)))**2-RZ**2)
ANA = ANA + DA
ANC = ANC + DB
RZ = RZ + 0.01*(RB(I) - RA(I))
ZETA = ZETA + SIG(J)
374 CONTINUE
IF (1.005*HDCT - ETA - ZETA) 376,350,375
375 IF (0.995*HDCT - ETA - ZETA) 350,350,376
376 TS(I) = TS(I) + (HDOT - ETA - ZETA)/(0.5*(VP(I) + VS(I))*RS**2)
GO TO 373
350 FLAG = FLAG + 1.0
IF (VP(I) - VS(I)) 400,401,401
400 \( VP(I) = VAVE \)
\( VS(I) = VAVE + 0.000000001 \)
\( TP(I) = TAVE \)
\( TS(I) = TAVE \)
\( PSI(I) = 1.0 \)
401 PRINT 153, DIST(I),RA(I),RB(I),VP(I),VS(I),RAT(I),RBT(I),
\( 1TP(I),TS(I),DP(I),PSI(I) \)
153 FORMAT (11F13.4/)
\( VP(I + 1) = VP(I) - 2.0 \)
\( VS(I + 1) = VS(I) + 0.0001 \)
\( IF (VP(I) - VS(I)) 134,154,154 \)
154 \( I = I + 1 \)
GO TO 147
134 WRITE OUTPUT TAPE 4 , 191
191 FORMAT (1H1)
71 STOP
END
END
APPENDIX II

Appendix II is a graphical presentation of the data obtained by programs EJECTMIX I and EJECTMIX II. Various physical characteristics are plotted against the axial distance. The axial distance is expressed as a multiple of the central jet radius. The various curves shown represent data obtained using different initial central velocity ratios.
Non-dimensional Secondary Velocity Jet Boundary vs. Axial Distance for an Area Ratio of 2.25:1
Axial Velocity Ratios vs. Axial Distance for an Ejector Area Ratio of 2.25:1
Peripheral Velocity Ratio vs. Axial Distance for an Ejector Area Ratio of 2.25:1
Non-dimensional Temperature Jet Boundary vs. Axial Distance for an Ejector Area Ratio of 2.25:1
Axial Temperature vs. Axial Distance for an Ejector Area Ratio of 2.25:1
Non-dimensional Pressure Difference vs. Axial Distance for an Ejector Area Ratio of 2.25:1
Multiple of Final Momentum Rate vs. Axial Distance
for an Ejector Area Ratio of 2.25:1

Axial Distance \((X/r_{c_0})\)
Non-dimensional Velocity Jet Boundary vs. Axial Distance for an Ejector Area Ratio of 9:1
Axial Velocity Ratios vs. Axial Distance for an Ejector Area Ratio of 9:1
Peripheral Velocity Ratio vs. Axial Distance for an Ejector Area Ratio of 9:1
Non-dimensional Temperature Jet Boundary vs. Axial Distance for an Ejector Area Ratio of 9:1
Axial Temperature vs. Axial Distance
for an Ejector Area Ratio of 9:1
Non-dimensional Pressure Difference vs. Axial Distance for an Ejector Area Ratio of 9:1
Multiple of Final Momentum Rate vs. Axial Distance for an Ejector Area Ratio of 9:1
Non-dimensional Velocity Jet Boundary vs. Axial Distance for an Ejector Area Ratio of 100:1
Axial Velocity Ratio vs. Axial Distance for an Ejector Area Ratio of 100:1
Peripheral Velocity Ratio vs. Axial Distance for an Ejector Area Ratio of 100:1
Non-dimensional Temperature Jet Boundary vs. Axial Distance for an Ejector Area Ratio of 100:1
Axial Temperature vs. Axial Distance for an Ejector Area Ratio of 100:1.
Non-dimensional Pressure Difference vs. Axial Distance
for an Ejector Area Ratio of 100:1
Multiple of Final Momentum Rate vs. Axial Distance for an Ejector Area Ratio of 100:1
APPENDIX III

Appendix III contains edited data from which the graphs of Appendix II were drawn. The headings are the same as defined in the section of Symbols and Abbreviations.
# Edited Data for Initial Conditions of Central Velocity Ratio of 1.5 and Peripheral Radius Ratio of 1.5

<table>
<thead>
<tr>
<th>$X/r_a$</th>
<th>RA</th>
<th>RB</th>
<th>VP</th>
<th>VS</th>
<th>RAT</th>
<th>RBT</th>
<th>TP</th>
<th>TS</th>
<th>DP</th>
<th>MOMENTUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>1.0000</td>
<td>1.0003</td>
<td>1.5000</td>
<td>1.0000</td>
<td>1.0000</td>
<td>1.0000</td>
<td>100.0000</td>
<td>.0000</td>
<td>.0000</td>
<td>1.0413</td>
</tr>
<tr>
<td>3.9</td>
<td>.9000</td>
<td>1.1075</td>
<td>1.4987</td>
<td>.9980</td>
<td>.8596</td>
<td>1.1398</td>
<td>100.0000</td>
<td>.0000</td>
<td>.0089</td>
<td>1.0384</td>
</tr>
<tr>
<td>5.6</td>
<td>.8000</td>
<td>1.2222</td>
<td>1.4950</td>
<td>.9925</td>
<td>.6866</td>
<td>1.2888</td>
<td>100.0000</td>
<td>.0000</td>
<td>.0199</td>
<td>1.0347</td>
</tr>
<tr>
<td>6.9</td>
<td>.7000</td>
<td>1.3333</td>
<td>1.4905</td>
<td>.9857</td>
<td>.4243</td>
<td>1.4378</td>
<td>100.0000</td>
<td>.0000</td>
<td>.0311</td>
<td>1.0309</td>
</tr>
<tr>
<td>8.0</td>
<td>.6000</td>
<td>1.4514</td>
<td>1.4852</td>
<td>.9776</td>
<td>.2622</td>
<td>1.5000</td>
<td>100.0000</td>
<td>3.1283</td>
<td>.0427</td>
<td>1.0270</td>
</tr>
<tr>
<td>9.1</td>
<td>.5000</td>
<td>1.5000</td>
<td>1.4837</td>
<td>.9938</td>
<td>1.1621</td>
<td>1.5000</td>
<td>100.0000</td>
<td>3.3169</td>
<td>.0593</td>
<td>1.0215</td>
</tr>
<tr>
<td>10.2</td>
<td>.4000</td>
<td>1.5003</td>
<td>1.4789</td>
<td>1.0306</td>
<td>1.0021</td>
<td>1.5000</td>
<td>100.0000</td>
<td>4.6390</td>
<td>.0738</td>
<td>1.0166</td>
</tr>
<tr>
<td>11.3</td>
<td>.3000</td>
<td>1.5003</td>
<td>1.4750</td>
<td>1.0597</td>
<td>0.619</td>
<td>1.5000</td>
<td>100.0000</td>
<td>5.8913</td>
<td>.0849</td>
<td>1.0129</td>
</tr>
<tr>
<td>15.0</td>
<td>.2000</td>
<td>1.5003</td>
<td>1.4721</td>
<td>1.0830</td>
<td>0.0000</td>
<td>1.5000</td>
<td>99.4874</td>
<td>7.1436</td>
<td>.0933</td>
<td>1.0101</td>
</tr>
<tr>
<td>18.5</td>
<td>.1000</td>
<td>1.5003</td>
<td>1.4700</td>
<td>1.1019</td>
<td>0.0000</td>
<td>1.5000</td>
<td>99.1098</td>
<td>7.2033</td>
<td>.0998</td>
<td>1.0079</td>
</tr>
<tr>
