COMPUTER MODELING OF LAMINAR FLOW OF CIRCLES AND ARCS SUBMERGED IN FLUID

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For simulation of fluid or gas, program package including FLUENT and GAMBIT is used.

Various shapes of forms submerged in fluid: circle, 3/4, ½ and 1/4 arcs of circles, flow computer images are presented on graphics I, II, III and IV. Average value of Reynolds numbers is equal to $Re_L = 0.112$*, and flow velocity 1-4.7 mm/s. There is seen couple of whirlpool per circle flow, center-to-center distance of which is in correlation with data received by experiments (semi-circle flow). At laminar flow, flow reverse of circles and its various arcs, practically have no effect on hydrodynamic picture of flow.*

Firstly, visual imagination of hydrodynamic processes is important for studying purposes. Visual images and animated pictures significantly raise understanding of theoretical skills at lectures and workshops. Supporting of formation of hydrodynamic intuition in attendees is also key factor.

From old times, visualization of flows had important role in observing of hydrodynamic processes. It allowed understanding the facts from qualitative and in last periods, from numerical points of view.

There are different flow regimes, such as laminar flow, occurring at very low velocity conditions (at low Reynolds numbers).

Pictures of various flow bodies in narrow gap (Instrument Hele-Shaw) bear both practical and theoretical interests.

In [1], there are presented results of experimental researches carried out by the specialists of the USA, England, France, Japan and other countries, in photos depicting flows of fluids and gases in different conditions. Classification, processing and comments of these materials are accomplished by outstanding American scientist Milton Van Dyke. This book is unique as it is the only work in this type of field through two and half century existence of hydrodynamics.

Instrument Hele-Shaw is defined as two parallel flat plates separated by an infinitesimally small gap filled with fluid, moved by variety of permanent pressures geared between the ends. Various bodies -"resistance" are submerged in fluid, which are the objects of research. For better visual observation of flow and photo-shooting of hydraulic occurrences contrasting material is injected in entrance of the instrument.

Accomplishment of this type experiments bear huge technical difficulties, whereas, photos of flow velocity and pressure field lines are received more simply for various occurrences of body flows.

For simulation of fluid or gas, aerohydrodynamic programs, such as FLUENT and GAMBIT are used. This program package is widely used in fields, such as: aviation, power supplies, automotive industry, chemistry, physics, etc; worldwide brands such as Boeing, BMW and others use these programs.

Working with FLUENT and GAMBIT include three major stages [2]: 1. net generation program in GAMBIT and drawing transferring program in FLUENT. 2. calculations and 3. Submitting of results in FLUENT; calculations in 2D and 3D areas. Before second stage, it is necessary to enter initial data of the flow: velocity, temperature, pressure, density, flow regime and other characteristics. For the last stage, we can define velocity of the flow,

velocity vector, temperature in target points and we can receive profile of velocity and pressure in any cross-sectional area of the flow.

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Various shapes of forms submerged in fluid: circle, 3/4, ½ and 1/4 arcs of circles, flow computer images are presented on graphics I, II, III and IV.

In relevant graphics, 1, 2, 3 and 4, one can see velocity field lines, velocity vectors, velocity curves in corresponding cross-sectional areas and occurrences of flow reverse.

Calculations are carried out with glycerin within laminar flow conditions: ρ=1266.5 kg/m^3; dynamic viscosity $\mu = 0.799$ **Pa·s and kinematic viscosity** $\nu = 6.31 \cdot 10^{-4}$ **(m²/s); Flow parameters are presented in cross-sectional areas, which are indicated in graphics on distances separated from conditional zero (conditional zero is separated in 100 mm from circle center). Direction of flow on every picture is depicted from left to right, if not specifically indicated about flow direction.**

Fig. 1.1. Circle flow with glycerin flow. circle diameter 20mm, flow velocity 1 m/s and Reynolds numbers $Re_d = 0.0317$ **and** $Re_L = 0.0995$.

