Automated Assistance for Designing Active Magnetic Bearings

Stennis Space Center, Mississippi

MagBear12 is a computer code (see figure) that assists in the design of radial, heteropolar active magnetic bearings (AMBs). MagBear12 was developed to help in designing the system described in "Advanced Active-Magnetic-Bearing Thrust-Measurement System" (SSC-00177-1), which appears in *NASA Tech Briefs,* Vol. 32, No. 9 (September 2008), p. 61.. (See the Mechanics/Machinery section in the accompanying issue of *NASA Tech Briefs*). Beyond this initial application, MagBear12 is expected to be useful for designing AMBs for a variety of rotating machinery. This program incorporates design rules and governing equations that are also implemented in other, proprietary design software used by AMB manufacturers. In addition, this program incorporates an advanced unpublished fringing-magnetic-field model that increases accuracy beyond that offered by the other AMB-design software.

MagBear12 accepts input from the user in the form of parameters that specify the envelope, performance, and acceptable ranges of geometric features other than the envelope. The program then calculates optimized designs within those ranges. A series of designs are presented to the designer for review. The designer can accept one of the designs or can modify the input parameters to refine the designs. The program can also be used to analyze pre-existing AMB designs.

This work was done by Joseph Imlach of Innovative Concepts In Engineering LLC for Stennis Space Center.

Inquiries concerning rights for the commercial use of this invention should be addressed to:

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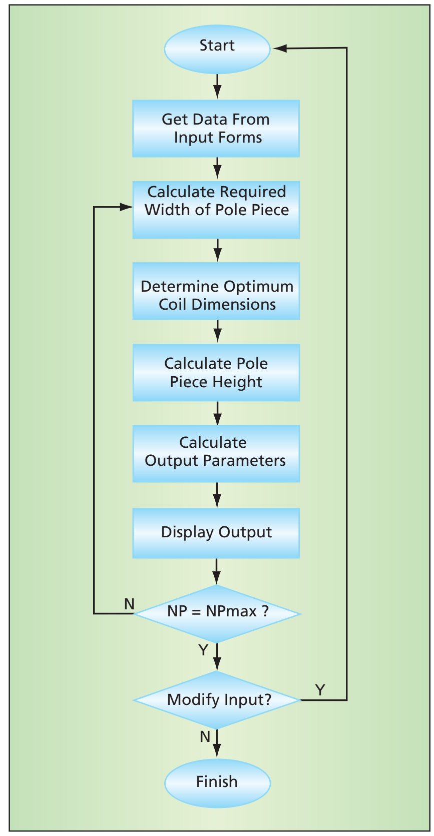
Refer to SSC-00176-1, volume and number of this NASA Tech Briefs *issue, and the page number.*



MagBear12 Flowchart

Computational Simulation of a Water-Cooled Heat Pump

Lyndon B. Johnson Space Center, Houston, Texas

A Fortran-language computer program for simulating the operation of a water-cooled vapor-compression heat pump in any orientation with respect to gravity has been developed by modifying a prior general-purpose heat-pump design code used at Oak Ridge National Laboratory (ORNL). Although it is specific to the design of a high-temperature-lift heat pump for the International Space Station, this program could serve as a basis for development of general-purpose computational software for designing and analyzing liquid-cooled heat-pumps. The ORNL program contained models of refrigerant-fluid-to-air heat exchangers; the main modification consisted in replacing those models with models of plate-type heat exchangers utilizing water as both the cooling and the heating source liquid.

The present program incorporates a Fortran implementation of the American Society of Mechanical Engineers water-properties tables. Semi-empirical models of the heat transfer coefficients for these heat exchangers were developed from vendor and laboratory test data, inasmuch as applicable published correlations were not available. The program produces estimates of evaporator and condenser capacities, coefficients of performance, and operating temperatures over a range of compressor speeds.

This work was done by Duane Bozarth of H and R Technical Associates for Johnson Space Center. Further information is contained in a TSP (see page 1). MSC-23375-1

Computational Model of Heat Transfer on the ISS

Lyndon B. Johnson Space Center, Houston, Texas

SCRAM Lite ("SCRAM" signifies "Station Compact Radiator Analysis Model") is a computer program for analyzing convective and radiative heat-transfer and heat-rejection performance of coolant loops and radiators, respectively, in the active thermal-control systems of the International Space Station (ISS). SCRAM Lite is a derivative of prior versions of SCRAM but is more robust.