<td>22.5</td>
<td>.0000</td>
<td>1.5003</td>
<td>1.3700</td>
<td>1.1591</td>
<td>0.0000</td>
<td>1.5000</td>
<td>81.1250</td>
<td>25.4019</td>
<td>1.1819</td>
<td>1.0018</td>
</tr>
<tr>
<td>26.1</td>
<td>.0000</td>
<td>1.5003</td>
<td>1.2700</td>
<td>1.2015</td>
<td>0.0000</td>
<td>1.5000</td>
<td>63.1402</td>
<td>45.0112</td>
<td>.1245</td>
<td>.9996</td>
</tr>
<tr>
<td>30.0</td>
<td>.0000</td>
<td>1.5003</td>
<td>1.1700</td>
<td>1.2437</td>
<td>0.0000</td>
<td>1.5000</td>
<td>45.1555</td>
<td>63.5511</td>
<td>1.247</td>
<td>.9996</td>
</tr>
</tbody>
</table>
## Edited Data for Initial Conditions of Central Velocity Ratio of 3.0 and Peripheral Radius Ratio of 1.5

<table>
<thead>
<tr>
<th>$x/r_a$</th>
<th>RA</th>
<th>RB</th>
<th>VP</th>
<th>VS</th>
<th>RAT</th>
<th>RBT</th>
<th>TP</th>
<th>TS</th>
<th>DP</th>
<th>MOMENTUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>1.0000</td>
<td>1.0000</td>
<td>3.0000</td>
<td>1.0000</td>
<td>1.0000</td>
<td>1.0000</td>
<td>1.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>1.2768</td>
</tr>
<tr>
<td>4.6</td>
<td>0.9000</td>
<td>1.1463</td>
<td>2.9793</td>
<td>0.9361</td>
<td>0.8470</td>
<td>1.1902</td>
<td>1.0000</td>
<td>0.0000</td>
<td>0.1278</td>
<td>1.2589</td>
</tr>
<tr>
<td>6.5</td>
<td>0.8000</td>
<td>1.2953</td>
<td>2.9545</td>
<td>0.8537</td>
<td>0.6785</td>
<td>1.3839</td>
<td>1.0000</td>
<td>0.0000</td>
<td>0.2747</td>
<td>1.2383</td>
</tr>
<tr>
<td>8.1</td>
<td>0.7000</td>
<td>1.4505</td>
<td>2.9242</td>
<td>0.7423</td>
<td>0.5435</td>
<td>1.5000</td>
<td>1.0000</td>
<td>10.9593</td>
<td>0.4516</td>
<td>1.2135</td>
</tr>
<tr>
<td>9.7</td>
<td>0.6000</td>
<td>1.5000</td>
<td>2.8625</td>
<td>0.8866</td>
<td>0.4354</td>
<td>1.5000</td>
<td>1.0000</td>
<td>10.9593</td>
<td>0.8466</td>
<td>1.1502</td>
</tr>
<tr>
<td>10.8</td>
<td>0.5000</td>
<td>1.5000</td>
<td>2.8056</td>
<td>0.8989</td>
<td>0.3487</td>
<td>1.5000</td>
<td>1.0000</td>
<td>26.2395</td>
<td>1.1676</td>
<td>1.1132</td>
</tr>
<tr>
<td>12.8</td>
<td>0.4000</td>
<td>1.5000</td>
<td>2.7685</td>
<td>0.2338</td>
<td>0.2794</td>
<td>1.5000</td>
<td>1.0000</td>
<td>26.2395</td>
<td>1.1676</td>
<td>1.1132</td>
</tr>
<tr>
<td>14.3</td>
<td>0.3000</td>
<td>1.5000</td>
<td>2.7426</td>
<td>0.3417</td>
<td>0.2238</td>
<td>1.5000</td>
<td>1.0000</td>
<td>32.7374</td>
<td>1.5154</td>
<td>1.0645</td>
</tr>
<tr>
<td>15.8</td>
<td>0.2000</td>
<td>1.5000</td>
<td>2.7236</td>
<td>0.4255</td>
<td>0.2238</td>
<td>1.5000</td>
<td>1.0000</td>
<td>32.7374</td>
<td>1.5154</td>
<td>1.0645</td>
</tr>
<tr>
<td>17.4</td>
<td>0.1000</td>
<td>1.5000</td>
<td>2.7092</td>
<td>0.4921</td>
<td>0.0000</td>
<td>1.5000</td>
<td>1.0000</td>
<td>98.3493</td>
<td>38.8691</td>
<td>1.1063</td>
</tr>
<tr>
<td>19.0</td>
<td>0.0000</td>
<td>1.5000</td>
<td>2.6921</td>
<td>0.9403</td>
<td>0.0000</td>
<td>1.5000</td>
<td>1.0000</td>
<td>98.3493</td>
<td>38.8691</td>
<td>1.1063</td>
</tr>
<tr>
<td>20.5</td>
<td>0.0000</td>
<td>1.5000</td>
<td>2.5092</td>
<td>1.6258</td>
<td>0.0000</td>
<td>1.5000</td>
<td>1.0000</td>
<td>98.3493</td>
<td>38.8691</td>
<td>1.1063</td>
</tr>
<tr>
<td>22.0</td>
<td>0.0000</td>
<td>1.5000</td>
<td>2.4092</td>
<td>1.6681</td>
<td>0.0000</td>
<td>1.5000</td>
<td>1.0000</td>
<td>88.5139</td>
<td>49.6494</td>
<td>1.8863</td>
</tr>
<tr>
<td>23.5</td>
<td>0.0000</td>
<td>1.5000</td>
<td>2.3092</td>
<td>1.7104</td>
<td>0.0000</td>
<td>1.5000</td>
<td>1.0000</td>
<td>88.5139</td>
<td>49.6494</td>
<td>1.8863</td>
</tr>
<tr>
<td>24.9</td>
<td>0.0000</td>
<td>1.5000</td>
<td>2.2092</td>
<td>1.7528</td>
<td>0.0000</td>
<td>1.5000</td>
<td>1.0000</td>
<td>81.6236</td>
<td>58.1286</td>
<td>1.9432</td>
</tr>
<tr>
<td>26.2</td>
<td>0.0000</td>
<td>1.5000</td>
<td>2.1092</td>
<td>1.7951</td>
<td>0.0000</td>
<td>1.5000</td>
<td>1.0000</td>
<td>81.6236</td>
<td>58.1286</td>
<td>1.9432</td>
</tr>
<tr>
<td>27.5</td>
<td>0.0000</td>
<td>1.5000</td>
<td>2.0092</td>
<td>1.8374</td>
<td>0.0000</td>
<td>1.5000</td>
<td>1.0000</td>
<td>74.7334</td>
<td>65.1401</td>
<td>1.9735</td>
</tr>
<tr>
<td>28.7</td>
<td>0.0000</td>
<td>1.5000</td>
<td>1.9092</td>
<td>1.8797</td>
<td>0.0000</td>
<td>1.5000</td>
<td>1.0000</td>
<td>71.2882</td>
<td>68.9570</td>
<td>1.9735</td>
</tr>
<tr>
<td>30.0</td>
<td>0.0000</td>
<td>1.5000</td>
<td>1.8092</td>
<td>1.9220</td>
<td>0.0000</td>
<td>1.5000</td>
<td>1.0000</td>
<td>67.8431</td>
<td>72.5203</td>
<td>1.9765</td>
</tr>
</tbody>
</table>
## Edited Data for Initial Conditions of
Central Velocity Ratio of 10.0 and Peripheral Radius Ratio of 1.5

<table>
<thead>
<tr>
<th>X/r_a</th>
<th>RA</th>
<th>RB</th>
<th>VP</th>
<th>VS</th>
<th>RAT</th>
<th>RBT</th>
<th>TP</th>
<th>TS</th>
<th>DP</th>
<th>MOMENTUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>1.0000</td>
<td>1.0000</td>
<td>10.0000</td>
<td>1.0000</td>
<td>1.0000</td>
<td>1CC.000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>1.8000</td>
<td></td>
</tr>
<tr>
<td>5.3</td>
<td>0.9000</td>
<td>1.1560</td>
<td>9.9693</td>
<td>0.6213</td>
<td>0.8566</td>
<td>1.2028</td>
<td>1CC.000</td>
<td>0.0000</td>
<td>1.0681</td>
<td>1.7786</td>
</tr>
<tr>
<td>7.7</td>
<td>0.8000</td>
<td>1.3350</td>
<td>9.9487</td>
<td>-0.1512</td>
<td>0.7106</td>
<td>1.4355</td>
<td>1CC.000</td>