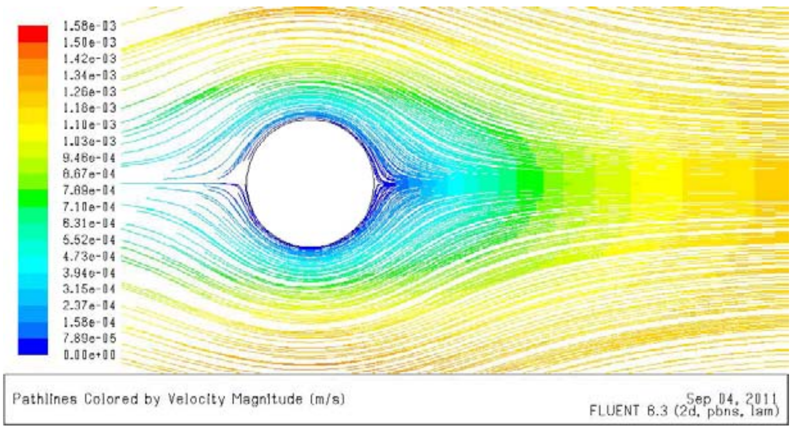
Flow moves without whirlpool of separate fluid volumes. Flow picture is symmetrical.

Fig. 2.1. 20 mm diameter circle ¾ arc flow. Flow velocity 1.6 mm/s and Reynolds number Re_L **=0.119.**

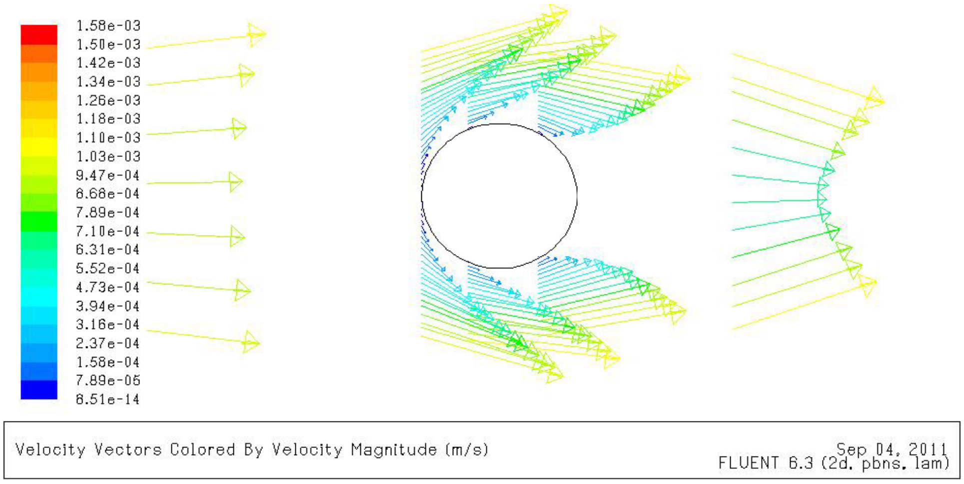
Fig. 3.1. 20 mm diameter circle ½ arc flow. Flow velocity 2.3 mm/s and Reynolds number Re_L **=0.114.**

Fig. 4.1. 20 mm diameter ¼ arc flow. Flow velocity 4.7 mm/s and Reynolds number Re_L =0.117.

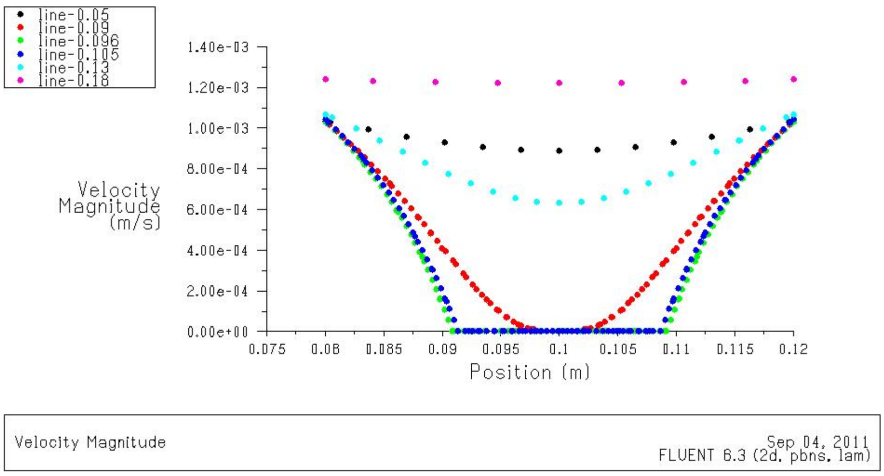
1.4, 2.4, 3.4 and 4.4 figures correspond with the occurrences of flow reverse. Practically, all flow pictures are symmetric.



