SECTION 2. Applied mathematics. Mathematical modeling.

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DEVELOPMENT OF THE MATHEMATICAL MODEL THE TWO-STAGE SOIL RIPPER

The paper describes the process and computer algorithms for constructing a mathematical model of soil Ripper.

Key words: soil, Ripper, Delphi.

Consider the process of constructing a mathematical model of soil Ripper (Fig.1)

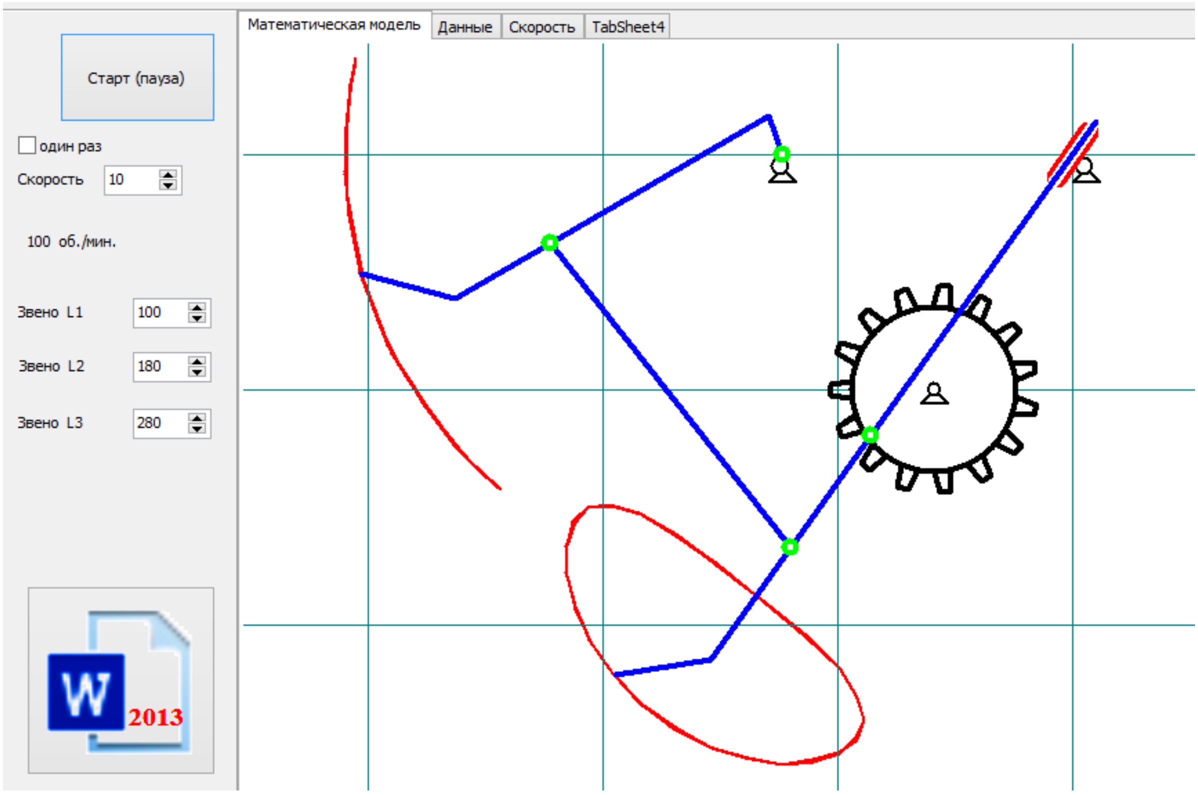

Figure 1 - Model of a Ripper.

First need to determine and specify all fixed points of the model. We have a 3 fixed points. The two upper stipulated by the hinge and the axis of rotation gear. And also, we will need the exact value of the angle of rotation of the gear in the specified period of time.

```
x0:=600;
y0:=80;
x01:=390;
y01:=80;

x1:=500;
y1:=250;

ii:=15; /// step angle of rotation of the gear.
```

