Compact, Lightweight Servo-Controllable Brakes

Lyndon B. Johnson Space Center, Houston, Texas

Compact, lightweight servo-controllable brakes capable of high torques are being developed for incorporation into robot joints. A brake of this type is based partly on the capstan effect of tension elements, which is described by the well-known equation

$$T_h / T_l = e^{\mu\beta},$$

where T_h is the higher tension at one end and T_l is the lower tension at the other end of a rope, belt, chain, or other tension element that is wrapped around a capstan so as not to slip; β is the total wrap angle in radians; and μ is the coefficient of friction between the capstan and the tension element. For example, a tension-multiplication factor of the order of 10^6 can be achieved by wrapping several turns of steel wire around a steel capstan. Heretofore, the capstan effect has been exploited in wound-spring clutches that operate in an on-or-off fashion. In a brake of the type under development, a controllable intermediate state of torque is reached through on/off switching at a high frequency.

This work was done by Christopher S. Lovchik of Johnson Space Center, William Townsend and Jeffrey Guertin of Barrett Technology, Inc., and Yoky Matsuoka of Carnegie Mellon University. For further information, contact the JSC Innovation Partnerships Office at (281) 483-3809.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to MSC-23389-1, volume and number of this NASA Tech Briefs *issue, and the page number.*

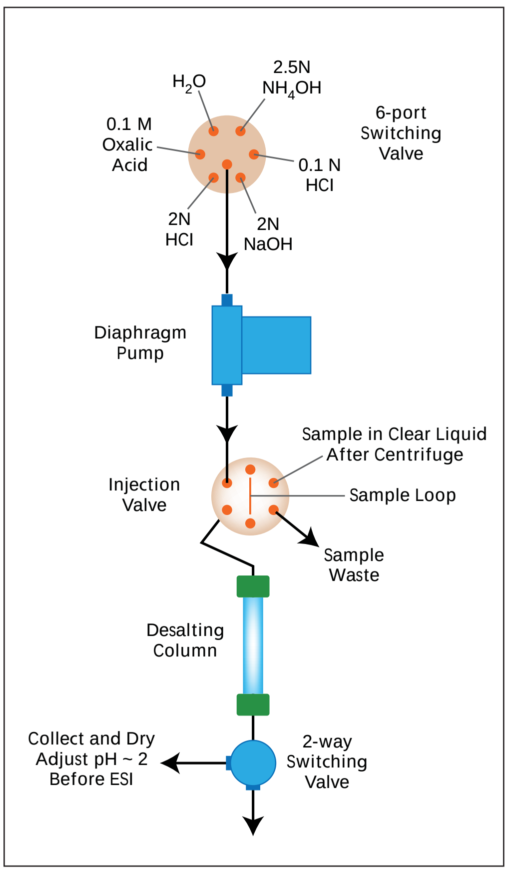
Automated Desalting Apparatus

By purifying field samples, this technology can be used for monitoring of water quality for applications in chemical, manufacturing, and farming industries.

NASA's Jet Propulsion Laboratory, Pasadena, California

Because salt and metals can mask the signature of a variety of organic molecules (like amino acids) in any given sample, an automated system to purify complex field samples has been created for the analytical techniques of electrospray ionization/mass spectroscopy (ESI/MS), capillary electrophoresis (CE), and biological assays where unique identification requires at least some processing of complex samples. This development allows for automated sample preparation in the laboratory and analysis of complex samples in the field with multiple types of analytical instruments.

Rather than using tedious, exacting protocols for desalting samples by hand, this innovation, called the Automated Sample Processing System (ASPS), takes analytes that have been extracted through high-temperature solvent extraction and introduces them into the desalting column. After 20 minutes, the eluent is produced. This clear liquid can then be directly analyzed by the techniques listed above. The current apparatus including the computer and power supplies is sturdy, has an approximate mass of 10 kg, and a volume of about 20×20×20 cm, and is undergoing further miniaturization.



The **Automated Desalting Apparatus** includes two mutliport valves, a diaphragm valve, and an ion exchange column. Six different solvents are required to both process the sample and condition the column before and after processing.