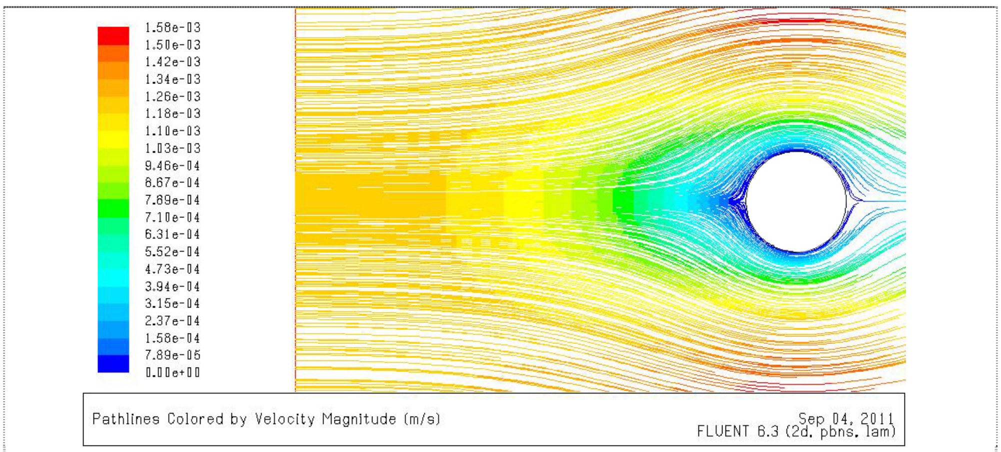
1.1 **Computer modeling of circle flow with glycerin.**
Velocity field lines $Re_d = 0.0995$.



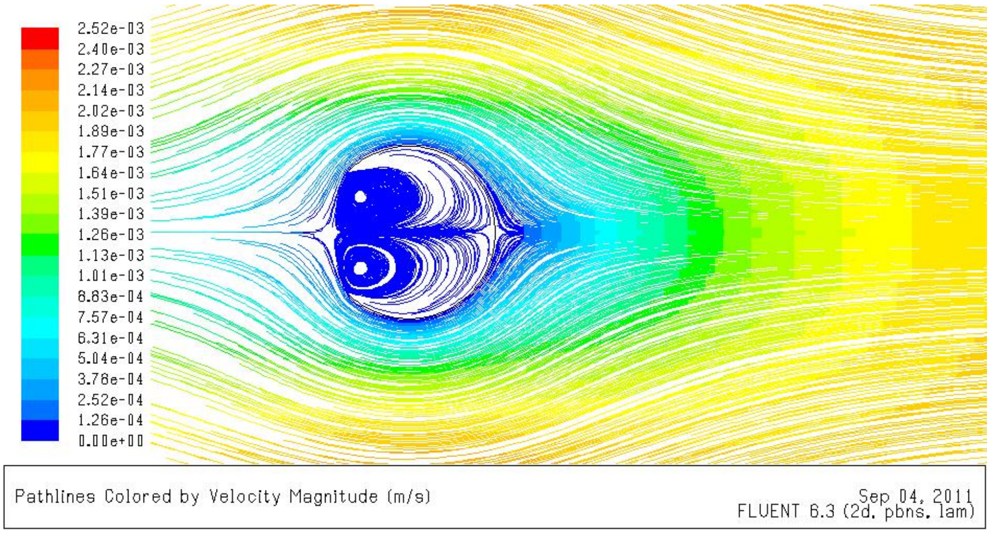
1.2. Computer modeling of circle flow with glycerin.
Velocity vectors in relevant cross-sectional areas.



