An Easy to Manufacture Non-Contact Precision Linear Motion System And Its Applications

by

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ABSTRACT

The Axtrusion is a new linear motion element developed by Professor Alexander Slocum and Roger Cortesi of the Massachusetts Institute of Technology's Mechanical Engineering Department. It is an easy to manufacture non-contact linear motion system. The prototype uses porous graphite air bearings and an open face permanent magnet linear motor to support and propel the carriage. Since there is no contact between the carriage and the way, the Axtrusion is ideal for high speed where reliability is at a premium. Initial testing of the prototype carriage indicates that it has the following performance specifications: a vertical load capacity of 2000 N (450 lbs); horizontal load capacity of 4000 N (900 lbs); a carriage pitch error of 12 micro-radians (2.5 arc seconds); a yaw error of 7.7 micro-radians (1.6 arc seconds); a vertical straightness at the center of the carriage of 0.3 microns (0.000012 inches); and a vertical stiffness of the carriage of 422 Newtons per micron (2,400,000 lbs/in).

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NOMENCLATURE

A	area [m^2]
$\vec{C}$	carriage compliance matrix (6 x 6)
$\overrightarrow{D_{carriage}}$	the displacement and rotational vector (1 x 6) of the carriage
E	Young's modulus [Pa]
$\vec{E}$	The displacement vector (1 x 4) of the point $\vec{P}$
f	frequency [Hz]
F	force [N]
F_m	attractive force between the motor coil and magnet track [N]
F_s	force on each side bearing [N]
F_{top1}	force on each inboard top bearing [N]
F_{top2}	force on each inboard top bearing [N]
g	gravitational acceleration [m/s^2]
h	air gap between air bearing and way surface [m] or [microns]
$\overrightarrow{HTM}$	The Homogenious Transformation Matrix (4 x 4)
K	stiffness [N/m]
K_{50x100}	stiffness of the 50 x 100 mm bearings [N/m]
K_{75x150}	stiffness of the 75 x 150 mm bearings [N/m]
L	load [N]
L_{50x100}	load on 50 x 100 mm bearing [N]
L_{75x150}	load on 75 x 150 mm bearings[N]
$L_{bmaxside}$	the maximum load that can be supported by a side bearing [N]
$L_{bmaxtop}$	the maximum load that can be supported by a top bearing [N]
L_{cmaxh}	the maximum working load of the carriage in the horizontal direction [N]
L_{cmaxv}	the maximum working load of the carriage in the vertical direction [N]
L_{lr}	the distance between the left and right pairs of top bearings [mm]
$\vec{P}$	The vector (1 x 4) containing the cordinates of a point with respect to the carriage's center of stiffness.
P_s	supply pressure [Pa]
q	motor angle [degrees]
w_m	width of the motor track [mm]
Y_1	location of the inboard pair of top bearings in the Y direction [mm]
Y_2	location of the outboard pair of top bearings in the Y direction [mm]
Y_m	motor coil location in the Y axis [mm]
Z	the center of the side bearings in the Z direction [mm]
Z_m	motor coil location in the Z axis [mm]