<td>0.0000</td>
<td>1.4735</td>
<td>1.7705</td>
</tr>
<tr>
<td>10.2</td>
<td>0.7000</td>
<td>1.5000</td>
<td>9.4931</td>
<td>-0.6303</td>
<td>0.5895</td>
<td>1.5000</td>
<td>1CC.000</td>
<td>42.3383</td>
<td>10.3283</td>
<td>1.5934</td>
</tr>
<tr>
<td>12.7</td>
<td>0.6000</td>
<td>1.5000</td>
<td>8.7561</td>
<td>1.0354</td>
<td>0.4890</td>
<td>1.5000</td>
<td>1CC.000</td>
<td>60.1028</td>
<td>23.7104</td>
<td>1.3258</td>
</tr>
<tr>
<td>15.1</td>
<td>0.5000</td>
<td>1.5000</td>
<td>8.4268</td>
<td>1.9226</td>
<td>0.4056</td>
<td>1.5000</td>
<td>1CC.000</td>
<td>70.7816</td>
<td>29.3393</td>
<td>1.2132</td>
</tr>
<tr>
<td>17.6</td>
<td>0.4000</td>
<td>1.5000</td>
<td>8.2319</td>
<td>2.5090</td>
<td>0.3365</td>
<td>1.5000</td>
<td>1CC.000</td>
<td>73.1986</td>
<td>32.5725</td>
<td>1.1485</td>
</tr>
<tr>
<td>20.1</td>
<td>0.3000</td>
<td>1.5000</td>
<td>8.1018</td>
<td>2.9326</td>
<td>0.0000</td>
<td>1.5000</td>
<td>99.5527</td>
<td>76.1276</td>
<td>34.6869</td>
<td>1.1063</td>
</tr>
<tr>
<td>22.6</td>
<td>0.2000</td>
<td>1.5000</td>
<td>8.0095</td>
<td>3.2540</td>
<td>0.0000</td>
<td>1.5000</td>
<td>99.2354</td>
<td>77.5881</td>
<td>36.1660</td>
<td>1.0767</td>
</tr>
<tr>
<td>25.1</td>
<td>0.1000</td>
<td>1.5000</td>
<td>7.9415</td>
<td>3.5053</td>
<td>0.0000</td>
<td>1.5000</td>
<td>99.0016</td>
<td>77.5988</td>
<td>37.2453</td>
<td>1.0551</td>
</tr>
<tr>
<td>27.6</td>
<td>0.0000</td>
<td>1.5000</td>
<td>5.9415</td>
<td>6.0009</td>
<td>0.0000</td>
<td>1.5000</td>
<td>52.1258</td>
<td>82.5090</td>
<td>39.7071</td>
<td>1.0059</td>
</tr>
<tr>
<td>30.0</td>
<td>0.0000</td>
<td>1.5000</td>
<td>4.6944</td>
<td>4.6944</td>
<td>0.0000</td>
<td>1.5000</td>
<td>87.8288</td>
<td>87.8288</td>
<td>39.6281</td>
<td>1.0000</td>
</tr>
</tbody>
</table>
## Edited Data for Initial Conditions of
Central Velocity Ratio of 50.0 and Peripheral Radius Ratio of 1.5

<table>
<thead>
<tr>
<th>$X/r_a$</th>
<th>RA</th>
<th>RB</th>
<th>VP</th>
<th>VS</th>
<th>RAT</th>
<th>RBT</th>
<th>TP</th>
<th>TS</th>
<th>DP</th>
<th>MOMENTUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>1.000</td>
<td>1.000</td>
<td>50.000</td>
<td>1.000</td>
<td>1.000</td>
<td>100.000</td>
<td>0.000</td>
<td>0.000</td>
<td>2.1427</td>
<td></td>
</tr>
<tr>
<td>6.7</td>
<td>0.900</td>
<td>1.161</td>
<td>49.9689</td>
<td>-1.4517</td>
<td>0.8618</td>
<td>1.2093</td>
<td>100.000</td>
<td>0.000</td>
<td>15.0757</td>
<td>2.1251</td>
</tr>
<tr>
<td>9.8</td>
<td>0.800</td>
<td>1.340</td>
<td>49.6806</td>
<td>-5.5528</td>
<td>0.7583</td>
<td>1.4420</td>
<td>100.000</td>
<td>0.000</td>
<td>43.0149</td>
<td>2.1012</td>
</tr>
<tr>
<td>12.8</td>
<td>0.700</td>
<td>1.500</td>
<td>46.7428</td>
<td>-7.1640</td>
<td>0.6673</td>
<td>1.5000</td>
<td>100.000</td>
<td>72.2358</td>
<td>336.7149</td>
<td>1.8182</td>
</tr>
<tr>
<td>15.8</td>
<td>0.600</td>
<td>1.500</td>
<td>41.9593</td>
<td>2.5901</td>
<td>0.5871</td>
<td>1.5000</td>
<td>100.000</td>
<td>85.4229</td>
<td>756.8047</td>
<td>1.4133</td>
</tr>
<tr>
<td>19.0</td>
<td>0.500</td>
<td>1.500</td>
<td>40.0679</td>
<td>7.2986</td>
<td>0.5166</td>
<td>1.5000</td>
<td>100.000</td>
<td>94.1778</td>
<td>910.3820</td>
<td>1.2653</td>
</tr>
<tr>
<td>22.0</td>
<td>0.400</td>
<td>1.500</td>
<td>38.9865</td>
<td>10.3271</td>
<td>0.4546</td>
<td>1.5000</td>
<td>100.000</td>
<td>94.9378</td>
<td>995.0087</td>
<td>1.1838</td>
</tr>
<tr>
<td>22.8</td>
<td>0.300</td>
<td>1.500</td>
<td>38.2799</td>
<td>12.4847</td>
<td>0.0000</td>
<td>1.5000</td>
<td>99.8937</td>
<td>95.1514</td>
<td>1049.0897</td>
<td>1.1316</td>
</tr>
<tr>
<td>23.5</td>
<td>0.200</td>
<td>1.500</td>
<td>37.7825</td>
<td>14.1063</td>
<td>0.0000</td>
<td>1.5000</td>
<td>99.8188</td>
<td>94.9089</td>
<td>1086.6187</td>
<td>1.0955</td>
</tr>
<tr>
<td>24.5</td>
<td>0.100</td>
<td>1.500</td>
<td>37.4198</td>
<td>15.3703</td>
<td>0.0000</td>
<td>1.5000</td>
<td>99.7642</td>
<td>94.6664</td>
<td>1113.6232</td>
<td>1.0694</td>
</tr>
<tr>
<td>25.0</td>
<td>0.000</td>
<td>1.500</td>
<td>35.4198</td>
<td>17.4271</td>
<td>0.0000</td>
<td>1.5000</td>
<td>99.4633</td>
<td>93.0335</td>
<td>1131.3694</td>
<td>1.0523</td>
</tr>
<tr>
<td>25.8</td>
<td>0.000</td>
<td>1.500</td>
<td>33.4198</td>
<td>18.2735</td>
<td>0.0000</td>
<td>1.5000</td>
<td>99.1623</td>
<td>92.0432</td>
<td>1147.2041</td>
<td>1.0371</td>
</tr>
<tr>
<td>26.5</td>
<td>0.000</td>
<td>1.500</td>
<td>31.4198</td>
<td>19.1199</td>
<td>0.0000</td>
<td>1.5000</td>
<td>98.8614</td>
<td>92.6695</td>
<td>1160.3187</td>
<td>1.0244</td>
</tr>
<tr>
<td>27.3</td>
<td>0.000</td>
<td>1.500</td>
<td>29.4198</td>
<td>19.9663</td>
<td>0.0000</td>
<td>1.5000</td>
<td>98.5604</td>
<td>93.3000</td>
<td>1170.7131</td>
<td>1.0144</td>
</tr>
<tr>
<td>27.9</td>
<td>0.000</td>
<td>1.500</td>
<td>27.4198</td>
<td>20.8127</td>
<td>0.0000</td>
<td>1.5000</td>
<td>98.2595</td>
<td>93.9347</td>
<td>1178.3873</td>
<td>1.0076</td>
</tr>
<tr>
<td>28.5</td>
<td>0.000</td>
<td>1.500</td>
<td>25.4198</td>
<td>21.6591</td>
<td>0.0000</td>
<td>1.5000</td>
<td>97.9585</td>
<td>94.5739</td>
<td>1183.3412</td>
<td>1.0023</td>
</tr>
<tr>
<td>29.3</td>
<td>0.000</td>
<td>1.500</td>
<td>23.4198</td>
<td>22.5055</td>
<td>0.0000</td>
<td>1.5000</td>
<td>97.6576</td>
<td>95.2173</td>