Now define the coordinates of the rolling hinge mounted on the gear.

```
k:=1;
a0:=a0+3.14*(ii)/180;
shesterenka00(x01-10,y01);// drawing of the upper hinges.
shesterenka00(x0,y0);
```

```
stringgrid1.Cells[0,ik]:=inttostr(ik);
a00:=a0;

while a00>6.28 do a00:=a00-6.28;
a00:=roundto(180*a00/3.14,0);
stringgrid1.Cells[1,ik]:=floattostr(a00);


k:=2;
shesterenka(x1,y1,a0,0);// drawing gear with moveable joint


zzz(x0,y0,zx[2],zy[2]);

v:=60/(180/ii*timer1.Interval/1000);// calculation of the speed of rotation
label3.Caption:=floattostr(int(v*100)/100)+'  об./мин.' ;

if (a0>6.28)and b2 then begin timer2.Enabled:=true;b2:=false;   end;
```

Go to the subroutine ZZZ, where we continue the calculation of the remaining points of the model. Model movable upper hinge. It should turn to an angle depending on the coordinate hinge located on the gear.

```
image1.Canvas.Pen.Width:=4;
image1.Canvas.Pen.Color:=clblue;

image1.Canvas.MoveTo(x1,y1);
vx:=(x1-x0)/sqrt(sqr(x1-x0)+sqr(y1-y0));
vy:=(y1-y0)/sqrt(sqr(x1-x0)+sqr(y1-y0));
shred(x0,y0,vx,vy);
image1.Canvas.MoveTo(x1,y1);

x2:=x1-trunc(280*vx);
y2:=y1-trunc(280*vy);
image1.Canvas.LineTo(x2,y2);
image1.Canvas.MoveTo(x1,y1);
```

By the coordinates of the two hinges, we defined the direction vector, and now we draw hinge.

```
procedure TForm1.shred(x0,y0:integer;vx,vy:real);
begin
```

```
 image1.Canvas.Pen.Width:=16;
image1.Canvas.Pen.Color:=clred;
image1.Canvas.moveto(x0-trunc(20*vx),y0-trunc(20*vy));
image1.Canvas.LineTo(x0+trunc(20*vx),y0+trunc(20*vy));
 image1.Canvas.Pen.Width:=8;
image1.Canvas.Pen.Color:=clwhite;
image1.Canvas.moveto(x0-trunc(25*vx),y0-trunc(25*vy));
image1.Canvas.LineTo(x0+trunc(25*vx),y0+trunc(25*vy));
 image1.Canvas.Pen.Width:=4;
image1.Canvas.Pen.Color:=clblue;
end;
```

We have the following result:

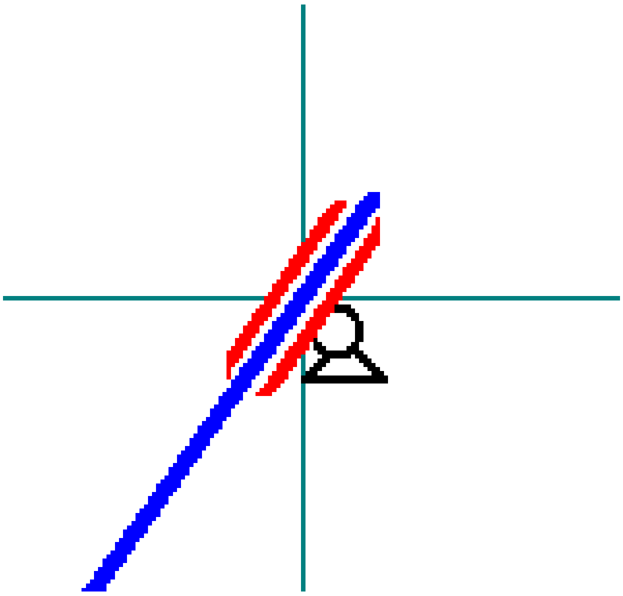

Figure 2 - Movable joint №0.

To determine the rest of the points, we will need the values of the three links with constant or variable values.

```
L1:=spinedit2.Value;
L2:=spinedit4.Value;
L3:=spinedit5.Value;
```

Data are entered manually by the user when working with the program

```
x3:=x1+trunc(L1*vx);   //100
y3:=y1+trunc(L1*vy);
```

```
x4:=x1+trunc(200*vx);
y4:=y1+trunc(200*vy);
image1.Canvas.LineTo(x4,y4);

shzel(x1,y1);

x5:=x4+trunc(50*(vx-vy));
y5:=y4+trunc(50*(vy+vx));
image1.Canvas.LineTo(x5,y5);
```

Complexity is the only definition of the next joint №6:

