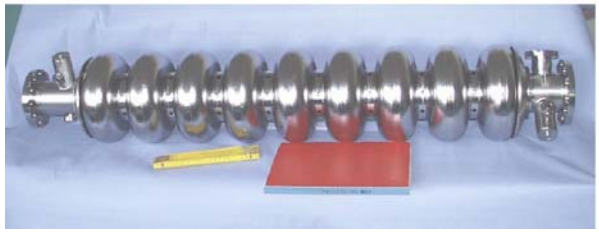
SRF 

Construction tube necking machine
Milestone Report: finished 24.02.05
WP Task 3.2.3.5

W.Singer
DESY, Hamburg, Germany

The tube necking machine was successfully constructed according the time table. The main schema and a machine photo can be seen in Figure 1 and 2.

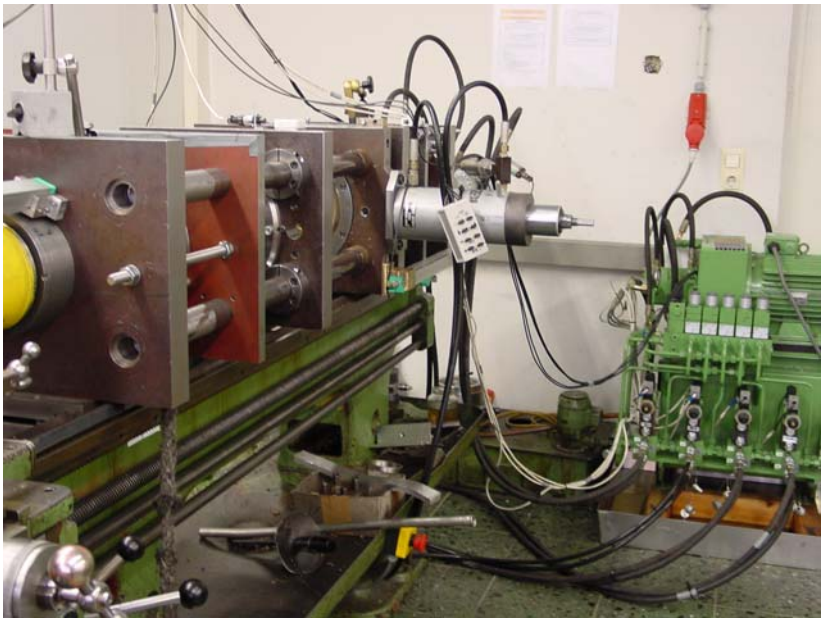


Fig. 1: Photo of the tube necking machine

Work supported by the European Community-Research Infrastructure Activity under the FP6 "Structuring the European Research Area" programme (CARE, contract number RII3-CT-2003-506395).

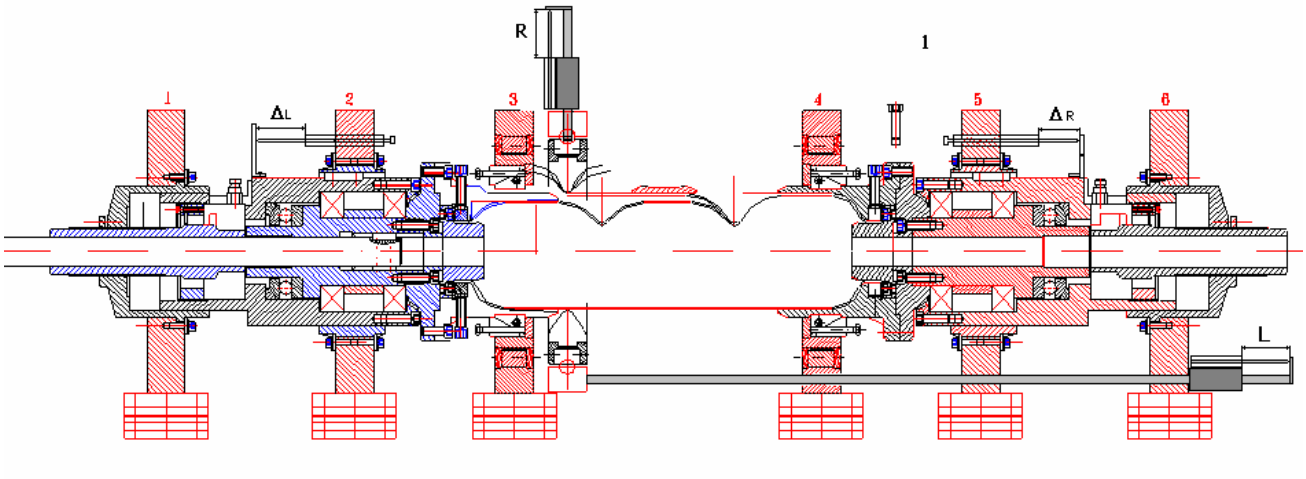


Fig.2: Schema of the tube necking machine (cross section)

The machine is foreseen for necking of Nb and NbCu tubes with diameter of 136 mm. The diameter should be reduced till 75.6 or 83.6 mm.

The machine consists of seven transversal plates. Several hydraulic cylinders are fixed on the plates.

- Left and the right cylinder for the application of axial pressure. Cylinder parameters: diameter 150 mm, stroke 125 mm, pressure 200 bar
- Cylinder for movement of the central plate. Cylinder parameters: diameter 100 mm, stroke 600 mm, pressure 200 bar
- Cylinder for movement of the instrument. Cylinder parameters: diameter 100 mm, stroke 45 mm, pressure 200 bar

All plates connected to each other using four bars of diameter 50 mm. Bars fixed rigidly on end plates.

All cylinders equipped with position and pressure sensors.

The necking machine is fixed on the lathe. The tube rotation is caused by lathe mechanism.

The machine is PC controlled. Two options of the software are created for two types of the tube necking (see Appendix 1 and 2):

Option 1: necking of the tube end to diameter of 75.6 or 83.6 mm (Software Neckend)

Option 2: necking of the tube middle (iris) to diameter of 75.6 mm (software Neckiris)

The first experiments have shown a good function of the machine. The necking of the Cu tubes both at the tube end and at the tube middle (iris) was successfully implemented (see figure 3). The optimization of the necking parameters is going on.

Fig. 3: Necking at the tube end and tube middle implemented by necking machine

Appendix: 1

Operating manual of the program "**Neckirism2.vi**" for necking of the middle part of the tube

For necking of the middle part of the tube they are used "Necking Machine" controlled by PC computer. Necked peace of tube is fixed with collets in "Necking Machine" and can be rotated in bearing supports (Fig.1.)