<td>1185.5750</td>
<td>1.0001</td>
</tr>
<tr>
<td>30.0</td>
<td>0.000</td>
<td>1.500</td>
<td>22.3858</td>
<td>22.3858</td>
<td>0.0000</td>
<td>1.5000</td>
<td>96.6109</td>
<td>96.6109</td>
<td>1185.0886</td>
<td>1.0000</td>
</tr>
</tbody>
</table>
### Edited Data for Initial Conditions of Central Velocity Ratio of 1.5 and Peripheral Radius Ratio of 3.0

<table>
<thead>
<tr>
<th>(X/r_{e_0})</th>
<th>RA</th>
<th>RB</th>
<th>VP</th>
<th>VS</th>
<th>RAT</th>
<th>RBT</th>
<th>TP</th>
<th>TS</th>
<th>DP</th>
<th>MOMENTUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>1.000</td>
<td>1.000</td>
<td>1.500</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>100.000</td>
<td>.0000</td>
<td>.0000</td>
<td>1.0222</td>
</tr>
<tr>
<td>11.7</td>
<td>.9000</td>
<td>1.0813</td>
<td>1.5007</td>
<td>1.001</td>
<td>.8997</td>
<td>1.1063</td>
<td>100.000</td>
<td>.0000</td>
<td>.0028</td>
<td>1.0209</td>
</tr>
<tr>
<td>18.1</td>
<td>.8000</td>
<td>1.1943</td>
<td>1.5000</td>
<td>1.0000</td>
<td>.7238</td>
<td>1.2525</td>
<td>100.000</td>
<td>.0000</td>
<td>.0049</td>
<td>1.0199</td>
</tr>
<tr>
<td>22.6</td>
<td>.7000</td>
<td>1.3063</td>
<td>1.4991</td>
<td>.9987</td>
<td>.4992</td>
<td>1.3983</td>
<td>100.000</td>
<td>.0000</td>
<td>.0069</td>
<td>1.0191</td>
</tr>
<tr>
<td>26.4</td>
<td>.6000</td>
<td>1.4193</td>
<td>1.4981</td>
<td>.9971</td>
<td>.0647</td>
<td>1.5450</td>
<td>100.000</td>
<td>.0000</td>
<td>.0087</td>
<td>1.0183</td>
</tr>
<tr>
<td>29.8</td>
<td>.5000</td>
<td>1.5313</td>
<td>1.4969</td>
<td>.9953</td>
<td>.0000</td>
<td>1.6913</td>
<td>85.8086</td>
<td>.0000</td>
<td>.0104</td>
<td>1.0175</td>
</tr>
<tr>
<td>32.8</td>
<td>.4000</td>
<td>1.6443</td>
<td>1.4955</td>
<td>.9933</td>
<td>.0000</td>
<td>1.8375</td>
<td>73.7677</td>
<td>.0000</td>
<td>.0119</td>
<td>1.0168</td>
</tr>
<tr>
<td>35.4</td>
<td>.3000</td>
<td>1.7563</td>
<td>1.4940</td>
<td>.9909</td>
<td>.0000</td>
<td>1.9833</td>
<td>64.1954</td>
<td>.0000</td>
<td>.0132</td>
<td>1.0162</td>
</tr>
<tr>
<td>37.7</td>
<td>.2000</td>
<td>1.8491</td>
<td>1.4930</td>
<td>.9895</td>
<td>.0000</td>
<td>2.1038</td>
<td>57.1810</td>
<td>.0000</td>
<td>.0159</td>
<td>1.0150</td>
</tr>
<tr>
<td>39.6</td>
<td>.1000</td>
<td>1.9343</td>
<td>1.4924</td>
<td>.9886</td>
<td>.0000</td>
<td>2.2145</td>
<td>52.1133</td>
<td>.0000</td>
<td>.0177</td>
<td>1.0142</td>
</tr>
<tr>
<td>43.0</td>
<td>.0000</td>
<td>2.1047</td>
<td>1.4467</td>
<td>.9886</td>
<td>.0000</td>
<td>2.4360</td>
<td>43.9363</td>
<td>.0000</td>
<td>.0224</td>
<td>1.0121</td>
</tr>
<tr>
<td>46.1</td>
<td>.0000</td>
<td>2.2751</td>
<td>1.3816</td>
<td>.9882</td>
<td>.0000</td>
<td>2.6576</td>
<td>37.6743</td>
<td>.0000</td>
<td>.0282</td>
<td>1.0095</td>
</tr>
<tr>
<td>49.2</td>
<td>.0000</td>
<td>2.4455</td>
<td>1.3354</td>
<td>.9865</td>
<td>.0000</td>
<td>2.8791</td>
<td>32.5584</td>
<td>.0000</td>
<td>.0315</td>
<td>1.0080</td>
</tr>
<tr>
<td>52.0</td>
<td>.0000</td>
<td>2.6159</td>
<td>1.2966</td>
<td>.9850</td>
<td>.0000</td>
<td>3.0000</td>
<td>29.3300</td>
<td>.9996</td>
<td>.0343</td>
<td>1.0068</td>
</tr>
<tr>
<td>53.2</td>
<td>.0000</td>
<td>2.7011</td>
<td>1.2792</td>
<td>.9844</td>
<td>.0000</td>
<td>3.0000</td>
<td>28.3535</td>
<td>2.0774</td>
<td>.0356</td>
<td>1.0062</td>
</tr>
<tr>
<td>54.6</td>
<td>.0000</td>
<td>2.7863</td>
<td>1.2632</td>
<td>.9839</td>
<td>.0000</td>
<td>3.0000</td>
<td>27.4540</td>
<td>3.1552</td>
<td>.0368</td>
<td>1.0056</td>
</tr>
<tr>
<td>55.9</td>
<td>.0000</td>
<td>2.8715</td>
<td>1.2484</td>
<td>.9832</td>
<td>.0000</td>
<td>3.0000</td>
<td>26.6255</td>
<td>4.1525</td>
<td>.0380</td>
<td>1.0051</td>
</tr>
<tr>
<td>57.2</td>
<td>.0000</td>
<td>2.9567</td>
<td>1.2348</td>
<td>.9826</td>
<td>.0000</td>
<td>3.0000</td>
<td>25.8623</td>
<td>5.0281</td>
<td>.0391</td>
<td>1.0046</td>
</tr>
<tr>
<td>58.5</td>
<td>.0000</td>
<td>3.0000</td>
<td>1.1348</td>
<td>1.0219</td>
<td>.0000</td>
<td>3.0000</td>
<td>20.2438</td>
<td>10.7704</td>
<td>.0475</td>
<td>1.0008</td>
</tr>
<tr>
<td>60.0</td>
<td>.0000</td>
<td>3.0000</td>
<td>1.0349</td>
<td>1.0642</td>
<td>.0000</td>
<td>3.0000</td>
<td>14.6254</td>
<td>16.7642</td>
<td>.0497</td>
<td>0.9999</td>
</tr>
<tr>
<td>$X/r_{ag}$</td>
<td>RA</td>
<td>RB</td>
<td>VP</td>
<td>VS</td>
<td>RAT</td>
<td>RBT</td>
<td>TP</td>
<td>TS</td>
<td>DP</td>
<td>M\text{EMENTUM}</td>
</tr>
<tr>
<td>-----------</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>----------------</td>
</tr>
<tr>
<td>0.0</td>
<td>1.000</td>
<td>1.000</td>
<td>3.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.2645</td>
</tr>
<tr>
<td>0.122</td>
<td>0.900</td>
<td>1.134</td>
<td>2.957</td>
<td>0.991</td>
<td>0.947</td>
<td>0.991</td>
<td>0.8726</td>
<td>1.1534</td>
<td>1.000</td>
<td>0.0224</td>
</tr>
<tr>
<td>0.172</td>
<td>0.800</td>
<td>1.268</td>
<td>2.993</td>
<td>0.980</td>
<td>0.938</td>
<td>0.980</td>
<td>0.7381</td>
<td>1.3070</td>
<td>1.000</td>
<td>0.0429</td>
</tr>
<tr>
<td>0.212</td>
<td>0.700</td>
<td>1.403</td>
<td>2.987</td>
<td>0.968</td>
<td>0.956</td>
<td>0.968</td>
<td>0.5651</td>
<td>1.4606</td>
<td>1.000</td>
<td>0.0612</td>
</tr>
<tr>
<td>0.243</td>
<td>0.600</td>
<td>1.533</td>
<td>2.957</td>
<td>0.956</td>
<td>0.936</td>
<td>0.956</td>