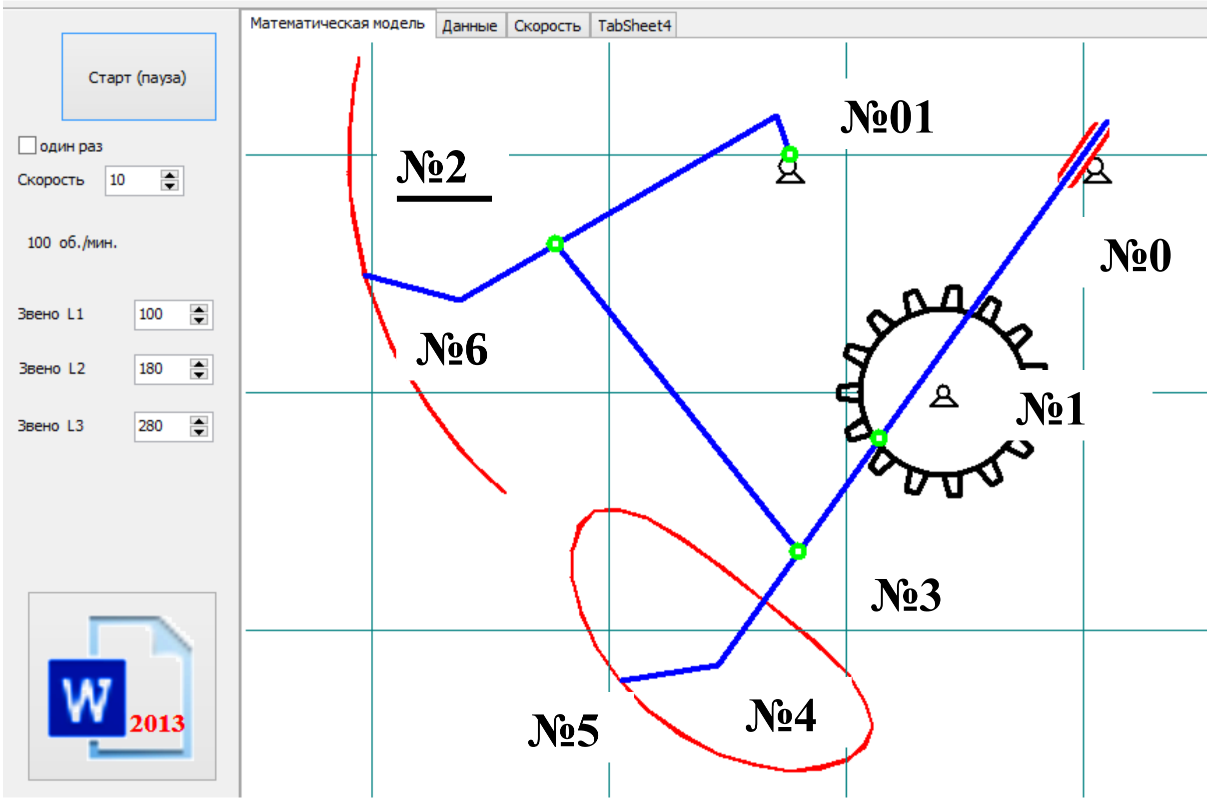

Figure 3 - Position and numbering hinges.

To determine its coordinates have two circles through №01 and №3, draw up a system of two equations and solve it by finding the intersection point, if you know the radius L2 and L3.

```
r1:=L2;//180;
r2:=L3;//200;

a:=(x3-x01)/(y01-y3);
```

```
b:=-(sqr(r1)-sqr(r2)-sqr(x01)+sqr(x3)-sqr(y01)+sqr(y3))/2/(y01-y3);

x6:=trunc((-a*b+a*y01+
-sqrt(-sqr(a*x01)+sqr(a*r1)-2*a*b*x01+2*a*x01*y01-sqr(b)+2*b*y01-
sqr(y01)+sqr(r1))+x01)/(a*a+1));

y6:=trunc(a*x6+b);

image1.Canvas.MoveTo(x3,y3);
image1.Canvas.LineTo(x6,y6);
shzel(x3,y3);

vx:=(x6-x01)/sqrt(sqr(x6-x01)+sqr(y6-y01));
vy:=(y6-y01)/sqrt(sqr(x6-x01)+sqr(y6-y01));
vpx:=-vy;
vpy:= vx;
x7:=x01+trunc(30*vpx);
y7:=y01+trunc(30*vpy);
image1.Canvas.MoveTo(x01,y01);
image1.Canvas.LineTo(x7,y7);
image1.Canvas.LineTo(x6,y6);

vx:=(x6-x7)/sqrt(sqr(x6-x7)+sqr(y6-y7));
vy:=(y6-y7)/sqrt(sqr(x6-x7)+sqr(y6-y7));

x8:=x6+trunc(80*vx);
y8:=y6+trunc(80*vy);
image1.Canvas.LineTo(x8,y8);

x9:=x8+trunc(50*(vx-vy));
y9:=y8+trunc(50*(vy+vx));
image1.Canvas.LineTo(x9,y9);

shzel(x6,y6);
shzel(x01,y01);
```

