forces. *Science in China Series G: Physics, Mechanics and Astronomy*, 52:1364–1374, 2009.

پیوست آ

برنامه نوشته شده برای نرم‌افزار فلوئنت

```
#include ”udf.h”

/*Constant Parameter Definition*/
#define J0 11.9281
#define B0 1.0
#define a 0.01
#define Pi 3.14159
#define Th 0.12
#define Ch 1.0
#define D 5.0
#define K 0.5
#define ep 0.0000009

/*Define Source Term; X-Momentum Equation*/
DEFINE_SOURCE(xmom, c, t, dS, eqn)
{
real Z[ND_ND];
real Airfoil_Tet,Y_Airfoil;
real Xloc,Yloc,X,Y,R,Teta,Angle;
real Alpha,TIME,XDC,XC;
real source,Yprim,Eta;
FILE *fp2;
TIME=CURRENT_TIME;
Alpha=0.1745329-D*0.01745329*sin(2.0*K*TIME);
C_CENTROID(Z, c, t);
X=Z[0];
Y=Z[1];
R=sqrt(pow(X,2)+pow(Y,2));
Teta=atan(Y/X);
```

```
Xloc=R*cos(Angle);
Xloc=-Xloc;
* Yloc=R*sin(Angle);
}
if (X>0.0)
{
if (Teta<(15.77777-Alpha))
{
Angle=fabs(Teta)+fabs(Alpha);
Xloc=R*cos(Angle);
Yloc=R*sin(Angle);
}
if (Teta==(15.77777-Alpha))
```

```
{
Xloc=0.0;
Yloc=R;
}
if (Teta>(15.77777-Alpha))
{
Angle=fabs(Teta)-fabs(Alpha);
Xloc=R*cos(Angle);
Xloc=-Xloc;
Yloc=R*sin(Angle);
}
}
XDC=(Xloc+0.25)/Ch;
XC=(Xloc+0.25)*Ch;
Y_Airfoil=(Th*Ch/0.2)*(0.2969*pow(XDC,0.5)-0.1260*XDC-0.3516*pow(XDC,2)
+0.2843*pow(XDC,3)-0.1015*pow(XDC,4));
Airfoil_Tet=(Th*Ch/0.2)*(((0.2969/2.0)*sqrt(1.0/XC))-(0.1260/Ch)-(2.0*0.3516*XDC)
+(3.0*0.2843*pow(XDC,2))-(4.0*0.1015*pow(XDC,3)));
Yprim=Yloc-Y_Airfoil;
Eta=(-Pi)/a;
source=J0*B0*exp(Eta*Yprim)*cos(fabs(Airfoil_Tet-Alpha));
dS[eqn]=J0*B0*Eta*exp(Eta*Yprim)*cos(fabs(Airfoil_Tet-Alpha));
return source;
}

/*Define Source Term; Y-Momentum Equation*/
DEFINE_SOURCE(xmom, c, t, dS, eqn)
{
real Z[ND_ND];
real Airfoil_Tet,Y_Airfoil;
real Xloc,Yloc,X,Y,R,Teta,Angle;
```

```
real Alpha,TIME,XDC,XC;
real source,Yprim,Eta;
FILE *fp2;
TIME=CURRENT_TIME;
Alpha=0.1745329-D*0.01745329*sin(2.0*K*TIME);
C_CENTROID(Z, c, t);
X=Z[0];
Y=Z[1];
R=sqrt(pow(X,2)+pow(Y,2));
Teta=atan(Y/X);
if (X<=0.0)
{
Angle=fabs(Teta)-fabs(Alpha);
Xloc=R*cos(Angle);
Xloc=-Xloc;
Yloc=R*sin(Angle);
}
if (X>0.0)
{
if (Teta<(15.77777-Alpha))
{
Angle=fabs(Teta)+fabs(Alpha);
Xloc=R*cos(Angle);
Yloc=R*sin(Angle);
}
if (Teta==(15.77777-Alpha))
{
Xloc=0.0;
Yloc=R;
}
if (Teta>(15.77777-Alpha))
{
Angle=fabs(Teta)-fabs(Alpha);
Xloc=R*cos(Angle);
Xloc=-Xloc;
Yloc=R*sin(Angle);
}
}
XDC=(Xloc+0.25)/Ch;
XC=(Xloc+0.25)*Ch;
```

```
Eta=(-Pi)/a;
source=J0*B0*exp(Eta*Yprim)*sin(fabs(Airfoil_Tet-Alpha));
dS[eqn]=J0*B0*Eta*exp(Eta*Yprim)*sin(fabs(Airfoil_Tet-Alpha));
return source;
}

/*Motion of Oscillatory Airfoil*/
DEFINE_CG_MOTION(airfoil, dt, vel, omega, time, dtime)
{
Thread *t;
FILE *fp1;
int zone_id;
real alpha;
t=DT_THREAD(dt);
zone_id=THREAD_ID(t);
omega[2]=0.0174532*D*2.0*K*cos(2.0*K*time);
}
```

Abstract

The growing applications of low Reynolds Number (LRN) like micro-aerial vehicles (MAVs), flapping wing and etc. has increased the need for understanding the physics of these kinds of flow. The investigations carried out in this field illustrated that the angle of attack and the motion function parameters of oscillating airfoil have significant effects on the flow field and consequently its aerodynamics coefficients. The present study focuses on controlling of separated flow field to keep or increase the aerodynamic efficiency of oscillating airfoil. This issue was accomplished with active and passive control methods, and two different approaches are used. For this purpose, in the passive method, having installed some slots on the surface of the airfoil, we have investigated the effects of the position, width, and angle of the slot. Utilizing this method, the improvement in aerodynamics efficiency is observed when a slot with 0.02 width is vertically located in 0.7 airfoil's chord from the leading edge. Then, using electromagnetic forces and making Lorentz forces in active method, we try to control the flow separation. The results show the high performance of this method which not only causes to increase the lift coefficient but also decreases the drag coefficient and when the magnetic momentum coefficient is equal 0.5, there is thrust force too.

Keywords: *Separation Flow Control, Lorentz Force, Electromagnetic Fields*