<td>0.3659</td>
<td>1.6691</td>
<td>1.000</td>
<td>0.0869</td>
</tr>
<tr>
<td>0.270</td>
<td>0.500</td>
<td>1.654</td>
<td>2.982</td>
<td>0.945</td>
<td>0.922</td>
<td>0.945</td>
<td>0.1222</td>
<td>1.7482</td>
<td>1.000</td>
<td>1.023</td>
</tr>
<tr>
<td>0.286</td>
<td>0.400</td>
<td>1.772</td>
<td>2.978</td>
<td>0.937</td>
<td>0.900</td>
<td>0.937</td>
<td>0.8837</td>
<td>1.8831</td>
<td>93.7517</td>
<td>1.000</td>
</tr>
<tr>
<td>0.314</td>
<td>0.300</td>
<td>1.887</td>
<td>2.970</td>
<td>0.922</td>
<td>0.883</td>
<td>0.922</td>
<td>0.800</td>
<td>2.0137</td>
<td>85.0029</td>
<td>1.000</td>
</tr>
<tr>
<td>0.332</td>
<td>0.200</td>
<td>1.997</td>
<td>2.971</td>
<td>0.910</td>
<td>0.800</td>
<td>0.910</td>
<td>0.000</td>
<td>2.1403</td>
<td>77.7731</td>
<td>1.000</td>
</tr>
<tr>
<td>0.350</td>
<td>0.100</td>
<td>2.105</td>
<td>2.968</td>
<td>0.899</td>
<td>0.000</td>
<td>0.899</td>
<td>0.000</td>
<td>2.2620</td>
<td>71.1400</td>
<td>1.000</td>
</tr>
<tr>
<td>0.366</td>
<td>0.000</td>
<td>2.212</td>
<td>2.952</td>
<td>0.883</td>
<td>0.000</td>
<td>0.883</td>
<td>0.000</td>
<td>2.3854</td>
<td>66.0369</td>
<td>1.000</td>
</tr>
<tr>
<td>0.398</td>
<td>0.000</td>
<td>2.426</td>
<td>2.728</td>
<td>0.858</td>
<td>0.000</td>
<td>0.858</td>
<td>0.000</td>
<td>2.6304</td>
<td>57.8661</td>
<td>1.000</td>
</tr>
<tr>
<td>0.427</td>
<td>0.000</td>
<td>2.641</td>
<td>2.540</td>
<td>0.827</td>
<td>0.000</td>
<td>0.827</td>
<td>0.000</td>
<td>2.8754</td>
<td>51.4610</td>
<td>1.000</td>
</tr>
<tr>
<td>0.454</td>
<td>0.000</td>
<td>2.855</td>
<td>2.350</td>
<td>0.795</td>
<td>0.000</td>
<td>0.795</td>
<td>0.000</td>
<td>3.1100</td>
<td>47.3503</td>
<td>1.000</td>
</tr>
<tr>
<td>0.481</td>
<td>0.000</td>
<td>3.000</td>
<td>2.208</td>
<td>0.804</td>
<td>0.000</td>
<td>0.804</td>
<td>0.000</td>
<td>3.3333</td>
<td>44.3797</td>
<td>1.000</td>
</tr>
<tr>
<td>0.508</td>
<td>0.000</td>
<td>3.000</td>
<td>2.058</td>
<td>0.889</td>
<td>0.000</td>
<td>0.889</td>
<td>0.000</td>
<td>3.5555</td>
<td>40.5114</td>
<td>1.000</td>
</tr>
<tr>
<td>0.536</td>
<td>0.000</td>
<td>3.000</td>
<td>1.908</td>
<td>0.973</td>
<td>0.000</td>
<td>0.973</td>
<td>0.000</td>
<td>3.7777</td>
<td>37.4430</td>
<td>1.000</td>
</tr>
<tr>
<td>0.561</td>
<td>0.000</td>
<td>3.000</td>
<td>1.768</td>
<td>1.058</td>
<td>0.000</td>
<td>1.058</td>
<td>0.000</td>
<td>3.9999</td>
<td>33.9747</td>
<td>1.000</td>
</tr>
<tr>
<td>0.582</td>
<td>0.000</td>
<td>3.000</td>
<td>1.587</td>
<td>1.143</td>
<td>0.000</td>
<td>1.143</td>
<td>0.000</td>
<td>4.2222</td>
<td>30.5064</td>
<td>1.000</td>
</tr>
<tr>
<td>0.600</td>
<td>0.000</td>
<td>3.000</td>
<td>1.208</td>
<td>1.227</td>
<td>0.000</td>
<td>1.227</td>
<td>0.000</td>
<td>4.4444</td>
<td>27.0381</td>
<td>1.000</td>
</tr>
</tbody>
</table>
Edited Data for Initial Conditions of Central Velocity Ratio of 10.0 and Peripheral Radius Ratio of 3.0

<table>
<thead>
<tr>
<th>$X/r_{a_e}$</th>
<th>RA</th>
<th>RE</th>
<th>VP</th>
<th>VS</th>
<th>RAT</th>
<th>RET</th>
<th>TP</th>
<th>TS</th>
<th>DP</th>
<th>MEMENTUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>10.8</td>
<td>0.900</td>
<td>1.124</td>
<td>0.958</td>
<td>0.979</td>
<td>0.953</td>
<td>1.1612</td>
<td>0.953</td>
<td>0.953</td>
<td>0.953</td>
<td>0.953</td>
</tr>
<tr>
<td>16.1</td>
<td>0.800</td>
<td>1.276</td>
<td>0.991</td>
<td>0.911</td>
<td>0.756</td>
<td>1.3588</td>
<td>0.756</td>
<td>0.756</td>
<td>0.756</td>
<td>0.756</td>
</tr>
<tr>
<td>20.1</td>
<td>0.700</td>
<td>1.428</td>
<td>0.984</td>
<td>0.832</td>
<td>0.6018</td>
<td>1.5564</td>
<td>0.6018</td>
<td>0.6018</td>
<td>0.6018</td>
<td>0.6018</td>
</tr>
<tr>
<td>23.5</td>
<td>0.600</td>
<td>1.580</td>
<td>0.9775</td>
<td>0.7425</td>
<td>0.4267</td>
<td>1.7540</td>
<td>0.4267</td>
<td>0.4267</td>
<td>0.4267</td>
<td>0.4267</td>
</tr>
<tr>
<td>26.3</td>
<td>0.500</td>
<td>1.732</td>
<td>0.9707</td>
<td>0.6446</td>
<td>0.2564</td>
<td>1.5516</td>
<td>0.2564</td>
<td>0.2564</td>
<td>0.2564</td>
<td>0.2564</td>
</tr>
<tr>
<td>28.9</td>
<td>0.400</td>
<td>1.884</td>
<td>0.9641</td>
<td>0.5327</td>
<td>0.2062</td>
<td>1.4942</td>
<td>0.2062</td>
<td>0.2062</td>
<td>0.2062</td>
<td>0.2062</td>
</tr>
<tr>
<td>31.3</td>
<td>0.300</td>
<td>2.036</td>
<td>0.9584</td>
<td>0.4109</td>
<td>0.1932</td>
<td>1.42468</td>
<td>0.1932</td>
<td>0.1932</td>
<td>0.1932</td>
<td>0.1932</td>
</tr>
<tr>
<td>32.0</td>
<td>0.200</td>
<td>2.188</td>
<td>0.9537</td>
<td>0.2755</td>
<td>0.1969</td>
<td>1.5444</td>
<td>0.1969</td>
<td>0.1969</td>
<td>0.1969</td>
<td>0.1969</td>
</tr>
<tr>
<td>34.8</td>
<td>0.100</td>
<td>2.340</td>
<td>0.9507</td>
<td>0.1254</td>
<td>0.1904</td>
<td>1.7420</td>
<td>0.1904</td>
<td>0.1904</td>
<td>0.1904</td>
<td>0.1904</td>
</tr>
<tr>
<td>39.0</td>
<td>0.000</td>
<td>2.9480</td>
<td>0.6111</td>
<td>0.0566</td>
<td>0.75421</td>
<td>1.61436</td>
<td>0.75421</td>
<td>0.75421</td>
<td>0.75421</td>
<td>0.75421</td>
</tr>
<tr>
<td>40.0</td>
<td>0.000</td>
<td>3.000</td>
<td>0.8011</td>
<td>0.0540</td>
<td>0.73620</td>
<td>2.27348</td>
<td>0.73620</td>
<td>0.73620</td>
<td>0.73620</td>
<td>0.73620</td>
</tr>
<tr>
<td>40.8</td>
<td>0.000</td>
<td>3.000</td>
<td>7.411</td>
<td>0.0540</td>
<td>0.72734</td>
<td>2.27348</td>