Now, knowing the coordinates of all points, display the trajectory of teeth Ripper.

```
image2.Canvas.Pen.Width:=2;
image2.Canvas.Pen.Color:=clred;

if b1 then
```

```
begin
image2.Canvas.MoveTo(x9,y9);
x99:=x9;
y99:=y9;
x55:=x5;
y55:=y5;

end
 else
begin
 image2.Canvas.MoveTo(x99,y99);
image2.Canvas.LineTo(x9,y9);


 image2.Canvas.MoveTo(x55,y55);
 image2.Canvas.Pen.Color:=clfuchsia;
 image2.Canvas.LineTo(x5,y5);

x99:=x9;
y99:=y9;
x55:=x5;
y55:=y5;
end;

b1:=false;

stringgrid1.Cells[2,ik]:=inttostr(x9);
stringgrid1.Cells[3,ik]:=inttostr(y9);
stringgrid1.Cells[4,ik]:=inttostr(x5);
stringgrid1.Cells[5,ik]:=inttostr(y5);
```

Output all data in the table, determine the coordinates of teeth, their offset in the specified period of time, and tangential velocity at each point in time.

```
if ik>=2 then
begin
ss:=roundto(sqrt(sqr(x9-strtoint(stringgrid1.Cells[2,ik-1]))
   +sqr(y9-strtoint(stringgrid1.Cells[3,ik-1]))),-4);
ss1:=roundto(sqrt(sqr(x5-strtoint(stringgrid1.Cells[4,ik-1]))
   +sqr(y5-strtoint(stringgrid1.Cells[5,ik-1]))),-4);

ss2:=ss;
stringgrid1.Cells[6,ik]:=floattostr(roundto(0.25*ss2/dy,-4));
```

```
vv:=roundto(0.25*ss2/dy/timer1.Interval*1000,-4);
stringgrid1.Cells[7,ik]:=floattostr(vv);

ss2:=ss1;
stringgrid1.Cells[8,ik]:=floattostr(roundto(0.25*ss2/dy,-4));
vv1:=roundto(0.25*ss2/dy/timer1.Interval*1000,-4);
stringgrid1.Cells[9,ik]:=floattostr(vv1);
```

Математическая модель | Данные | Скорость | TabSheet4

№	Угол повор	X1	Y1	X2	Y2	путь S1 (м)	скорость V1 (м/с)	путь S2 (м)	скорость V2 (м/с)
1	15	149	286	324	362				
2	30	183	319	358	388	0,0697	1,3936	0,0629	1,2589
3	45	218	346	390	414	0,065	1,3001	0,0606	1,2127
4	60	253	365	417	439	0,0586	1,1713	0,0541	1,0823
5	75	281	377	439	461	0,0448	0,896	0,0458	0,9151
6	90	295	382	446	477	0,0219	0,4372	0,0257	0,5137
7	105	310	386	448	494	0,0228	0,4566	0,0252	0,5034
8	120	313	386	440	506	0,0044	0,0882	0,0212	0,4242
9	135	309	385	425	516	0,0061	0,1213	0,0265	0,5302
10	150	295	381	403	519	0,0214	0,4282	0,0327	0,653
11	165	277	375	379	519	0,0279	0,5581	0,0353	0,7059
12	180	253	365	355	513	0,0382	0,7647	0,0364	0,7276
13	195	225	349	327	504	0,0474	0,9485	0,0433	0,865
14	210	195	329	302	488	0,053	1,0605	0,0436	0,873
15	225	169	306	279	469	0,051	1,021	0,0439	0,8774
16	240	142	276	260	446	0,0594	1,1871	0,0439	0,8774
17	255	123	250	245	421	0,0474	0,9471	0,0429	0,8575
18	270	109	227	238	398	0,0396	0,7919	0,0354	0,7071
19	285	98	203	233	375	0,0388	0,7765	0,0346	0,6923

Figure 4 - Data of model.