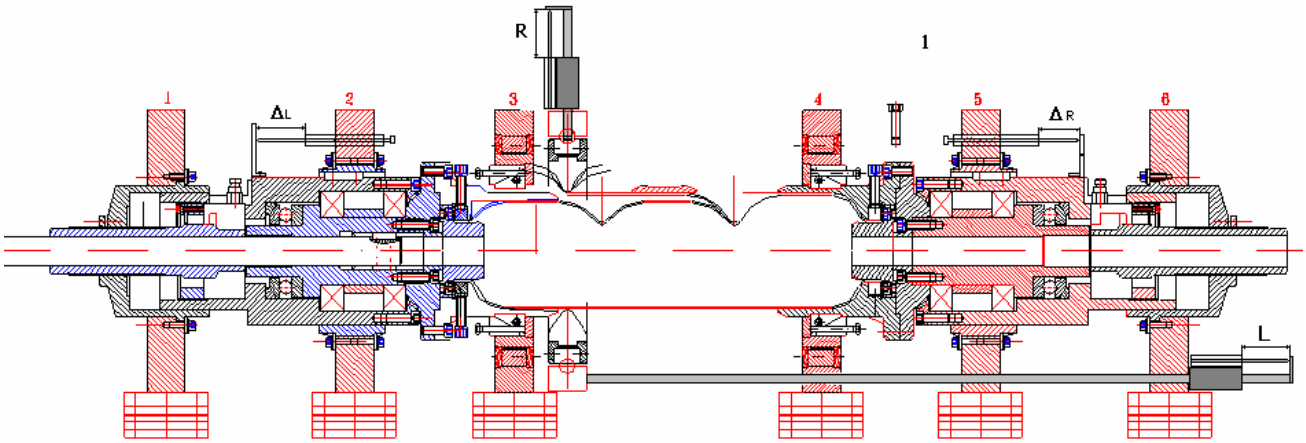


Fig.1 Fixation of the tube in "Necking Machine".

For measurement of the pressure of the oil in hydraulic cylinders are used two tensometrical pressure sensors Burster 8201-5200. Three potentiometrical sensors of the type Burster 8711-50 and one of the type 8718-500 are used for measurement of position of the necking ring in a radial direction, axial cylinders displacement and position of the necking ring in the longitudinal direction. Schema of cable connections is shown on Fig.2.

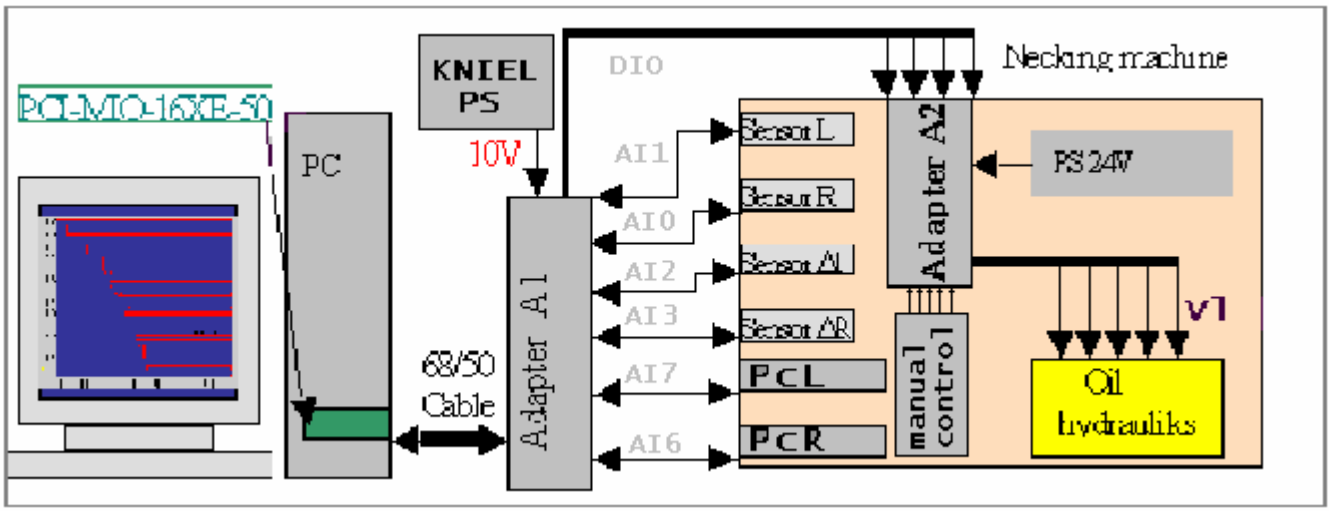


Fig.2 Schema of cable connections.

Electronics for measurement is this:

Power supply “KNIEL CPM 0802/PFS” supplied 10V voltage for normal operation of potentiometers and pressure sensors. Adapters A1 and A2 are for commutation of cables from computer, power supply, sensors and oil hydraulics control system.

1.“Sensor L”, 175 mm - length potentiometer is connected to input Nº1 of the adapter A1.
2.“Sensor R”, 50 mm - length potentiometer - input Nº0.
3.“Sensor ΔR(ight)”; 25 mm - length potentiometer - input Nº2.
4.“Sensor ΔL(eft)”, 25 mm - length potentiometer - input Nº3
5.“Sensor P**cR**”, 200 bar - potentiometer - input Nº6.
6.“Sensor P**cL**”, 200 bar - potentiometer - input Nº7.
-Output “C1” of adapter A2 (control of moving in L direction) is connected to input “VL” of -oil hydraulics.
-Output “C2”(opening of the hydraulics input valve) - to input “IN”.
-Output “C3”(control of moving in R-direction) - to input “VR”.
-Output “C4”(control of moving of the right axial cylinder) - to input “VΔR(ight)”.
-Output “C5”(control of moving of the left axial cylinder) - to input “VΔL(eft)”.

Program "**Neckendm3.vi**" is LabView code and located in the directory D:\Necking\ Front panel of the program is showed on Fig.3.