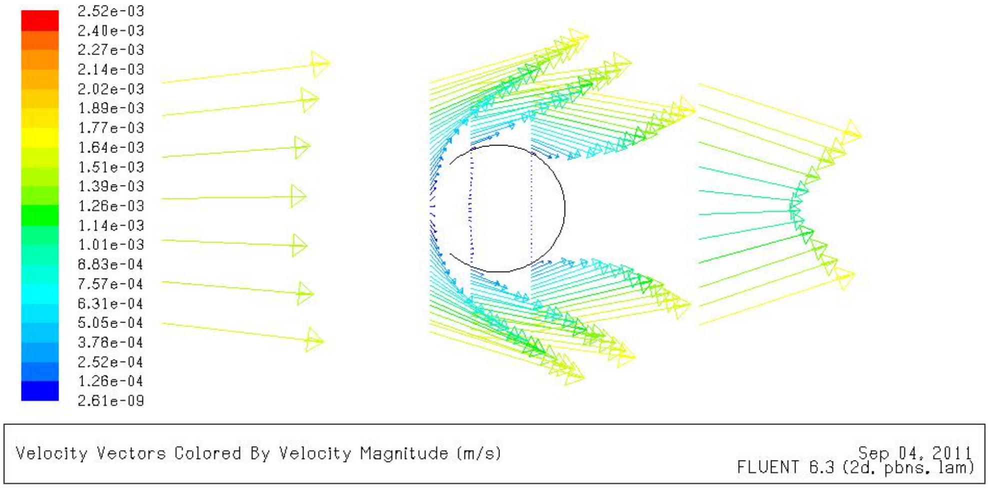
1.3. Computer modeling of circle flow with glycerin.
Velocity Distribution curves in relevant cross-sectional areas



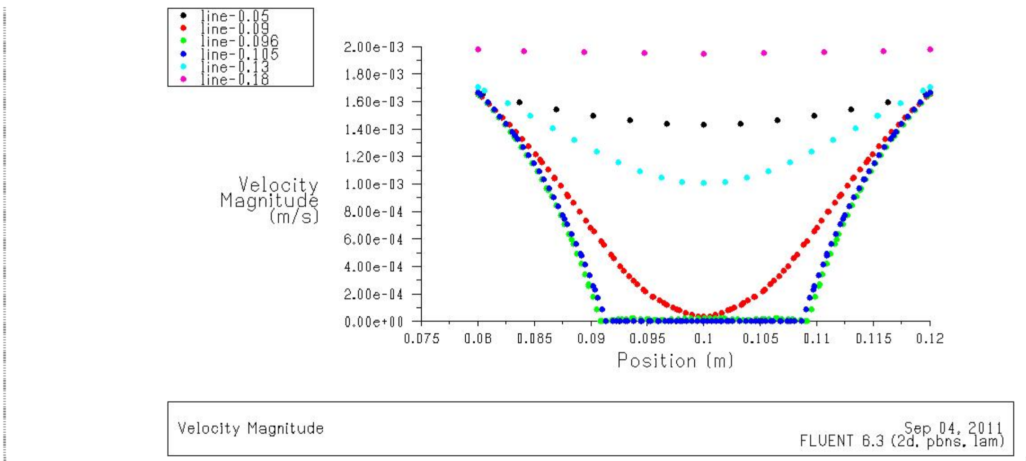
1.4. Computer modeling of circle flow with glycerin.
Flow reverse



