Creep Factor Validation of Piezoelectric Actuator

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Abstract- *A major deficiency of piezo stack actuator is their hysteresis and creep characteristics. Because of this lack of accuracy introduce in the system, it laid to different result of actuation. In which creep factor is very important factor but it less inspecting in comparison with hysteresis characteristics of piezo actuator. This creep of piezo actuator gives some drift (displacement) due to their logarithmic increasing in nature. This paper proposed technique to find out creep characteristics of piezo actuator .Indeed, creep factor also find out and finally validate their results with comparing theoretical values and graphical values.*

Keywords- Piezo actuator, Creep, Hysteresis.

I. INTRODUCTION

Piezoelectric translator actuators, with their high stiffness, fast frequency response, and high resolution, are increasingly being used in micro positioning applications, scanning tunnelling microscope, fast steering mirror.[7] However, there fundamentally nature are nonlinear. This nonlinearity observed when external electric field applied on piezo electric actuator. Cause of their nonlinearity is their ferromagnetic PZT materials. Non linearity of piezo electric actuator is classified in two categories. First hysteresis which is to relation between applied step of electric voltage and corresponds to their displacement. Second is creep characteristic, which is logarithmic in nature [3].Creep characteristic of piezo electric actuator gives drift after applying constant voltage to piezo electric actuator. There are so many methods to compensate these undesirable characteristics. Open loop compensation with inverse control of piezo actuator with hysteresis model, and creep model [2], by adding capacitor in their piezo electric actuating circuit to reduce its sensitivity [6].Close loop operation with the help of strain gauge attached piezo actuator.[2].However, creep characteristics of piezoelectric actuator have been investigated less frequently compared with hysteresis. But, Creep phenomenon is a very important factor in many application of the PZT actuator. For instance, in a fast steering jitter stabilization are in microns also their movements are in microns at that time this uneven characteristic s affect the on their results[7]. In which analyzing slow drift of PZT displacement after applying a constant electric field is very important for improving the precision positioning. The purpose of this article is to investigate the PZT actuator's creep characteristics. We suggest that the PZT actuator's creep has hysteretic properties and therefore it can be possible to predict an open loop response of a PZT actuator based on these properties.

II. CREEP MODELLING

A major problem of piezo electric actuator is that that their open loop control accuracy because of their creep and hysteresis characteristics. In which One "Creep" characteristics finding activity describe here. For creep characterisation of the piezo actuator let us first understand Creep of piezo actuator,When we apply the constant voltage to piezo actuator ,It gives the response in terms of displacement with respect to given voltage, but if this voltage is apply continuously over the period of time the minor displacement of piezo actuator will increase automatically which is called as Creep of piezo actuator. Genarally,The creep response has logarithmic shape over time. It is the Unwanted characteristics of piezo actuator that gives drift to fast steering mirror over the period of time. So, for this finding out of drift over the period of time we must find out the creep factor of piezo actuator from the given equation.

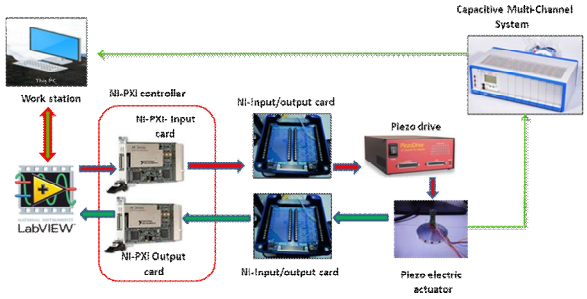
$$L(t) = Lo\left[1 + \gamma \log_{10}\left(\frac{t}{0.1}\right)\right]$$

where L(t) is a PZT actuator's displacement for any fixed input voltage,Lo is a initial displacement value with sometime after applying the input voltage, and γ is a creep factor. In which creep factor (γ) is used to determine the rate of the logarithm.

III. EXPERIMENTAL SET UP

The experimental setup of Finding out creep factor is shown in Fig. 1.Stack type piezo actuator is used. Which has nominal displacement of 5.3µm for 20V.creep factor is different for diffrent voltage[5].Fig.1 shows the structure of experiment test control system. For measurenment displacement in microns non contact type displacement sensor(capacitive probe) is used. capacitive probe mouted on the mouted assembly as sshown in fig.2For their fast by later interfacing Eather CAT cable is used,whose speed of receiver

has 100 MB/s. piezo electric actuator is mounted on small flate surface. For piezo actuator driving NI inputcard with piezo amplifier is used.