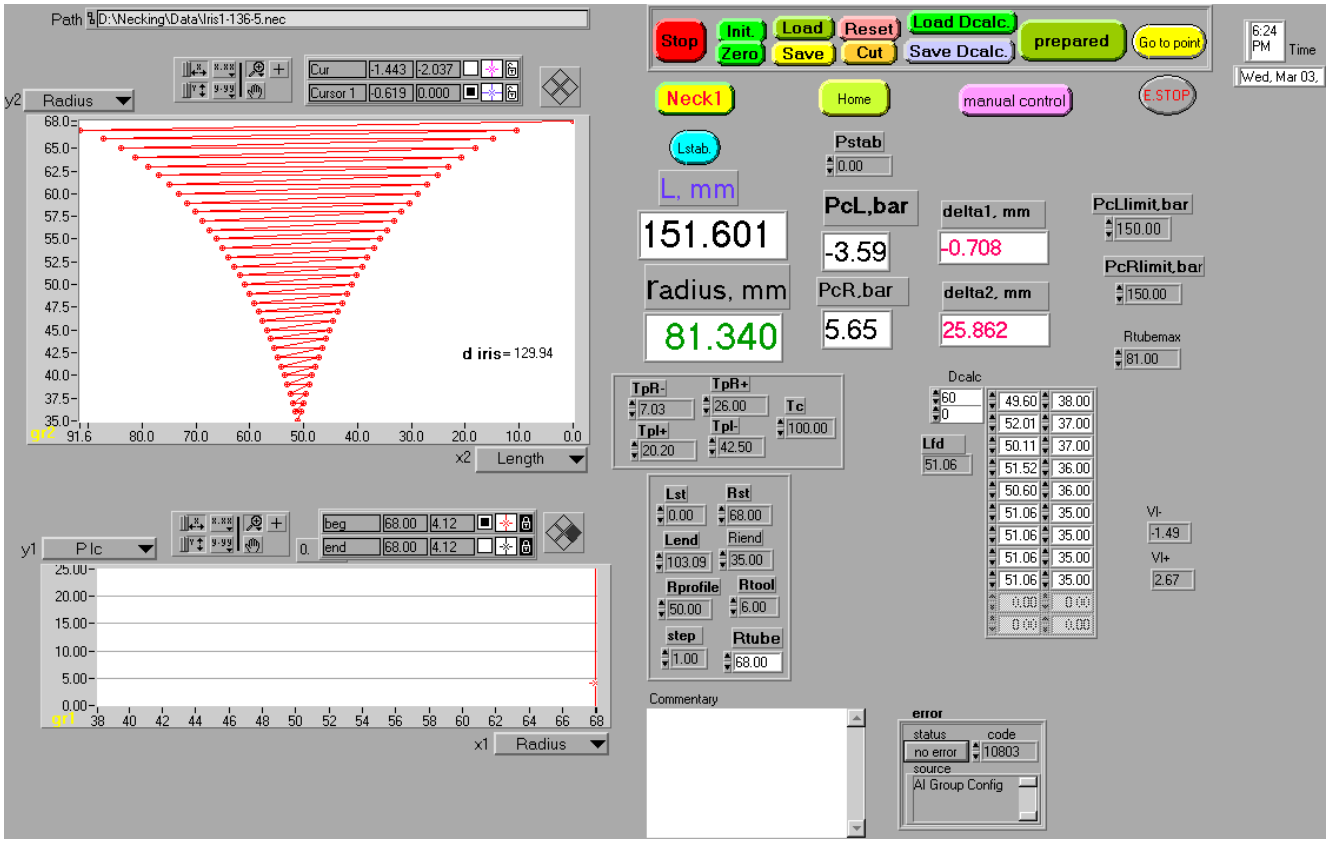


Fig.3 Front panel of the program Neckendm3.vi

The blue lines of graphs "gr1", "gr2" show the measured data, contained in the 2-dimentional arrays "**Data**".

1-st column of this array contains Time of the measurement,

2-nd column contain displacement L of the necking ring in the longitudinal direction from home position,

.3-d column is the radial position of the necking ring,

.4-th column is displacement Δright of the right holding cylinder,

.5-th pressure is in the left cylinder (in Bar).

.6-th pressure is in the right cylinder (in Bar).

.7-th column is displacement Δleft of the left holding cylinder

The Red lines of graphs "gr2" show the calculated data contained in the 2-dimentional array "**Dcalc**".

1st column of this array contains calculated displacement L (in mm) of the necking ring and 2nd column contains calculated radial position of the necking ring.

Indicators:

-L, mm shows displacement L (in mm) of the necking ring from home positional.

-radius, mm shows radial position of the necking ring.
-delta1, mm shows axial displacement of the left holding cylinder
-delta2, mm" shows axial displacement of the right holding cylinder
-PcL shows the oil pressure in left hydraulic cylinder.
-PcR shows the oil pressure in right hydraulic cylinder.
-Vl+, Vl-, - show velocities in time of necking.
-Error shows status and cod of device error.
-commentary are done for input parameters for saving in a data file.

Controls:

PcLlimit – maximum permitted pressure in the left cylinder.
PcRlimit – maximum permitted pressure in the right cylinder.
Pstab determinate the pressure in axial cylinders.
TpR- determinate the length of the pulse for moving in R- direction.
TpR+ determinate the length of the pulse for moving in R+ direction.
Tpl- determinate the length of the pulse for moving in L- direction.
Tpl+ determinate the length of the pulse for moving in L+ direction.
Tc determinate the period of the pulses.
Lst is the longitudinal start position for necking.
Rst is the radial start position for necking.
Lend is the longitudinal start position for necking.
Rprofile is the radius of tube profile circle.
Rinst is the radius of end part of the necking ring.
Rtube is the radius of tube.
Step is step of necking in radial directional.
Rtubemax determinate the maximal radius of tube for necking.
Pstab determinate the stabilize pressure in the holding cylinders.

Button "**Zero**".

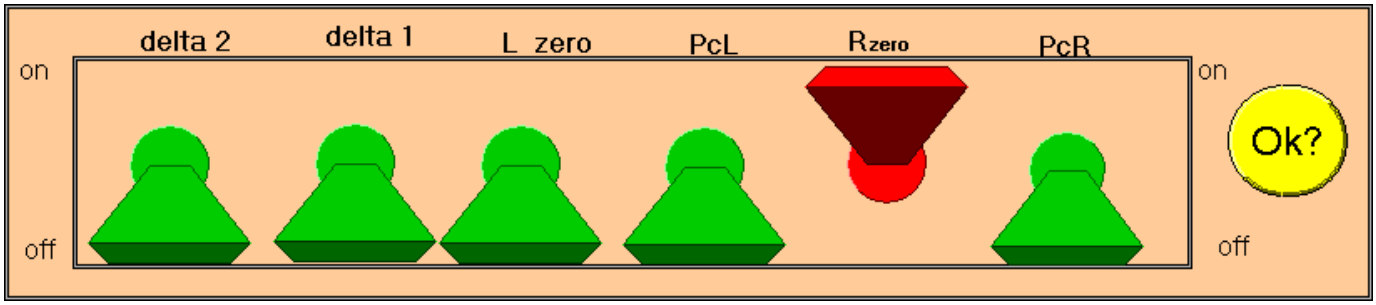


Fig.4 Front panel of the subprogram "zeromea.vi".