Also displaying provided the speed of each tooth on the chart.

```
series1.AddXY(a00,vv);
series2.AddXY(a00,vv1);
```

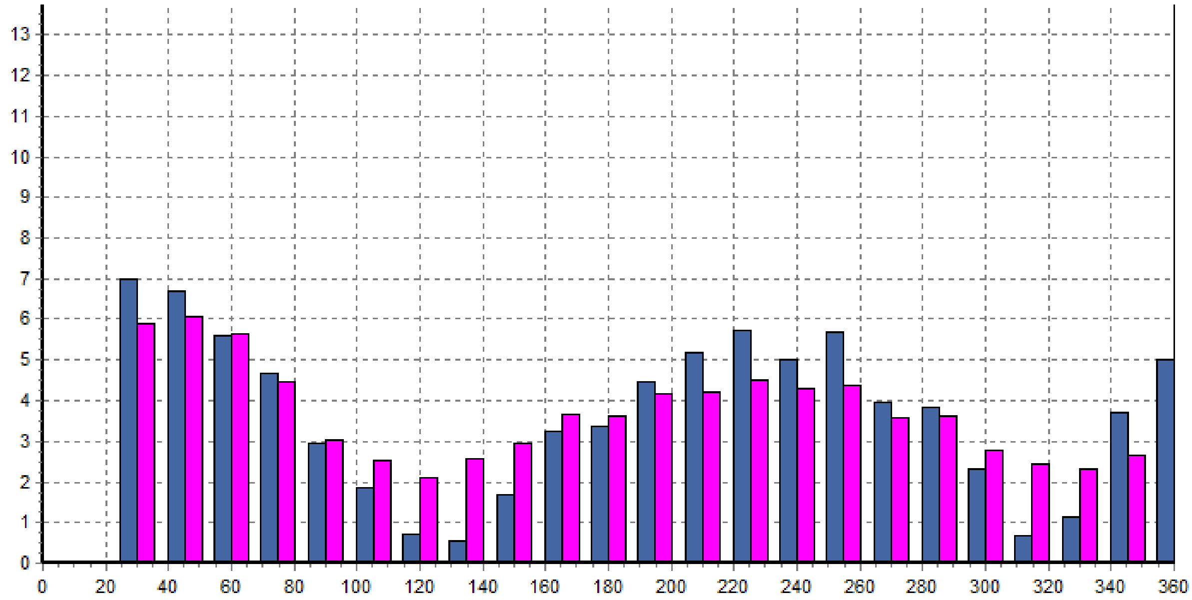

Figure 5 - Distribution of velocity in different moments.

When you install the Ripper on a tractor, an additional vector of horizontal movement. Determine the speed and agree the value of coordinate systems teeth Ripper and movement in space. All data will be **"image3".**

```
image3.Canvas.FillRect(rect(0,0,1000,1000));
image3.Canvas.Pen.Width:=1;
image3.Canvas.Pen.Color:=clteal;
dy1:=200;
for I := -5 to 29 do
begin
image3.Canvas.MoveTo(0,trunc(i*dy1/4)+trunc(dy1*(80/200)));
image3.Canvas.LineTo(1000,trunc(i*dy1/4)+trunc(dy1*(80/200)));
image3.Canvas.MoveTo(-trunc(35/200*dy1)+trunc(i*dy1/4),0);
image3.Canvas.LineTo(-trunc(35/200*dy1)+trunc(i*dy1/4),1000);
end;
px:=700-trunc(dy1/4);
py:=100-trunc(dy1/4);

skt:=spinedit3.Value*1000/3600;
label6.Caption:=floattostr(skt)+'  м/c';
image3.Canvas.Pen.Width:=2;
i:=1;
sd:=0;
image3.Canvas.Pen.Color:=clred;
```

```
image3.Canvas.MoveTo(px+trunc(dy1*(sd+strtoint(stringgrid1.Cells[2,i])/dy*0.
25)),
py+trunc(dy1*(strtoint(stringgrid1.Cells[3,i])/dy*0.25)));
for j := 0 to 3 do
for I := 1 to stringgrid1.RowCount - 2 do
begin
image3.Canvas.lineTo(px+trunc(dy1*(sd+strtoint(stringgrid1.Cells[2,i+1])/dy*0
.25)),
py+trunc(dy1*(strtoint(stringgrid1.Cells[3,i+1])/dy*0.25)));
sd:=(sd-skt*timer1.Interval/1000);
end;

i:=1;
sd:=0;
image3.Canvas.Pen.Color:=clfuchsia;

image3.Canvas.MoveTo(px+trunc(dy1*(sd+strtoint(stringgrid1.Cells[4,i])/dy*0.
25)),
py+trunc(dy1*(strtoint(stringgrid1.Cells[5,i])/dy*0.25)));
for j := 0 to 3 do

for I := 1 to stringgrid1.RowCount - 2 do
begin
image3.Canvas.lineTo(px+trunc(dy1*(sd+strtoint(stringgrid1.Cells[4,i+1])/dy*0
.25)),
py+trunc(dy1*(strtoint(stringgrid1.Cells[5,i+1])/dy*0.25)));

sd:=(sd-skt*timer1.Interval/1000);

end;
```