SCRAM Lite computes thermal operating characteristics of active heat-transport and heat-rejection subsystems for the major ISS configurations from Flight 5A through completion of assembly. The program performs integrated analysis of both internal and external coolant loops of the various ISS modules and of an external active thermal control system, which includes radiators and the coolant loops that transfer heat to the radiators.

The SCRAM Lite run time is of the order of one minute per day of mission time. The overall objective of the SCRAM Lite simulation is to process input profiles of equipment-rack, crew-metabolic, and other heat loads to determine flow rates, coolant supply temperatures, and available radiator heat-rejection capabilities. Analyses are performed for timelines of activities, orbital parameters, and attitudes for mission times ranging from a few hours to several months.

This program was written by John G. Torian and Michael L. Rischar of United Space Alliance for Johnson Space Center. Further information is contained in a TSP (see page 1). MSC-23622-1

Optimization of Angular-Momentum Biases of Reaction Wheels

NASA's Jet Propulsion Laboratory, Pasadena, California

RBOT [RWA Bias Optimization Tool (wherein "RWA" signifies "Reaction Wheel Assembly")] is a computer program designed for computing angular-momentum biases for reaction wheels used for providing spacecraft pointing in various directions as required for scientific observations. RBOT is currently deployed to support the Cassini mission to prevent operation of reaction wheels at unsafely high speeds while minimizing time in undesirable low-speed range, where elasto-hydrodynamic lubrication films in bearings become ineffective, leading to premature bearing failure. The problem is formulated as a constrained optimization problem in which maximum wheel speed limit is a hard constraint and a cost functional that increases as speed decreases below a low-speed threshold.

The optimization problem is solved using a parametric search routine known as the Nelder-Mead simplex algorithm. To increase computational efficiency for extended operation involving large quantity of data, the algorithm is designed to (1) use large time increments during intervals when spacecraft attitudes or rates of rotation are nearly stationary, (2) use sinusoidal-approximation sampling to model repeated long periods of Earth-point rolling maneuvers to reduce computational loads, and (3) utilize an efficient equation to obtain wheel-rate profiles as functions of initial wheel biases based on conservation of angular momentum (in an inertial frame) using pre-computed terms.

This work was done by Clifford Lee and Allan Lee of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-42011

Short- and Long-Term Propagation of Spacecraft Orbits

NASA's Jet Propulsion Laboratory, Pasadena, California

The Planetary Observer Planning Software (POPS) comprises four computer programs for use in designing orbits of spacecraft about planets. These programs are the Planetary Observer High Precision Orbit Propagator (POHOP), the Planetary Observer Long-Term Orbit Predictor (POLOP), the Planetary Observer Post Processor (POPP), and the Planetary Observer Plotting (POPLOT) program.

POHOP and POLOP integrate the equations of motion to propagate an initial set of classical orbit elements to a future epoch. POHOP models short-term (one revolution) orbital motion; POLOP averages out the short-term behavior but requires far less processing time than do older programs that perform long-term orbit propagations.

POPP postprocesses the spacecraft ephemeris created by POHOP or POLOP (or optionally can use a less-accurate internal ephemeris) to search for trajectory-related geometric events including, for example, rising or setting of a spacecraft as observed from a ground site. For each such event, POPP puts out such user-specified data as the time, elevation, and azimuth.

POPLOT is a graphics program that plots data generated by POPP. POPLOT can plot orbit ground tracks on a world map and can produce a variety of summaries and generic ordinate-vs.-abscissa plots of any POPP data.

This program was written by John C. Smith, Jr., Theodore Sweetser, Min-Kun Chung, Chen-Wan L. Yen, Ralph B. Roncoli, and Johnny H. Kwok of Caltech, and Mark A. Vincent of Raytheon for NASA's Jet Propulsion Laboratory.

This software is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (626) 395-2322. Refer to NPO-45418.

Monte Carlo Simulation To Estimate Likelihood of Direct Lightning Strikes

John F. Kennedy Space Center, Florida

A software tool has been designed to quantify the lightning exposure at launch sites of the stack at the pads under different configurations. In order to predict lightning strikes to generic structures, this model uses leaders whose origins (in the *x–y* plane) are obtained from a 2D random, normal distribution. The striking distance is a function of the stroke peak current, which is obtained from a random state machine that extracts the stroke peak current from a log-normal distribution. The height in which the leaders are originated is fixed and chosen to be several "strike dis-