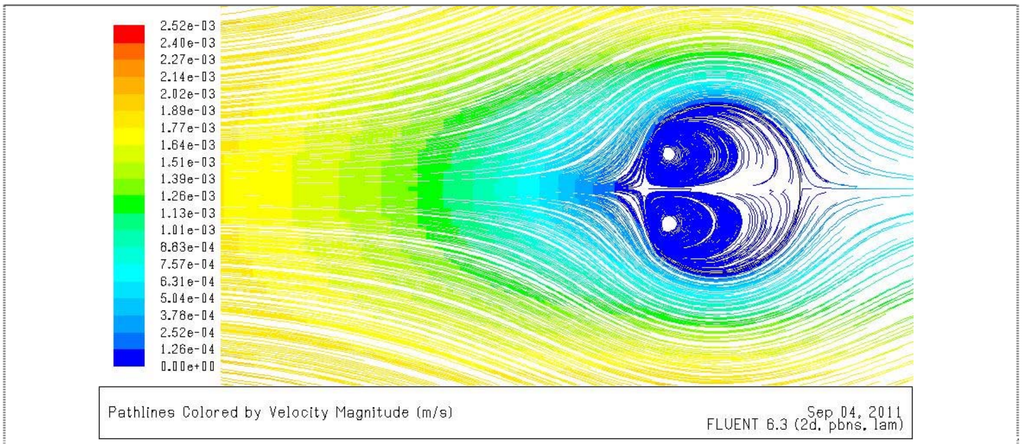
2.1. Computer modeling of circle ¾ arc flow with glycerin.
Velocity field lines $Re_L = 0.119$



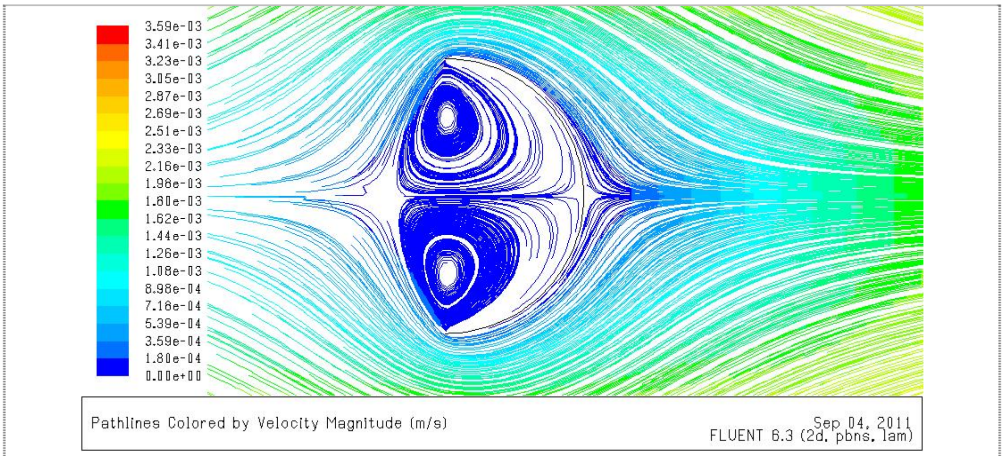
2.2. Computer modeling of circle ¾ arc flow with glycerin.
Velocity vectors



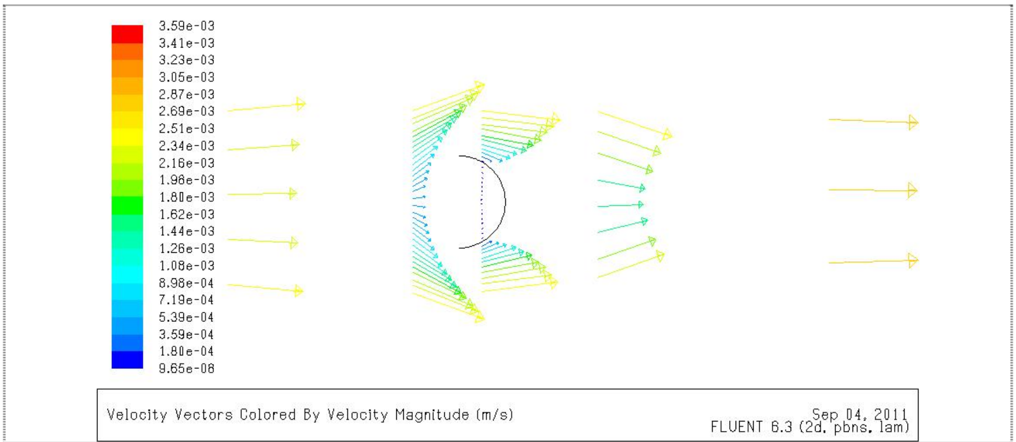
2.3. Computer modeling of circle ¾ arc flow with glycerin
Velocity graphics