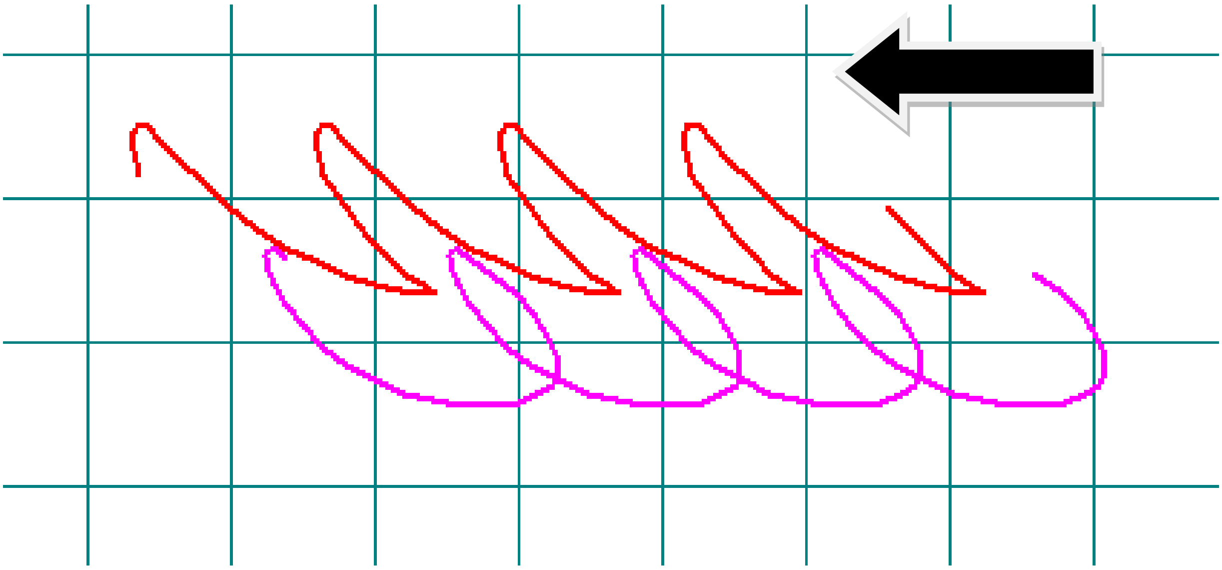

Figure 6 - The Trajectory of the teeth Ripper.

The given model allows to determine the path teeth-stage Ripper in the space for different initial parameters.

REFERENCE

1. Артоболевский И. И. Теория механизмов и машин; Учеб. для втузов. — 4-е изд., перераб. и доп. — М.: Наука. Гл. ред. физ.-мат. лит., 1988. — 640 с.
2. Трактор. [Электронный ресурс]. URL: http://23tehno.ru/blog/traktor/2012-07-19-7 (дата обращения: 20.06.2013).
3. Антимонов В.П., Бектлеуов А.Ш. Модельные испытания рыхлителя грунта с траекторным колебанием зуба // Водные ресурсы: опыт использования и проблемы. ЖГМСИ, – Тараз, 1997г., С. 176-181.