<td>0.72734</td>
<td>0.72734</td>
<td>0.72734</td>
<td>0.72734</td>
</tr>
<tr>
<td>41.5</td>
<td>0.000</td>
<td>3.000</td>
<td>6.8111</td>
<td>0.0362</td>
<td>0.73000</td>
<td>3.00000</td>
<td>0.73000</td>
<td>0.73000</td>
<td>0.73000</td>
<td>0.73000</td>
</tr>
<tr>
<td>43.0</td>
<td>0.000</td>
<td>3.000</td>
<td>6.0111</td>
<td>0.0324</td>
<td>0.73000</td>
<td>3.00000</td>
<td>0.73000</td>
<td>0.73000</td>
<td>0.73000</td>
<td>0.73000</td>
</tr>
<tr>
<td>45.5</td>
<td>0.000</td>
<td>3.000</td>
<td>5.0111</td>
<td>0.0324</td>
<td>0.73000</td>
<td>3.00000</td>
<td>0.73000</td>
<td>0.73000</td>
<td>0.73000</td>
<td>0.73000</td>
</tr>
<tr>
<td>48.5</td>
<td>0.000</td>
<td>3.000</td>
<td>4.0111</td>
<td>0.0324</td>
<td>0.73000</td>
<td>3.00000</td>
<td>0.73000</td>
<td>0.73000</td>
<td>0.73000</td>
<td>0.73000</td>
</tr>
<tr>
<td>51.2</td>
<td>0.000</td>
<td>3.000</td>
<td>3.0111</td>
<td>0.0324</td>
<td>0.73000</td>
<td>3.00000</td>
<td>0.73000</td>
<td>0.73000</td>
<td>0.73000</td>
<td>0.73000</td>
</tr>
<tr>
<td>55.0</td>
<td>0.000</td>
<td>3.000</td>
<td>2.5111</td>
<td>0.17836</td>
<td>0.73000</td>
<td>3.00000</td>
<td>0.73000</td>
<td>0.73000</td>
<td>0.73000</td>
<td>0.73000</td>
</tr>
<tr>
<td>60.0</td>
<td>0.000</td>
<td>3.000</td>
<td>1.9111</td>
<td>2.0375</td>
<td>0.73000</td>
<td>3.00000</td>
<td>0.73000</td>
<td>0.73000</td>
<td>0.73000</td>
<td>0.73000</td>
</tr>
<tr>
<td>$X/r_A$</td>
<td>RA</td>
<td>RE</td>
<td>VP</td>
<td>VS</td>
<td>RAT</td>
<td>RBT</td>
<td>TP</td>
<td>TS</td>
<td>DP</td>
<td>MCmomentum</td>
</tr>
<tr>
<td>-------</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>-----</td>
<td>-----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>------------</td>
</tr>
<tr>
<td>0.0</td>
<td>1.000</td>
<td>1.000</td>
<td>50.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.CC</td>
<td>CCCC</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>9.9</td>
<td>.900</td>
<td>1.133</td>
<td>49.9966</td>
<td>.8147</td>
<td>.9025</td>
<td>1.1729</td>
<td>1.CC</td>
<td>CCCC</td>
<td>1.3962</td>
<td>.6931</td>
</tr>
<tr>
<td>14.8</td>
<td>.800</td>
<td>1.2930</td>
<td>49.9914</td>
<td>.3752</td>
<td>.7643</td>
<td>1.3809</td>
<td>1.CC</td>
<td>CCCC</td>
<td>.CC00</td>
<td>2.7308</td>
</tr>
<tr>
<td>18.3</td>
<td>.700</td>
<td>1.4530</td>
<td>49.9898</td>
<td>-1.313</td>
<td>.6228</td>
<td>1.5889</td>
<td>1.CC</td>
<td>CCCC</td>
<td>.CC00</td>
<td>6.4985</td>
</tr>
<tr>
<td>21.4</td>
<td>.600</td>
<td>1.6130</td>
<td>49.9852</td>
<td>-6.946</td>
<td>.4813</td>
<td>1.7969</td>
<td>1.CC</td>
<td>CCCC</td>
<td>.CC00</td>
<td>6.7445</td>
</tr>
<tr>
<td>24.0</td>
<td>.500</td>
<td>1.7730</td>
<td>49.9724</td>
<td>-1.3275</td>
<td>.2429</td>
<td>2.0049</td>
<td>1.CC</td>
<td>CCCC</td>
<td>.CC00</td>
<td>9.6760</td>
</tr>
<tr>
<td>26.4</td>
<td>.400</td>
<td>1.9330</td>
<td>49.9489</td>
<td>-2.6274</td>
<td>.2154</td>
<td>2.2129</td>
<td>1.CC</td>
<td>CCCC</td>
<td>.CC00</td>
<td>11.9769</td>
</tr>
<tr>
<td>28.5</td>
<td>.300</td>
<td>2.0930</td>
<td>49.9113</td>
<td>-2.8036</td>
<td>.1162</td>
<td>2.4225</td>
<td>1.CC</td>
<td>CCCC</td>
<td>.CC00</td>
<td>12.5551</td>
</tr>
<tr>
<td>30.2</td>
<td>.200</td>
<td>2.2530</td>
<td>49.8625</td>
<td>-3.5685</td>
<td>.0532</td>
<td>2.6081</td>
<td>1.CC</td>
<td>CCCC</td>
<td>.CC00</td>
<td>13.0355</td>
</tr>
<tr>
<td>32.0</td>
<td>.100</td>
<td>2.3730</td>
<td>49.8101</td>
<td>-4.2372</td>
<td>.0158</td>
<td>2.7649</td>
<td>1.CC</td>
<td>CCCC</td>
<td>.CC00</td>
<td>25.0724</td>
</tr>
<tr>
<td>34.7</td>
<td>.000</td>
<td>3.0000</td>
<td>39.9713</td>
<td>-7.7442</td>
<td>.0000</td>
<td>97.0369</td>
<td>47.0827</td>
<td>92.0672</td>
<td>5.6015</td>
<td></td>
</tr>
<tr>
<td>36.3</td>
<td>.000</td>
<td>3.0000</td>
<td>35.0713</td>
<td>-5.6706</td>
<td>.0000</td>
<td>95.4541</td>
<td>55.7697</td>
<td>195.6232</td>
<td>4.3547</td>
<td></td>
</tr>
<tr>
<td>38.5</td>
<td>.000</td>
<td>3.0000</td>
<td>30.0713</td>
<td>-3.5546</td>
<td>.0000</td>
<td>93.8290</td>
<td>63.5551</td>
<td>284.4612</td>
<td>3.2852</td>
<td></td>
</tr>
<tr>
<td>41.0</td>
<td>.000</td>
<td>3.0000</td>
<td>25.9713</td>
<td>-1.8194</td>
<td>.0000</td>
<td>92.6146</td>
<td>68.0910</td>
<td>344.6214</td>
<td>2.5609</td>
<td></td>
</tr>
<tr>
<td>45.0</td>
<td>.000</td>
<td>3.0000</td>
<td>19.9712</td>
<td>.7158</td>
<td>.0000</td>
<td>90.5746</td>
<td>73.6293</td>
<td>412.0559</td>
<td>1.7490</td>
<td></td>
</tr>
<tr>
<td>47.9</td>
<td>.000</td>
<td>3.0000</td>
<td>16.9713</td>
<td>1.9899</td>
<td>.0000</td>
<td>89.6773</td>
<td>76.1109</td>
<td>436.5929</td>
<td>1.4536</td>
<td></td>
</tr>
<tr>
<td>50.4</td>
<td>.000</td>
<td>3.0000</td>
<td>13.9713</td>
<td>3.2589</td>
<td>.0000</td>
<td>88.6383</td>
<td>79.6422</td>
<td>455.0162</td>
<td>1.2319</td>
<td></td>
</tr>
<tr>
<td>53.5</td>
<td>.000</td>
<td>3.0000</td>
<td>10.9713</td>
<td>4.5285</td>
<td>.0000</td>
<td>87.6952</td>
<td>80.8150</td>
<td>467.3661</td>
<td>1.0639</td>
<td></td>
</tr>
<tr>
<td>56.0</td>
<td>.000</td>
<td>3.0000</td>
<td>8.9713</td>
<td>5.3749</td>
<td>.0000</td>
<td>87.0231</td>
<td>82.3272</td>
<td>472.1031</td>
<td>1.0261</td>
<td></td>
</tr>
<tr>
<td>60.0</td>
<td>.000</td>
<td>3.0000</td>
<td>6.4713</td>
<td>6.4329</td>
<td>.0000</td>