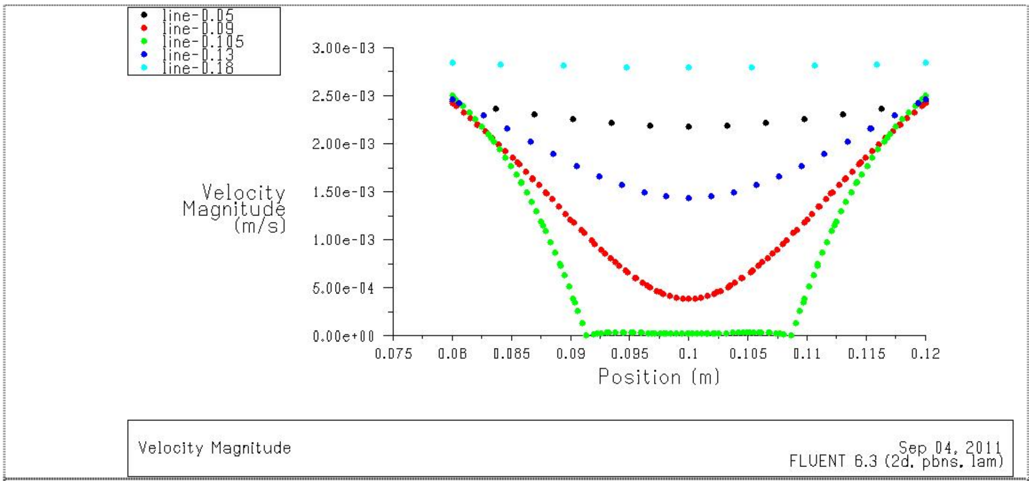
2.4. Computer modeling of circle ¾ arc flow with glycerin
Flow reverse



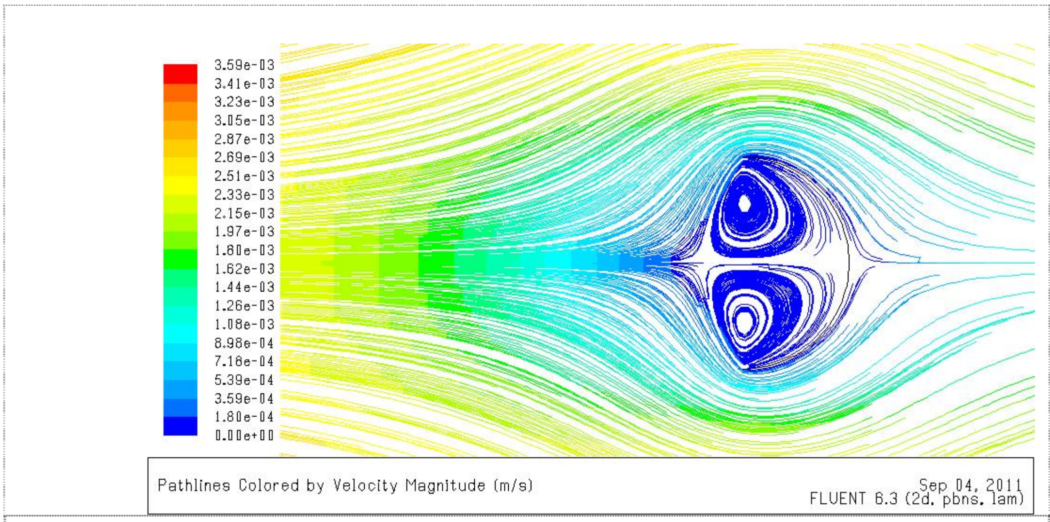
3.1. Computer modeling of circle ½ arc flow with glycerin.
Velocity field lines $Re_L = 0.114$