Because before starting of the necking, the positions of the potentiometers and pressure sensors are occasional, it's necessary to measure them and define these positions as initial (or zero) positions. To make this procedure is necessary to push button "Zero". After pressing of this button opens the window:

In this case buttons "**Rzero**" is pushed. After clicking on the button "**Ok?**" this window is closed and only the values of the indicator "**Rzero**" is seated to initial value.

For indicator "**Rzero**" initial value is Rtubemax. And for other indicators is zero.

Button "**Init**".

After pushing this button be opened the front panel of the "Neck init.vi"(Fig.5).

Fig.5 Front panel of the subprogram "zeromea.vi".

Button "**Init**" for initialization of the hardware (ADC card PCI-MIO-16XE-50). After clicking of this button opened the window:

Control "**DIO direction map**" defined direction (input = 0 or output = 1) of the channels of the 8-bit digital input/output port. For each cylinder are required two bits: 1-st bit for permission and 2-nd bit for direction.

Controls "**port number and N of chan**" is for serial port initialization.

Control "**AI channel setting**" define gain, input mode, polarity and of the input signal.

Controls "**Prc coef**", "**Plc coef**", "**L coef**", "**R coef**", "**delta coef1**", "**delta coef 2**" declare the coefficients for transfers of the volts in real physical values as global variables.

After setting of this controls click the button "OK".

Button "Load Dcalc."

For loading calculated data "Dcalc" from computer memory push the button "Load Dcalc". These data previously prepared by "Microsoft Excel" or another program and saved in text format.

Button "Save Dcalc"

After editing of the "**Dcalc**" to save them to computer memory push the button "**Save Dcalc.**".

Button "**Prepared**"

If parameters of Necking are ready press this button to calculate the points of necking curve (array Dcalc).

Button "**Go to point**"

After press this button they can input the point where they want to go and press button "Go".

Button "**Stab L**"

This button is switch between two types of stabilization. Stab-L is for holding cylinders in the same position, and Stab-P is for holding the pressure in axial cylinder constant.

Button

After clicking on this button starts (or continued) process of necking.

1) Necking ring is moved in start position Lst and then in Rst.
2) Start moving in R- direction on one step (dS).
3) Start moving in L+ direction to the point Lp (point where the circle of the necking instrument touch the profile circle of necking tube).
4) Start moving in R+ direction on two steps dS.
5) Start moving in L- direction to point Lst.
6) After reaching of position Lst process repeated again and instrument goes in R-direction on the two steps from Rst.

To stop process of necking and storing measured data in array "**Data**", push the button

In each step is checked the pressure inside of cylinders, if **Pcl**>Plcmax or **PcR**>Prcmax the oil pump's are stopped.

Button "Cut" and "Reset"

It's possible some editing of the array "**Data**".

1. Using of the button "**Cut**". Move red and black cursors in the graph "gr1" to the desired position and push button "**Cut**". Data between these cursors will be deleted from array "**Data**".

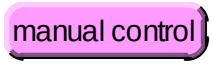
2. Using of the button "**Reset**". For deleting all data from array "**Data**" push the button "**Reset**".

Button "Save" and "Load"

For storing of the data of array "**Data**" and some commentary (from string "**Commentary**") to computer HD, click the button "**Save**".

For restoring of the data of array "**Data**" and string "**Commentary**" from computer HD, click the button "**Load**". If some mistakes occur during file dialog, old data will be returned.

In both case initial path for file dialog is defined by control "**Path**".

Button 

After clicking of the button you can see a cluster of 8-buttons (2-buttons for each
cylinder). For moving in L+ direction click and hold the button "L+" and etc.

Short instructions for User.

1. Start the program. If program started first time after restarting of the computer, automatically started initialization of the hardware.
2. Switch on hydraulic system and install a tube into Necking Machine.
3. Turn valves of the oil hydraulic system to desired positions. Velocity dependences of the oil hydraulic cylinders are shown on Fig.6, 7,8.
4. Before beginning of hydroforming of the tube:

a) Click the button "**Zero**" to measure initial positions of sensors.

b) Click the button "**Reset**" to clear array "**Data**".

c) Check the parameters of hydraulic system, start points, radii of tube, necking ring and profile of necking, type of stabilization.

d) click the button "**Prepared**" for calculation of profile data.

5. To start hydroforming process of the tube, click the button "**Start Neck**".
6. After hydroforming process of the tube insert some commentary and store measured data to computer HD by clicking on button "**Save**".

7. To stop "Neckirism3"click "**Stop**".

Dr	Vl+ mm/sec	Vl- mm/sec
-25	37.663	32.581
0	35.463	29.773
50	30.24	23.796
100	24.398	16.997
125	21.928	14.207
150	19.076	11.487
175	15.639	8.867
200	13.203	6.649
225	10.81	5.101
250	8.252	3.674
275	5.916	2.546
300	3.266	1.331
325	1.935	0.754
350	0.723	0.184
375	0.151	0.06

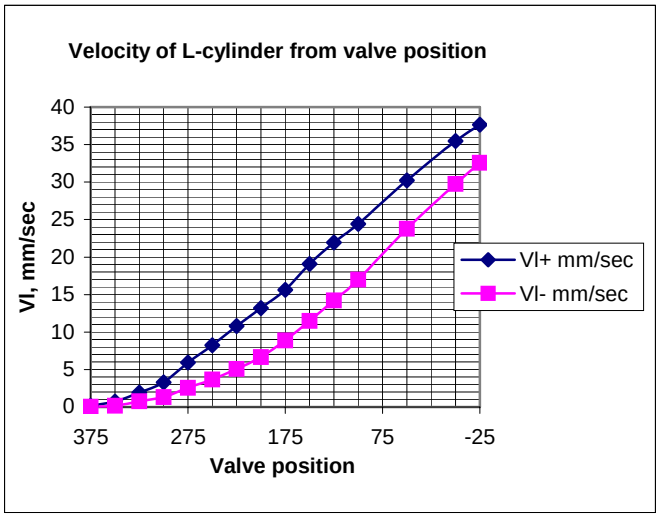


Fig.6. Velocity in L+-directions as a function of valve position.