This system currently targets amino acids. For these molecules, a slurry of 1 g cation exchange resin in deionized water is packed into a column of the apparatus. Initial generation of the resin is done by flowing sequentially 2–3 bed volumes of 2N NaOH and 2N HCl (1 mL each) to rinse the resin, followed by ≈5 mL of deionized water. This makes the pH of the resin near neutral, and eliminates cross sample contamination. Afterward, 2–3 mL of extracted sample is then loaded into the column onto the top of the resin bed. Because the column is packed tightly, the sample can be applied without disturbing the resin bed. This is a vital step needed to ensure that the analytes adhere to the resin.

After the sample is drained, oxalic acid (1 mL, pH 1.6-1.8, adjusted with NH_4OH) is pumped into the column. Oxalic acid works as a chelating reagent to bring out metal ions, such as calcium and iron, which would otherwise interfere with amino acid analysis. After oxalic acid, 1 mL 0.01 N HCl and 1 mL deionized water is used to sequentially rinse the resin. Finally, the amino acids attached to the resin, and the analytes are eluted using 2.5 M NH_4OH (1 mL), and the NH_4OH eluent is collected in a vial for analysis.

All of these steps are controlled by LabVIEW software, which controls 7-way, two 2-way valves, as well as a peristaltic pump. Solvents are all attached to the 7-way valve and are introduced by the peristaltic pump at flow rates on the order of 1-5 μL/min.

This work was done by Maegan K. Spencer of Stanford University, De-Ling Liu of Aerospace Corp., and Isik Kanik and Luther Beegle of Caltech for NASA's Jet Propulsion Laboratory.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to NPO-45428, volume and number of this NASA Tech Briefs *issue, and the page number.*

Durable Tactile Glove for Human or Robot Hand

Lyndon B. Johnson Space Center, Houston, Texas

A glove containing force sensors has been built as a prototype of tactile sensor arrays to be worn on human hands and anthropomorphic robot hands. Whereas the force sensors of a prior force-sensing glove are mounted on the outside, the force sensors of this glove are mounted inside, in protective pockets; as a result of this and other design features, the present glove is more durable. The sensors, which cost only $3 apiece (2002), produce analog force readings in the range of 0 to 5 lb (0 to 22 N) at numerous locations across the hand.

To minimize false readings due to internal glove motions and/or tight fit of the glove on the hand, the pockets are constructed as recesses within modular foam inserts that are sewn into the glove. High-friction material provides good gripping surfaces for finger and palm contact areas. Textile stiffeners on the backsides of the sensors prevent deformation of the foam during motion. To ensure that forces are directed into the sensors and not channeled through the relatively stiff gripping-surface material, stiff plastic beads are sewn in place between the sensors and the outer glove fabric.

This work was done by Melissa Butzer of Oceaneering Space Systems, Myron A. Diftler of Lockheed Martin Corp., and Eric Huber of Metrica, Inc., for Johnson Space Center. Further information is contained in a TSP (see page 1). MSC-23544-1

Robotic Arm Manipulator Using Active Control for Sample Acquisition and Transfer, and Passive Mode for Surface Compliance

NASA's Jet Propulsion Laboratory, Pasadena, California

A robotic arm that consists of three joints with four degrees of freedom (DOF) has been developed. It can carry an end-effector to acquire and transfer samples by using active control and comply with surface topology in a passive mode during a brief surface contact. The three joints are arranged in such a way that one joint of two DOFs is located at the shoulder, one joint of one DOF is located at the elbow, and one joint of one DOF is located at the wrist. Operationally, three DOFs are moved in the same plane, and the remaining one on the shoulder is moved perpendicular to the other three for better compliance with ground surface and more flexibility of sample handling. Three out of four joints are backdriveable, making the mechanism less complex and more cost effective.

Having joints of a robotic arm accomplish two different tasks is a new concept. The preliminary engineering shows this concept is workable with proper selection of actuators.

This work was done by Jun Liu, Michael L. Underhill, Brian P. Trease, and Randel A. Lindemann of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-47099