

Piezoelectric Actuator for precise and fast "Oval Pistons" manufacturing.

Thomas MAILLARD - Cedrat Technologies S.A.

Piezoelectric Actuator and related driving & control electronic for precise and fast «Oval Pistons» manufacturing

Oval pistons are used in all automotive industry. Every vehicle, motorbike, car and truck uses oval pistons. The reason is that pistons in these vehicles are working in very hot environment and as a consequence, the external shape deformation induced thermal growth of the piston is compensated by these «ovalities» (oval shapes).

Another important consequence is that «ovality» and barrel shape may significantly reduce the noise level and increase the lubricating effect.

Traditionally the «ovality» is made with machines using mechanical cams, with two limitations:

- The machining speed can't go over some 500 r.p.m,
- The «ovality» has to be constant, it is not possible to change the amount of radial displacement to produce the ellipse,

Latest developments recommend the machining of piston with variable «ovality», i.e different «ovalities» along the piston body, in order to achieve better working performances. This variable «ovality» is only possible thanks to the use of electronic programmable cam.

Some manufacturers of CNC Lathes provide an «oval» turning option thanks to the integration of a ball screw and servo motor as a programmable cam to pilot the piston machining tool. The ball screw and servo motor is the combination of an electrical rotating motor coupled with a ball screw in order to perform a linear movement. Despite of providing a solution for variable «ovality» compared to traditional cam, the ball screw linear motor suffers from three problems:

- A lack of precision, due to back lash of the screw,
- A poor linear velocity, due to the power limitation of the rotating motor.
- A drastical reduction in the ball screw's life, due to the high accelerations supported and high frequency movements.

A recent collaboration between ENTECH SA, a Spanish manufacturer of special machines, and CEDRAT TECHNOLOGIES SA, a French electromechanical engineering company and manufacturer of piezoelectric actuators, led to a major innovation in the field of oval piston machining. The innovation relies on the use of a piezoelectric actuator to move the cutting tool for precisely machining the oval shape on the piston contour (see figures 1, 2 & 3).

Piezoelectric actuators are well known for their high precision (sub micron) and short response time (sub millisecond) in actuation when they are driven and controlled through the best fitted electronic, but they are often considered as a fragile technology. Piezoelectric actuators from CEDRAT TECHNOLOGIES were developed initially for air & space applications, so in addition to usually precision, they are able to withstand large external vibrations. This advantage renders them adapted for several machine tool applications.



Figure 1: machining tool & oval piston (courtesy of Entech)

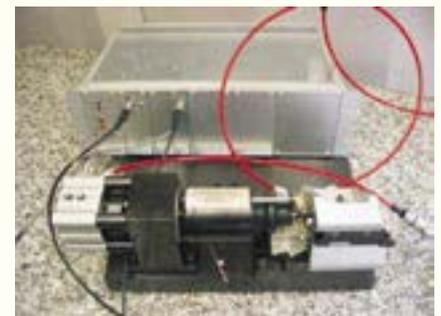


Figure 2: LA75B driver & machining tool with embedded PPA60L



Figure 3: PPA60L

References	Unit	PPA60L
Notes	-	-
Displacement	(μm)	60
Blocked force	(N)	3500
Stiffness	(N/ μm)	58.3
Resonance frequency (free-free)	(Hz)	9500
Response time (free-free)	(ms)	0.05
Resonance frequency (blocked-free)	(Hz)	4750
Response time (blocked-free)	(ms)	0.11
Voltage range	(V)	-20 ... 150
Capacitance	(μF)	20.0
Resolution	(nm)	0.6
Thermo-mechanical behaviour	($\mu\text{m}/^\circ\text{K}$)	-0.06
Height (in actuation direction)	(mm)	77.0
Base length	(mm)	23.5
Base width	(mm)	18.0
Mass	(g)	117.0

Table 1 Technical data sheet of PPA60L

(continued on page 7)

Piezoelectric Actuator for precise and fast "Oval Pistons" manufacturing. (continued)

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In the particular case of the oval piston machines, Cedrat Technologies has provided to Entech a complete piezoelectric solution based on a standard parallel pre-stressed actuator PPA60L and a customised linear driving electronic rack from its standard LA75B (see tables 1 & 2 for technical data). The PPA60L is equipped with strain gages (SG) in order to insure a precise feed back positioning control of the machining tool.

The performances of the piezoelectric machining tool for oval piston are summarised in the following table:

Characteristics	Unit	Datas
Mass	Kg	2.5
Generated force	N	15.5
Stroke	µm	50
Accuracy	µm	1
Resolution	µm	0.1
Bandwidth	Hz	66
Rotation Speed of the piston	rpm	2,000

As a conclusion, thanks to its standard piezoelectric actuator and related driving electronic, Cedrat Technologies allows the oval piston machining to be 6 times faster, more accurate and reliable than the traditional one. This innovation can also be adapted to other industrial machining process and in the field of manufacturing of challenging shapes in plastics, aluminium, brass, glass and nickel (contact lens, casting molds, etc...).

References	Unit	LA75B-x
Notes		x : number of channel
Function		Linear amplifier
Max. number of channels		2
Cooling		Largeur 10F, hauteur 3H
Supply voltage [j]	VDC	-35 / 168
Output voltage [j]	V	-20 ... 150
Quiescent current	mA	2.0
Maximal output current[a,b,d,h]	A	0.36
Maximal output power (continuous) [a,b,d,h]	VA	61
Max. output load capacitance	µF	400
Control input voltage	V	-1 ... 7.5
Signal to noise ratio [k]	dB	85
Output bandwidth [l]	Hz	616
DC offset setting		10 turn potentiometer
PZT connector		LEMO ERN.00.250.CTL
External Control Input		BNC / 50 Ohms
Input impedance	kOhms	10
Rear interface		DIN 41612 FormeC 64/96
Weight	kg	0.55 (1 channel) 0.97 (2 channels)
Dimensions	mm	10F wide, 3H high

Table 2 technical data sheet of LA75B

Piezo Products Catalogue V3.1 - June 2005 release.

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The PIEZO PRODUCTS catalogue Version 3.1 of CEDRAT TECHNOLOGIES includes many new devices, among which:

- **New mechanisms:** Objective Piezo Positionner (OPP120SM) for focussing microscope objective, Fast Piezo Shutter (FPS200M) for X-ray facilities, Tilt Translator (TT60SM) and Double Tip-Tilt (DTT35XS) ultra-compact mechanism for Laser deflection and cavity tuning, 3 dof stage (XYZ200M & XYRZ200M) for scanning and positioning tasks...

- **New electronics :** Low cost and single channel Compact Amplifier CA45 ...

All these new products in addition to existing ones lead to a 100 pages' catalogue in new printed release which satisfies you hopefully.

If you want to receive it: just download it in our website <http://www.cedrat.com> in ACTUATORS corner or please contact : Valérie CHOUARD, Tel (33) 4 76 90 50 45, Fax (33)4 76 90 16 09, or send an Email to actuator@cedrat.com - choose your form : Paper (100p) or PDF file (3Mb).



New Reps for Cedrat Technologies in USA, Canada and Singapore...

CEDRAT TECHNOLOGIES has signed agreements with MicroMechatronics Inc., Delta Photonics Corp and Laser 21 Pte Ltd for promotion and distribution of its piezo products respectively in USA, Canada and Singapore. CEDRAT TECHNOLOGIES now registers more than 14 partners for the promotion and distribution of its piezo products around the world.