valve position	Vr-
0	0.197
25	0.242
50	0.307
75	0.374
90	0.437
120	0.595
145	0.832
170	1.598
195	2.309
220	2.39
245	2.396
300	2.489
350	2.573

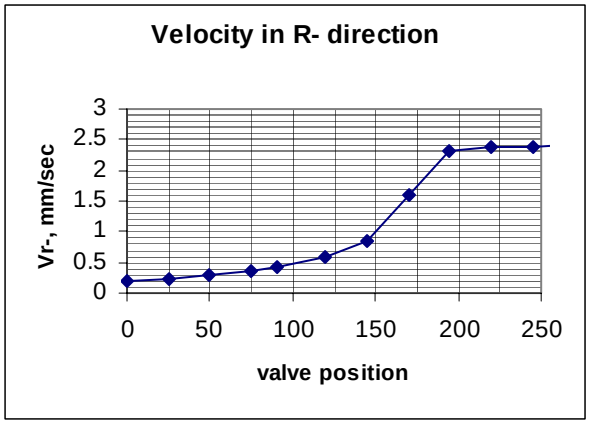
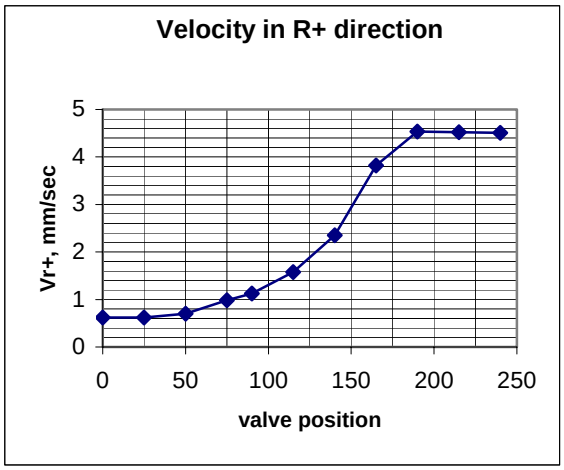


Fig.7. Velocity in R- directions as a function of valve position.

valve position	Vr+
0	0.618
25	0.62
50	0.704
75	0.986
90	1.122
115	1.58
140	2.351
165	3.824
190	4.533
215	4.522
240	4.511

Fig.8. Velocity in R+-directions as a function of valve position



Appendix 2

Operating manual
of the program "**Neckendm3.vi**" for necking of the tube end.

For necking of the tube end they are used "Necking Machine" controlled by PC computer. Necked peace of tube is fixed with collets in "Necking Machine" and can be rotated in bearing supports (Fig.1.)

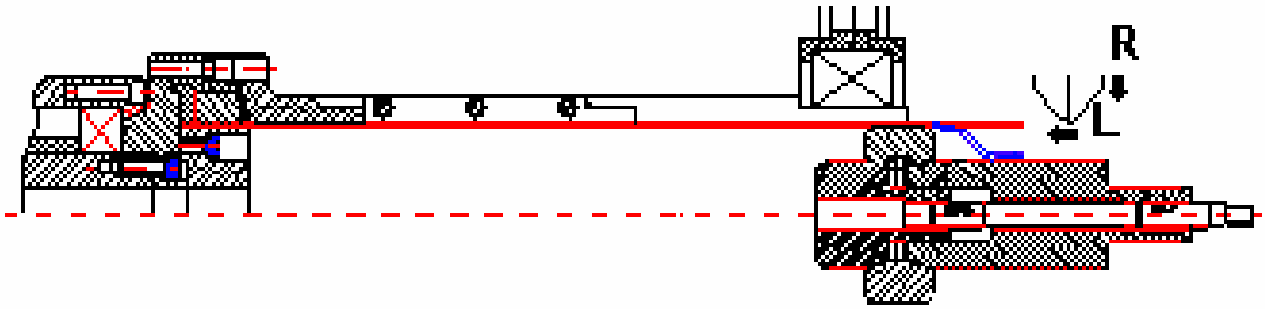


Fig.1 Fixation of the tube in "Necking Machine".

For measurement of the pressure of the oil in hydraulic cylinders are used two tensometrical pressure sensors Burster 8201-5200. Three potentiometrical sensors of the type Burster 8711-50 and one of the type 8718-500 are used for measurement of position of the necking ring in a radial direction, axial cylinders displacement and position of the necking ring in the longitudinal direction. Schema of cable connections is shown on Fig.2.

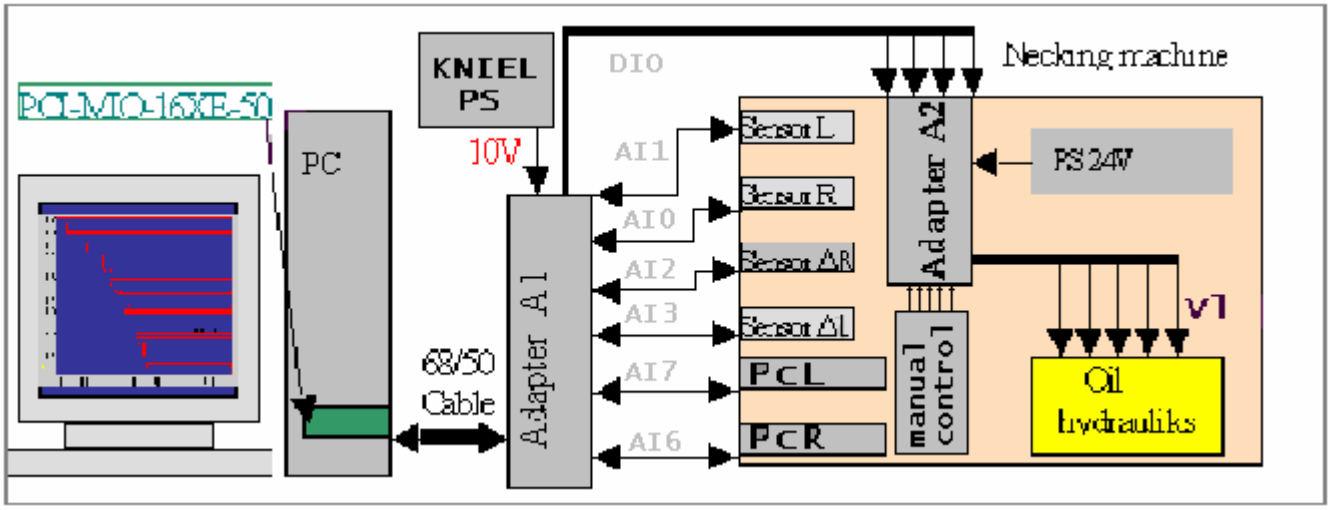


Fig.2 Schema of cable connections.