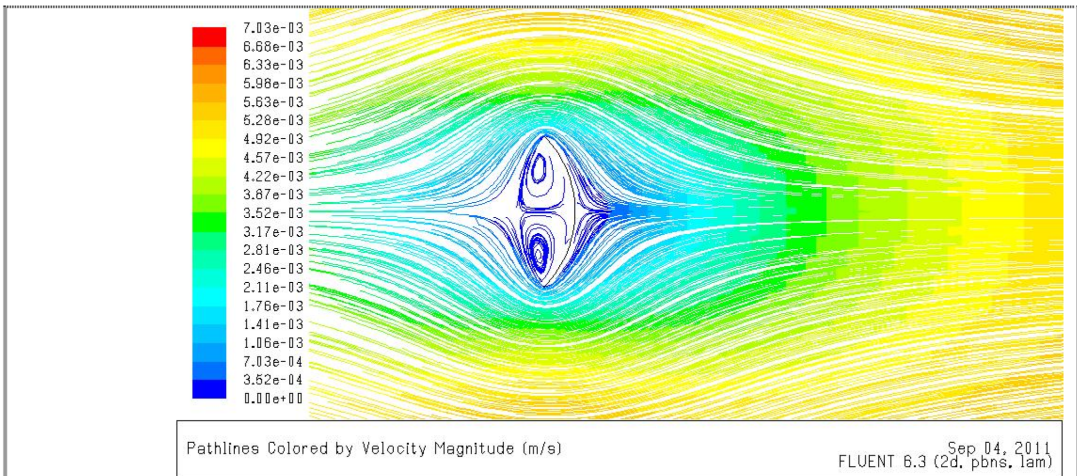
3.2. Computer modeling of circle ½ arc flow with glycerin.
Velocity vectors.



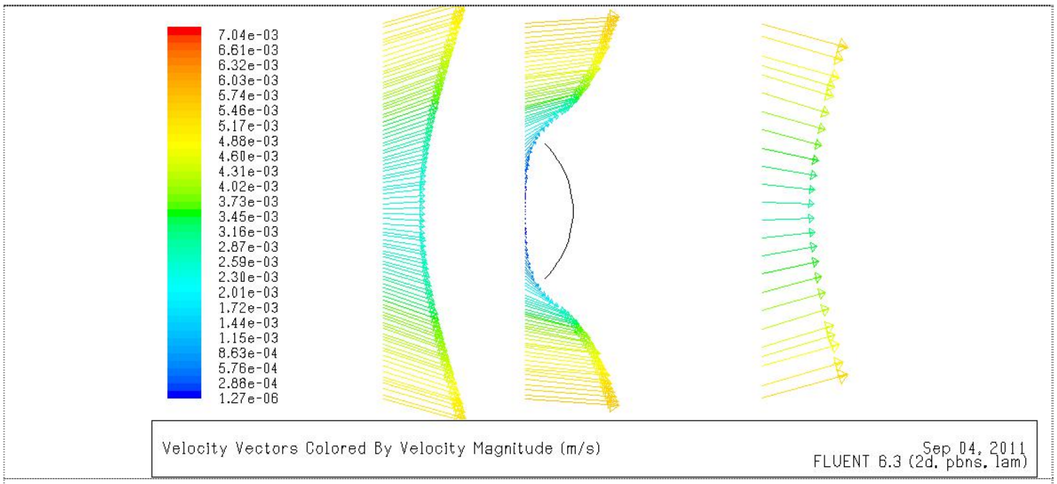
3.3. Computer modeling of circle ½ arc flow with glycerin. Velocity graphics



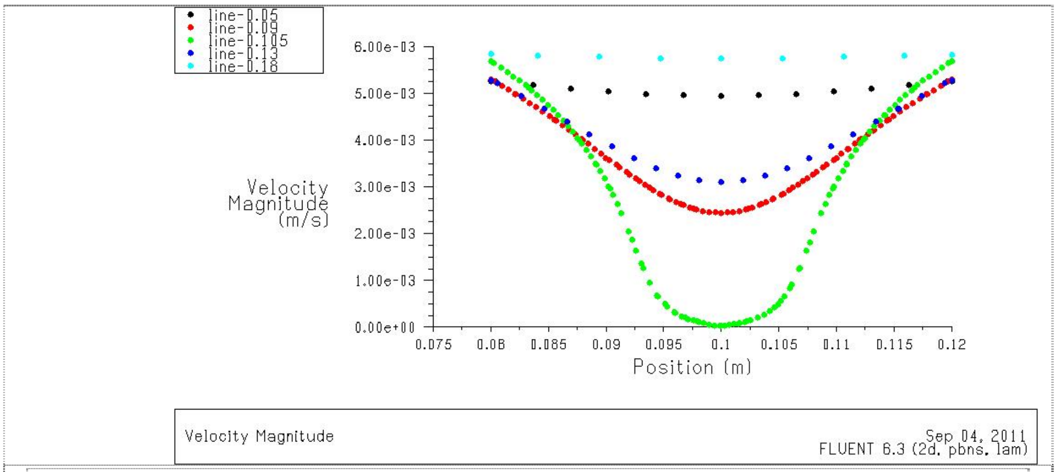
3.4. Computer modeling of circle 1/2 arc flow with glycerin. Flow reverse



