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Application Note 8

Considerations For Using Nanomotion Motors in Z Applications

Introduction

The intrinsic friction of the Nanomotion motor offers an interesting solution for Z applications, where gravity functions as a permanent load. Nevertheless, some considerations must be taken into account to assure safe and reliable system operation. This report highlights these considerations in order to assure successful implementation.

The Set Up

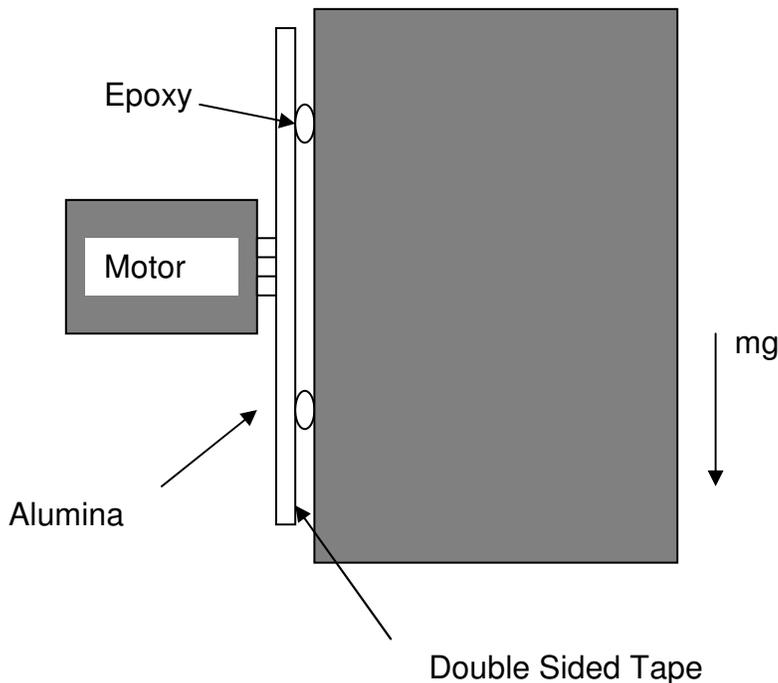


Figure 1

Motion Under Gravity

This application is very unsymmetrical, where much higher forces are required to move upwards as compared to downwards.

Special tuning of the control set up with different parameters for each direction are required. This application note concentrates on the intrinsic friction and the static hold force.

Figure 1 above highlights the correct installation of the Nanomotion motor as stipulated in the motor manuals.

While operating Nanomotion motors in the Z direction, the following points should be considered:

1. Intrinsic friction.
2. Shearing of the double sided tape.
3. Shearing of the epoxy.
4. Vibrations

Intrinsic Friction

The static holding force is typically 4N per motor fingertip in the HR series of motors. The intrinsic friction may be slightly reduced with time due to humidity and absorption of other contaminants on the alumina surface.

With a safety margin, we shall assume then a static holding force of $\approx 2 \text{ N}/\mu$ after very long periods of non-use (this is an exaggerated precaution).

Shearing

The shearing of the double sided tape may be very noticeable for a small contact area, nevertheless, the shear of the tape is overcome by the epoxy.

The shear of the epoxy is as follows:

Let shear modulus $G=800 \mu\text{Pa}$

Epoxy drop diameter $2r=2\text{mm}$

Shear section (thickness of the double sided tape) $d=0.1\text{mm}$

Number of drops = n

$$F = \frac{G \cdot n \cdot \frac{\pi r^2}{2}}{d} \cdot \Delta X$$

Where

ΔX is the shear

F is the applied force

$$F = \frac{800 \cdot 10^6 \cdot \frac{\pi}{2} \cdot 10^6 \cdot n}{10^{-4}} \Delta X$$

$$= 12.5 \cdot 10^6 n \Delta X$$

For $n=2$ drops we get

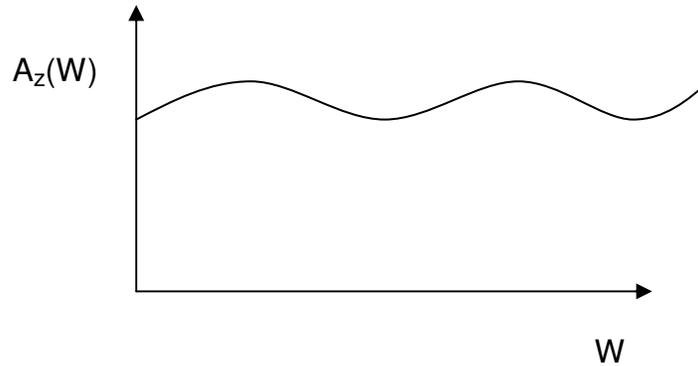
$$F = 25 \cdot 10^6 \Delta X \text{ or stiffness of } 25 \text{ N}/\mu$$

This value is far beyond the motor stiffness. However, in applications with multiple HR-8 motors, obviously more epoxy drops should be used.

Vibration

Assuming a vibration spectra $A_z (W)$ at the mass m in the gravitational direction, the vibration force F_v is given by:

$$F_v = m \int w^2 A_z(w) dw$$



Equilibrium

As the vibration is symmetrical and the gravity is not, the system will be stable when:

$$F_v + mg < F_H$$

Lets take a numerical example:

One) let m be 200 grams and an HR-1 motor, we get:

$$F_v + 2 = 2$$

$$F_v = 0$$

Any vibration will cause the stage to slip.

Two) Let m be 100 grams and an HR-1 motor:

Here $F_v \leq 1N$

At 100 Hz, the maximum vibration amplitude is:

$$A \bullet (2\pi \bullet 100)^2 = 10$$

$$A = 10^{-3} / 36$$

$$3 \bullet 10^{-5}$$

$$= 30 \mu$$

Consideration of Industrial Vibration

The attached table indicates vibration levels in various environments. The ISO workshop value is a typical industrial standard.

We see a value of 32000 μ inch/sec @ 50 – 100 Hz.

The vibration amplitude A is given by:

$$A = \frac{32 \bullet 10^3 \bullet 10^{-6}}{40 \Delta f} m$$

As $\Delta f = 50Hz$

$$A = 16 \mu$$

Taking a center frequency of 75 Hz, the acceleration a is given by:

$$a = Aw^2 = 16 \bullet 10^{-6} \bullet (2\pi \bullet 75) = 3.55 \text{ m/sec}$$

Bearing in mind that the vibration is a statistical effect, an additional factor 2 is suggested to overcome local fluctuations.

Thus, $a_v = 7 \text{ m/sec}$

Conclusions

Going back to $F_v + mg < F_H$

Where $F_v = m a_v$

We get for a single HR-1 motor

$$m = \frac{F_H}{a+7} = \frac{2}{17} = 117 \text{ gr}$$

An HR-1 motor will safely hold position, overcoming gravity and vibration, for a mass no larger than 117 grams. This statement can be generalized as follows: in an industrial environment, a Nanomotion motor can maintain vertical position for a mass which is 3.5 times less than the static holding force.

Summary

Considerations for the motor operational in the Z direction overcoming gravity is described. It is clear that with proper system design, the unique feature of intrinsic stall force can be implemented.

This report did not consider closed loop functions, but of course position can be maintained under closed loop, also overcoming vibration.

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