Electronics for measurement is this:

Power supply “KNIEL CPM 0802/PFS” supplied 10V voltage for normal operation of potentiometers and pressure sensors. Adapters A1 and A2 are for commutation of cables from computer, power supply, sensors and oil hydraulics control system.

1.“Sensor L”, 500 mm - length potentiometer is connected to input N^{o}1 of the adapter A1.
2.“Sensor R”, 50 mm - length potentiometer - input N^{o}0.
3.“Sensor ΔR(ight)”; 50 mm - length potentiometer - input N^{o}2.
4.“Sensor ΔL(eft)”, 50 mm - length potentiometer - input N^{o}3
5.“Sensor P**cR**”, 200 bar - potentiometer - input N^{o}6.
6.“Sensor P**cL**”, 200 bar - potentiometer - input N^{o}7.
-Output “C1” of adapter A2 (control of moving in L direction) is connected to input “VL” of -oil hydraulics.
-Output “C2”(opening of the hydraulics input valve) - to input “IN”.
-Output “C3”(control of moving in R-direction) - to input “VR”.
-Output “C4”(control of moving of the right axial cylinder) - to input “VΔR(ight)”.
-Output “C5”(control of moving of the left axial cylinder) - to input “VΔL(eft)”.

Program “**Neckendm3.vi**” is LabView code and located in the directory D:\Necking\ Front panel of the program is showed on Fig.3.

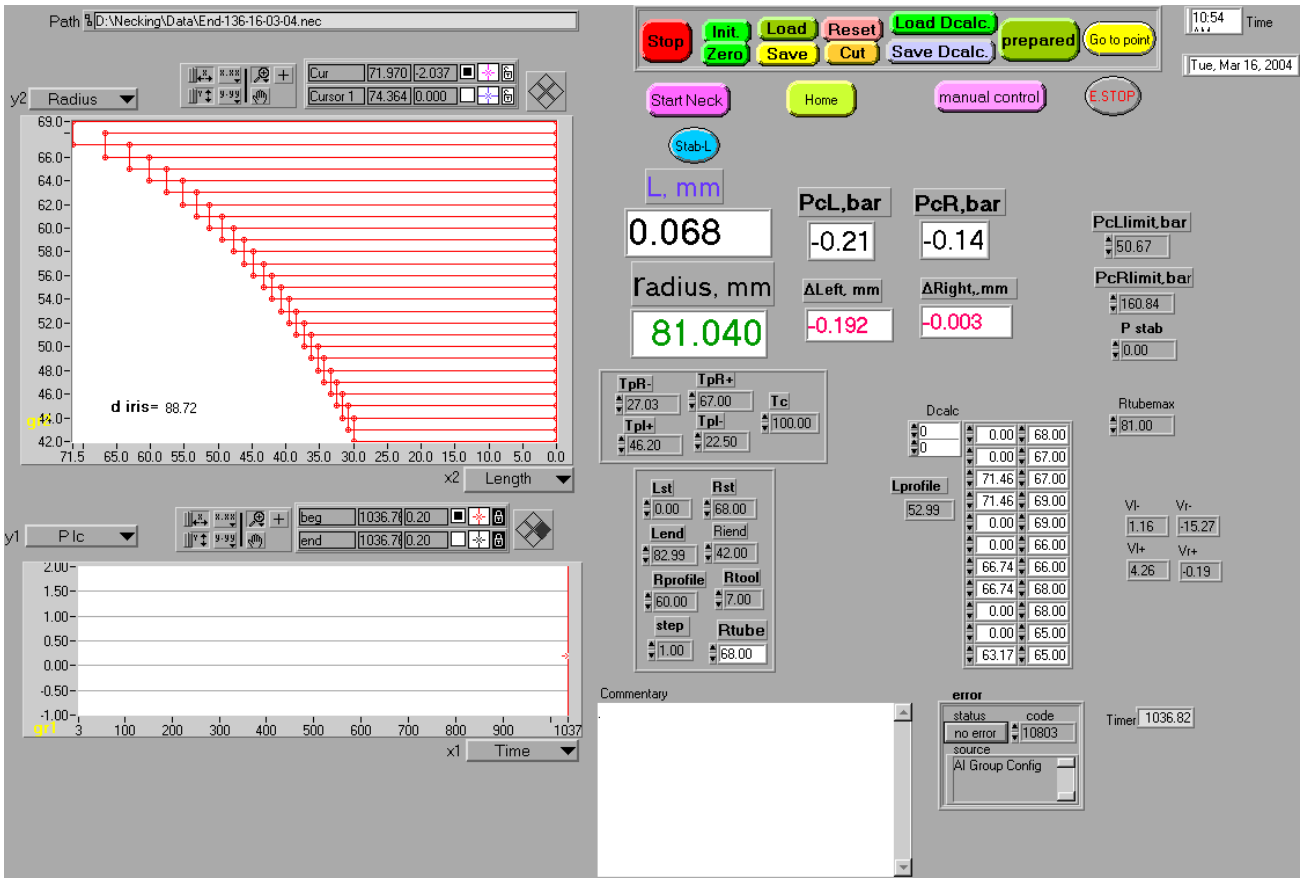


Fig.3 Front panel of the program Neckendm3.vi

The blue lines of graphs "gr1", "gr2" show the measured data, contained in the 2-dimentional arrays "**Data**".

1-st column of this array contains Time of the measurement,

2-nd column contain displacement L of the necking ring in the longitudinal direction from home position,

.3-d column is the radial position of the necking ring.

.4-th column is displacement Dright of the right holding cylinder.

.5-th pressure is in the left holding cylinder (in Bar).

.6-th pressure is in the right holding cylinder (in Bar).