<td>86.2156</td>
<td>84.1187</td>
<td>474.2740</td>
<td>1.0CC</td>
<td></td>
</tr>
<tr>
<td>$X/r_a$</td>
<td>RA</td>
<td>VP</td>
<td>VS</td>
<td>RBT</td>
<td>TP</td>
<td>DPT</td>
<td>TS</td>
<td>MOMENTUM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>----------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0025</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.01</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0022</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.02</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0021</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.03</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0019</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.04</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0018</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.05</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0016</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.06</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0014</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.07</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.08</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0011</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.09</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0010</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.10</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0009</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.11</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0008</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.12</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0007</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.13</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0006</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.14</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0005</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.15</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0003</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.16</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0002</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.17</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.18</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.0000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

83
## Edited Data for Initial Conditions of
Central Velocity Ratio of 3.0 and Peripheral Radius Ratio of 10.0

<table>
<thead>
<tr>
<th>$X/r_{Bo}$</th>
<th>RA</th>
<th>RB</th>
<th>VP</th>
<th>VS</th>
<th>RAT</th>
<th>RET</th>
<th>TP</th>
<th>TS</th>
<th>DP</th>
<th>MOMENTUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>1.0000</td>
<td>1.0000</td>
<td>3.0000</td>
<td>1.0000</td>
<td>1.0000</td>
<td>1.0000</td>
<td>100.0000</td>
<td>.0000</td>
<td>.0000</td>
<td>1.0381</td>
</tr>
<tr>
<td>19.6</td>
<td>.9000</td>
<td>1.1000</td>
<td>3.0101</td>
<td>1.0002</td>
<td>.9280</td>
<td>1.1144</td>
<td>100.0000</td>
<td>.0000</td>
<td>.0045</td>
<td>1.0359</td>
</tr>
<tr>
<td>31.0</td>
<td>.8000</td>
<td>1.2211</td>
<td>2.9998</td>
<td>.9994</td>
<td>7.641</td>
<td>1.2874</td>
<td>100.0000</td>
<td>.0000</td>
<td>.0061</td>
<td>1.0351</td>
</tr>
<tr>
<td>39.3</td>
<td>.7000</td>
<td>1.3542</td>
<td>2.9995</td>
<td>.9985</td>
<td>.5669</td>
<td>1.4605</td>
<td>100.0000</td>
<td>.0000</td>
<td>.0075</td>
<td>1.0345</td>
</tr>
<tr>
<td>52.0</td>
<td>.5000</td>
<td>1.6204</td>
<td>2.9988</td>
<td>.9963</td>
<td>.0000</td>
<td>1.8065</td>
<td>98.3064</td>
<td>.0000</td>
<td>.0093</td>
<td>1.0336</td>
</tr>
<tr>
<td>62.1</td>
<td>.3000</td>
<td>1.8866</td>
<td>2.9979</td>
<td>.9937</td>
<td>.0000</td>
<td>2.1526</td>
<td>74.5285</td>
<td>.0000</td>
<td>.0098</td>
<td>1.0334</td>
</tr>
<tr>
<td>69.7</td>
<td>.1000</td>
<td>2.1120</td>
<td>2.9972</td>
<td>.9916</td>
<td>.0000</td>
<td>2.4456</td>
<td>60.4734</td>
<td>.0000</td>
<td>.0118</td>
<td>1.0324</td>
</tr>
<tr>
<td>81.3</td>
<td>.0000</td>
<td>2.5164</td>
<td>2.9523</td>
<td>.9898</td>
<td>.0000</td>
<td>2.9713</td>
<td>46.0103</td>
<td>.0000</td>
<td>.0250</td>
<td>1.0260</td>
</tr>
<tr>
<td>91.3</td>
<td>.0000</td>
<td>2.9208</td>
<td>2.9298</td>
<td>.9867</td>
<td>.0000</td>
<td>3.4970</td>
<td>35.2190</td>
<td>.0000</td>
<td>.0309</td>
<td>1.0232</td>
</tr>
<tr>
<td>100.7</td>
<td>.0000</td>
<td>3.3252</td>
<td>2.9781</td>
<td>.9840</td>
<td>.0000</td>
<td>4.0220</td>
<td>28.0867</td>
<td>.0000</td>
<td>.0362</td>
<td>1.0207</td>
</tr>
<tr>
<td>110.0</td>
<td>.0000</td>
<td>3.8307</td>
<td>1.8721</td>
<td>.9811</td>
<td>.0000</td>
<td>4.6799</td>
<td>21.8323</td>
<td>.0000</td>
<td>.0421</td>
<td>1.0178</td>
</tr>
<tr>
<td>120.3</td>
<td>.0000</td>
<td>4.3362</td>
<td>1.7203</td>
<td>.9785</td>
<td>.0000</td>
<td>5.3371</td>
<td>17.4372</td>
<td>.0000</td>
<td>.0470</td>
<td>1.0155</td>
</tr>
<tr>
<td>131.3</td>
<td>.0000</td>
<td>4.9428</td>
<td>1.5826</td>
<td>.9759</td>
<td>.0000</td>
<td>6.1256</td>
<td>13.7198</td>
<td>.0000</td>
<td>.0521</td>
<td>1.0130</td>
</tr>
<tr>
<td>139.7</td>
<td>.0000</td>
<td>5.4483</td>
<td>1.4939</td>
<td>.9741</td>
<td>.0000</td>
<td>6.7928</td>
<td>11.4663</td>
<td>.0000</td>
<td>.0558</td>
<td>1.0113</td>
</tr>