CREEP MEASUREMENT METHODOLOGY

Here inspected creep factor by applying Constant 5V DC supply step voltage to piezo actuator. These are the steps that followed to find out creep factor.First made LabVIEW program to provide the single step input for 115 sec to the piezo actuator ,Through this program it gives continuously 0.5V through NI-PXI controller and this controller is connected to the piezo drive(amplifier), Gain of Ampliphire is 10,therefore it gives 10 times higher volt then given voltage, so indirectly provide 5V to piezo actuator next step is to measure this single step response which is given to piezo actuator with the help of non contact type displacement sensor or say capacitive probe. LabVIEW Programmed for automatic store the value of displacement of piezo actuator in Excel sheet every after 0.1919sec time interval.

Figure. 5. Structure of experiment test control system.

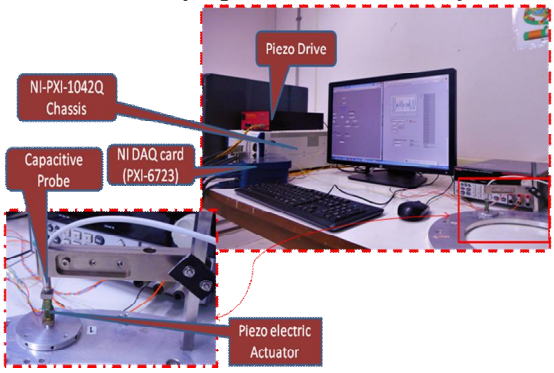
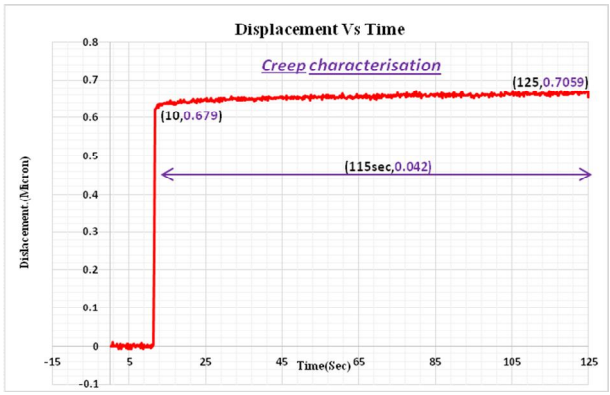


Figure 1. Experimental test set up

IV. RESULTS

In this experiment ,While applying this methology for inspecting the creep factor, Graph shows the intial step voltage value given at 10 second and with respect to it 0.679 micron displacement is measured,then provide 5V DC external supply for 125secons and at that time noticiable change in their displacement which is equal to 0.7059. So from creep factor finding equation we are getting the value of creep factor0.0435.



V. VERIFICATION AND DISCUSSION

To verify the proposed results of creep characteristics of piezoelectric actuator first finding values of creep factor First finding out their theoretical values from creep finding equation[1]and compare those values with actual graphical results, difference between the two values are shown in Table 1. This results so satisfactory as we show their error (difference). This difference is between desired displacement value from creep factor finding equation and actual displacement value getting from graph.

Table 1 Comparision of results

Creep Factor validation					
Creep Factor	0.0435	0.0435	0.0435	0.0435	0.0435
Lo(Initial_10.75 sec)	0.623	0.623	0.623	0.623	0.623
t(sec)	10	35	65	95	115
Lt(Theoretical _result)	0.6772	0.69195	0.69923	0.7037	0.70595
Graph Result	0.679	0.691	0.6991	0.70359	0.70599
Difference	0.0018	-0.0009	-0.0001	-0.0001	4.4E-05
% Error	0.26495	0.13683	0.01879	0.01475	0.00617

VI. CONCLUSION

In this paper, Creep characterization method proposed for continuous 5V external field. By this experiment we are getting .0435 creep factor. After inspecting this creep factor it is used to validate some interval and getting desired accuracy with average 0.088%.This experiment shows noticeable drift during creep characterization. We can use this value for any cycle time. For Fast steering mirror open loop operation these results are much useful to find out drift after period of time interval.

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