.7-th column is displacement Dleft of the left holding cylinder

The Red lines of graphs "gr2" show the calculated data contained in the 2-dimentional array "**Dcalc**".

1st column of this array contains calculated displacement L (in mm) of the necking ring and 2nd column contains calculated radial position of the necking ring.

Indicators:

-L, mm shows displacement L (in mm) of the necking ring from home positional.

-radius, mm shows radial position of the necking ring.

-dright, mm shows axial displacement of the right holding cylinder

-dleft, mm" shows axial displacement of the left holding cylinder
-PcL shows the oil pressure in left hydraulic cylinder.
-PcR shows the oil pressure in right hydraulic cylinder.
-Vl+, Vl-, Vr+, Vr- show velocities in time of necking.
-Error shows status and cod of device error.
-commentary are done for input parameters for saving in a data file.

Controls:

PcLlimit – maximum permitted pressure in the left cylinder.
PcRlimit – maximum permitted pressure in the right cylinder.
Pstab determinate the pressure in axial cylinders.
TpR- determinate the length of the pulse for moving in R- direction.
TpR+ determinate the length of the pulse for moving in R+ direction.
Tpl- determinate the length of the pulse for moving in L- direction.
Tpl+ determinate the length of the pulse for moving in L+ direction.
Tc determinate the period of the pulses.
Lst is the longitudinal start position for necking.
Rst is the radial start position for necking.
Lend is the longitudinal start position for necking.
Rprofile is the radius of tube profile circle.
Rinst is the radius of end part of the necking ring.
Rtube is the radius of tube.
Step is step of necking in radial directional.
Rtubemax determinate the maximal radius of tube for necking.
Pstab determinate the stabilize pressure in the holding cylinders.

Button "**Zero**".

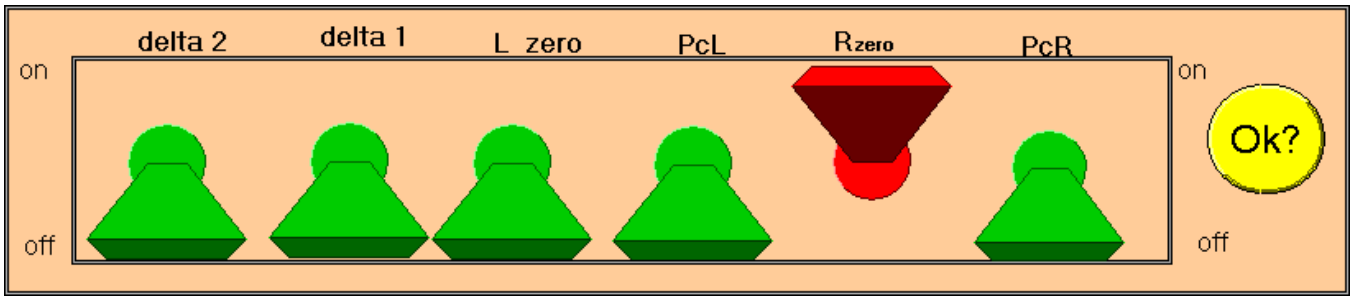


Fig.4 Front panel of the subprogram "zeromea.vi".

Because before starting of the necking, the positions of the potentiometers and pressure sensors are occasional, it's necessary to measure them and define these positions as initial (or zero) positions. To make this procedure is necessary to push button "Zero". After pressing of this button opens the window:

In this case buttons "**Rzero**" is pushed. After clicking on the button "**Ok?**" this window is closed and only the values of the indicator "**Rzero**" is seated to initial value.

For indicator "**Rzero**" initial value is Rtubemax. And for other indicators is zero.

Button "**Init**".

After pushing this button be opened the front panel of the "Neck init.vi"(Fig.5).

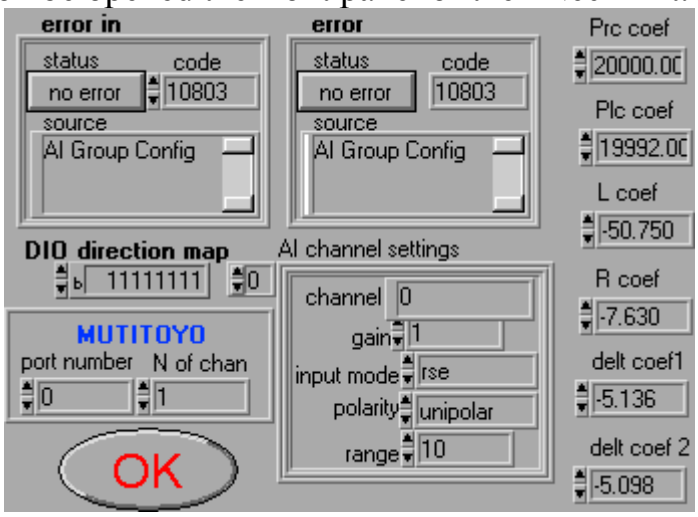


Fig.5 Front panel of the subprogram "zeromea.vi".

Button "**Init**" for initialization of the hardware (ADC card PCI-MIO-16XE-50). After clicking of this button opened the window:

Control "**DIO direction map**" defined direction (input = 0 or output = 1) of the channels of the 8-bit digital input/output port. For each cylinder are required two bits: 1-st bit for permission and 2-nd bit for direction.

Controls "**port number and N of chan**" is for serial port initialization.

Control "**AI channel setting**" define gain, input mode, polarity and of the input signal. Controls "**Prc coef**", "**Plc coef**", "**L coef**", "**R coef**", "**delta coef1**", "**delta coef 2**" declare the coefficients for transfers of the volts in real physical values as global variables

After setting of this controls click the button "OK".

Button "Load Dcalc.**"**

For loading calculated data "Dcalc**" from computer memory push the button "**Load Dcalc**". These data previously prepared by "Microsoft Excel" or another program and saved in text format.**

Button "Save Dcalc**"**

After editing of the "**Dcalc**" to save them to computer memory push the button "**Save Dcalc.**".

Button "**Prepared**"

If parameters of Necking are ready press this button to calculate the points of necking curve (array Dcalc).

Button "**Go to point**"

After press this button they can input the point where they want to go and press button "Go".

Button "**Home**"

For coming in "Home" position (R=81, L=0) one can use this button. Home position for R direction is determinated by control "Rtubemax".

Button "**Stab L**"

This button is switch between two types of stabilization. Stab-L is for holding cylinders in the same position, and Stab-P is for holding the pressure in axial cylinder constant.