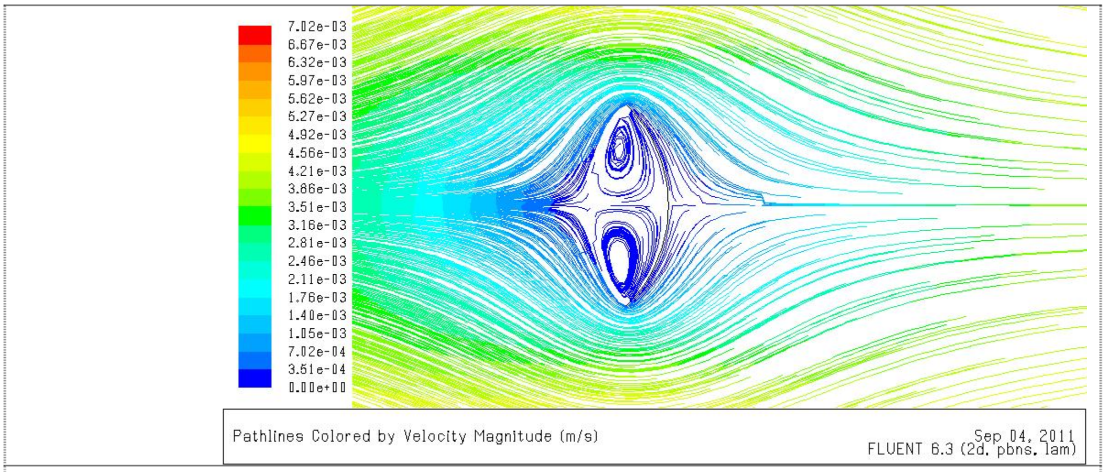
4.1. Computer modeling of circle1/4 arc flow with glycerin. Velocity field lines $Re_L = 0.117$



4.2. Computer modeling of circle1/4 arc flow with glycerin. Velocity vectors



4.3. Computer modeling of circle1/4 arc flow with glycerin. Velocity Vectors



4.4. Computer modeling of circle1/4 arc flow with glycerin. Flow reverse

As it was expected, in inner part of the arcs, there is one couple of whirlpool, center-to-center distances of which are equal (mm), according to the graphics: Fig. 2.1. - 8,4; Fig. 2.4.- 8,3; Fig. 3.1. - 11,5; Fig. 3.4. - 11,3; Fig. 4.1. - 7.8 and Fig. 4.4. - 7,9. i.e. dimensions generated on circle diameter are: 0.42, 0.57 and 0.39, respectively and similarly generated on arc length 0.176, 0.360 and 0.509 respectively.

In references [1], there is given distance-052d experimentally determined between couple whirlpools of semi-circle glycerin flow dispersed with aluminum powder ($Re_d = 0.031$). Deviation of the later one is 9% via computer modeling, which may be referred to the differences of thermal and physical characteristics and Reynolds Numbers.

R E F E R E N C E S

1. Альбом течений жидкости и газа/Пер. с англ./Сост. М.Ван-Дайк. М.:Мир. 1986.

2. გიგიტელაშვილი კ., კილურაძე დ., კილურაძე ო. სითხის ნაკადის რეჟიმების მოდელირება თანამედროვე პროგრამული პაკეტების გამოყენებით//ენერგია. 2011. №3 (59). თბილისი.