<tr>
<td>150.0</td>
<td>.0000</td>
<td>6.1560</td>
<td>1.3993</td>
<td>.9718</td>
<td>.0000</td>
<td>7.7028</td>
<td>9.1290</td>
<td>.0000</td>
<td>.0606</td>
<td>1.0092</td>
</tr>
<tr>
<td>160.2</td>
<td>.0000</td>
<td>6.8637</td>
<td>1.3268</td>
<td>.9700</td>
<td>.0000</td>
<td>8.6228</td>
<td>7.4293</td>
<td>.0000</td>
<td>.0635</td>
<td>1.0075</td>
</tr>
<tr>
<td>170.0</td>
<td>.0000</td>
<td>7.5714</td>
<td>1.2705</td>
<td>.9685</td>
<td>.0000</td>
<td>9.5428</td>
<td>6.1664</td>
<td>.0000</td>
<td>.0665</td>
<td>1.0061</td>
</tr>
<tr>
<td>181.2</td>
<td>.0000</td>
<td>8.4813</td>
<td>1.2151</td>
<td>.9669</td>
<td>.0000</td>
<td>10.0000</td>
<td>5.2914</td>
<td>.3924</td>
<td>.0695</td>
<td>1.0047</td>
</tr>
<tr>
<td>190.1</td>
<td>.0000</td>
<td>9.2901</td>
<td>1.1772</td>
<td>.9657</td>
<td>.0000</td>
<td>10.0000</td>
<td>4.8347</td>
<td>.9263</td>
<td>.0718</td>
<td>1.0036</td>
</tr>
<tr>
<td>200.0</td>
<td>.0000</td>
<td>10.0000</td>
<td>1.0502</td>
<td>1.0072</td>
<td>.0000</td>
<td>10.0000</td>
<td>3.3052</td>
<td>2.4870</td>
<td>.0789</td>
<td>1.0002</td>
</tr>
</tbody>
</table>
### Edited Data for Initial Conditions of Central Velocity Ratio of 10.0 and Peripheral Radius ratio of 10.0

<table>
<thead>
<tr>
<th>$X/r_a$</th>
<th>RA</th>
<th>RB</th>
<th>VP</th>
<th>VS</th>
<th>RAT</th>
<th>RBT</th>
<th>TP</th>
<th>TS</th>
<th>DP</th>
<th>MOMENTUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>1.0000</td>
<td>1.0000</td>
<td>1.0000</td>
<td>1.0000</td>
<td>1.0000</td>
<td>1.0000</td>
<td>100.000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>1.6749</td>
</tr>
<tr>
<td>22.6</td>
<td>0.9000</td>
<td>1.1519</td>
<td>9.9995</td>
<td>9.9950</td>
<td>8.6986</td>
<td>1.1823</td>
<td>100.000</td>
<td>0.0000</td>
<td>0.0148</td>
<td>1.6687</td>
</tr>
<tr>
<td>32.0</td>
<td>0.8000</td>
<td>1.3033</td>
<td>9.9989</td>
<td>9.9892</td>
<td>7.3479</td>
<td>1.3646</td>
<td>100.000</td>
<td>0.0000</td>
<td>0.0233</td>
<td>1.6651</td>
</tr>
<tr>
<td>39.0</td>
<td>0.7000</td>
<td>1.4533</td>
<td>9.9983</td>
<td>9.8311</td>
<td>5.7987</td>
<td>1.5436</td>
<td>100.000</td>
<td>0.0000</td>
<td>0.0287</td>
<td>1.6628</td>
</tr>
<tr>
<td>49.4</td>
<td>0.6000</td>
<td>1.7275</td>
<td>9.9972</td>
<td>9.7176</td>
<td>2.6875</td>
<td>1.8731</td>
<td>100.000</td>
<td>0.0000</td>
<td>0.0513</td>
<td>1.6533</td>
</tr>
<tr>
<td>61.2</td>
<td>0.5000</td>
<td>2.1053</td>
<td>9.9955</td>
<td>9.5430</td>
<td>2.3266</td>
<td>2.3266</td>
<td>88.3180</td>
<td>0.0000</td>
<td>0.0848</td>
<td>1.6393</td>
</tr>
<tr>
<td>70.0</td>
<td>0.4000</td>
<td>2.4574</td>
<td>9.4966</td>
<td>9.3633</td>
<td>2.7489</td>
<td>2.7489</td>
<td>71.6680</td>
<td>0.0000</td>
<td>0.1257</td>
<td>1.6221</td>
</tr>
<tr>
<td>80.9</td>
<td>0.3000</td>
<td>2.9265</td>
<td>8.0202</td>
<td>8.0989</td>
<td>3.3119</td>
<td>3.3119</td>
<td>57.5169</td>
<td>0.0000</td>
<td>0.1763</td>
<td>1.6007</td>
</tr>
<tr>
<td>90.0</td>
<td>0.2000</td>
<td>3.3953</td>
<td>6.9540</td>
<td>8.8180</td>
<td>3.8750</td>
<td>3.8750</td>
<td>47.6419</td>
<td>0.0000</td>
<td>0.2249</td>
<td>1.5803</td>
</tr>
<tr>
<td>102.2</td>
<td>0.1000</td>
<td>4.0995</td>
<td>5.8142</td>
<td>8.4150</td>
<td>4.7195</td>
<td>4.7195</td>
<td>37.4954</td>
<td>0.0000</td>
<td>0.2948</td>
<td>1.5509</td>
</tr>
<tr>
<td>109.9</td>
<td>0.0000</td>
<td>4.5683</td>
<td>5.2518</td>
<td>8.1460</td>
<td>5.2826</td>
<td>5.2826</td>
<td>32.6706</td>
<td>0.0000</td>
<td>0.3388</td>
<td>1.5323</td>
</tr>
<tr>
<td>120.2</td>
<td>0.0000</td>
<td>5.2725</td>
<td>4.5968</td>
<td>7.7440</td>
<td>6.1271</td>
<td>6.1271</td>
<td>27.2208</td>
<td>0.0000</td>
<td>0.4030</td>
<td>1.5053</td>
</tr>
<tr>
<td>130.0</td>
<td>0.0000</td>
<td>5.9764</td>
<td>4.0970</td>
<td>7.3270</td>
<td>6.9717</td>
<td>6.9717</td>
<td>23.2470</td>
<td>0.0000</td>
<td>0.4656</td>
<td>1.4790</td>
</tr>
<tr>
<td>140.0</td>
<td>0.0000</td>
<td>6.7975</td>
<td>3.6472</td>
<td>6.8270</td>
<td>7.9570</td>
<td>7.9570</td>
<td>19.8283</td>
<td>0.0000</td>
<td>0.5359</td>
<td>1.4494</td>
</tr>
<tr>
<td>150.0</td>
<td>0.0000</td>
<td>7.6185</td>
<td>3.2958</td>
<td>6.2990</td>
<td>8.9423</td>
<td>8.9423</td>
<td>17.2912</td>
<td>0.0000</td>
<td>0.6052</td>
<td>1.4202</td>
</tr>
<tr>
<td>160.0</td>
<td>0.0000</td>
<td>8.5570</td>
<td>2.9803</td>
<td>5.6390</td>
<td>10.0000</td>
<td>10.0000</td>
<td>15.2695</td>
<td>0.0331</td>
<td>0.6835</td>
<td>1.3873</td>
</tr>
<tr>
<td>170.0</td>
<td>0.0000</td>
<td>9.4954</td>
<td>2.7324</td>
<td>4.8840</td>
<td>10.0000</td>
<td>10.0000</td>
<td>14.4701</td>
<td>0.8733</td>
<td>0.7626</td>
<td>1.3540</td>
</tr>
<tr>
<td>180.0</td>
<td>0.0000</td>
<td>10.0000</td>
<td>2.2393</td>
<td>3.0780</td>
<td>10.0000</td>
<td>10.0000</td>
<td>12.8481</td>
<td>4.5093</td>
<td>1.1624</td>
<td>1.1858</td>
</tr>
<tr>
<td>190.2</td>
<td>0.0000</td>
<td>10.0000</td>
<td>1.6293</td>
<td>2.8518</td>
<td>10.0000</td>
<td>10.0000</td>
<td>10.9134</td>
<td>4.0506</td>
<td>1.5049</td>
<td>1.0116</td>
</tr>
<tr>
<td>200.0</td>
<td>0.0000</td>
<td>10.0000</td>
<td>1.1203</td>
<td>1.0733</td>
<td>10.0000</td>
<td>10.0000</td>
<td>9.3012</td>
<td>3.9306</td>
<td>1.6033</td>
<td>1.0002</td>
</tr>
</tbody>
</table>
An analysis of the properties of two-dim