Button Start Neck

After clicking on this button starts (or continued) process of necking.

7) Necking ring is moved in start position Lst and then in Rst.
8) Start moving in R- direction on one step (dS).
9) Start moving in L+ direction to the point Lp (point where the circle of the necking instrument touch the profile circle of necking tube).
10) Start moving in R+ direction on two steps dS.
11) Start moving in L- direction to point Lst.
12) After reaching of position Lst process repeated again and instrument goes in R-direction on the two steps from Rst.

To stop process of necking and storing measured data in array "**Data**", push the button Stop Neck

In each step is checked the pressure inside of cylinders, if **PcL**>PcLlimit or **PcR**>PcRlimit the oil pump's are stopped.

Button "Cut" and "Reset"

It's possible some editing of the array "**Data**".

1. Using of the button "**Cut**". Move red and black cursors in the graph "gr1" to the desired position and push button "**Cut**". Data between these cursors will be deleted from array "**Data**".

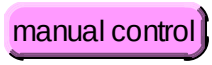
2. Using of the button "**Reset**". For deleting all data from array "**Data**" push the button "**Reset**".

Button "Save" and "Load"

For storing of the data of array "**Data**" and some commentary (from string "**Commentary**") to computer HD, click the button "**Save**".

For restoring of the data of array "**Data**" and string "**Commentary**" from computer HD, click the button "**Load**". If some mistakes occur during file dialog, old data will be returned.

In both case initial path for file dialog is defined by control "**Path**".

Button 

After clicking of the button you can see a cluster of 8-buttons (2-buttons for each
cylinder). For moving in L+ direction click and hold the button "L+" and etc.

Short instructions for User.

8. Start the program. If program started first time after restarting of the computer, automatically started initialization of the hardware.

9. Switch on hydraulic system and install a tube into Necking Machine.

10. Turn valves of the oil hydraulic system to desired positions. Velocity dependences of the oil hydraulic cylinders are shown on Fig.6, 7,8.

11. Before beginning of hydroforming of the tube:

e) Click the button "**Zero**" to measure initial positions of sensors.

f) Click the button "**Reset**" to clear array "**Data**".

g) Check the parameters of hydraulic system, start point, radii of tube, necking ring and profile of necking.

h) click the button "**Prepared**" for calculation of profile data.

12. To start hydroforming process of the tube, click the button "**Start Neck**".

13. After hydroforming process of the tube insert some commentary and store measured data to computer HD by clicking on button "**Save**".

14. To stop "Neckendm3"click "**Stop**".

Dr	Vl+ mm/sec	Vl- mm/sec
-25	37.663	32.581
0	35.463	29.773
50	30.24	23.796
100	24.398	16.997
125	21.928	14.207
150	19.076	11.487
175	15.639	8.867
200	13.203	6.649
225	10.81	5.101
250	8.252	3.674
275	5.916	2.546
300	3.266	1.331
325	1.935	0.754
350	0.723	0.184
375	0.151	0.06

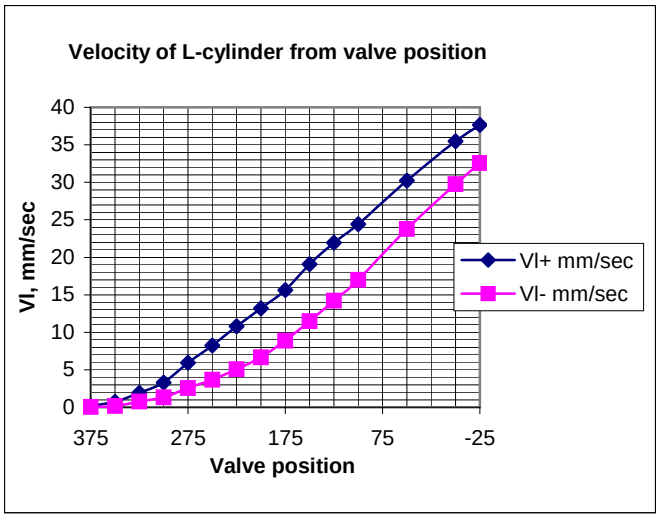


Fig.6. Velocity in L+-directions as a function of valve position.

valve position	Vr-
0	0.197
25	0.242
50	0.307
75	0.374
90	0.437
120	0.595
145	0.832
170	1.598
195	2.309
220	2.39
245	2.396
300	2.489
350	2.573

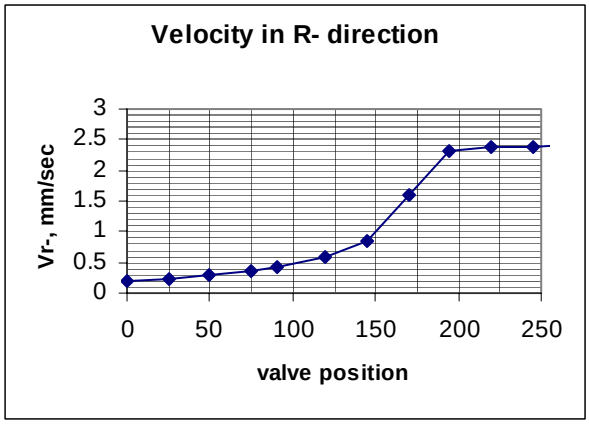


Fig.7. Velocity in R- directions as a function of valve position

valve position	Vr+
0	0.618
25	0.62
50	0.704
75	0.986
90	1.122
115	1.58
140	2.351
165	3.824
190	4.533
215	4.522
240	4.511

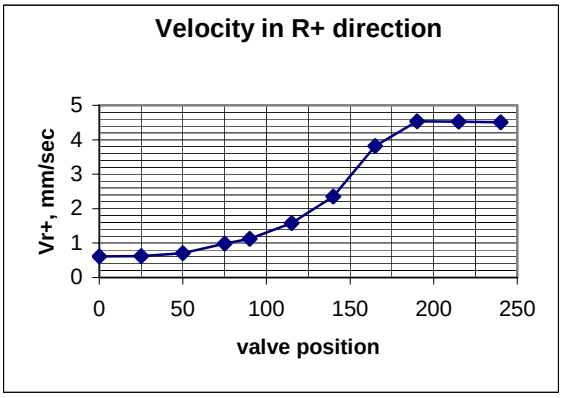


Fig.8. Velocity in R+-directions as a function of valve position