Y/AMT-426

Y-12

OAK RIDGE
Y-12
PLANT

LOCKHEED MARTIN

Final CRADA Report
for
CRADA Number Y-1296-0422

IN-SERVICE MOTOR PERFORMANCE DIAGNOSTICS

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Abstract

Efficiency evaluation of in-service motors is a challenge to industry. Without a dynamometer or torque cell attached, determining the output power is difficult. The purpose of this CRADA was to develop an on-line motor monitoring device that will determine the condition and performance of a motor without removing the motor from operation.

Objectives of the CRADA

To develop an instrument with the ability to assess the performance of a motor while the motor is operating in its service environment. In particular, the instrument will allow the assessment of the impact of service conditions such as voltage imbalance or harmonic distortion on motor performance.

Discussion of how the objectives of the CRADA were met.

The CRADA contemplated four tasks.

Task 1: Development of an equivalent circuit model.
Task 2: Development of hardware and software to implement equivalent circuit model.
Task 3: Fabrication of prototype instrument and software.
Task 4: Testing of Prototype.

In accordance to this plan, LMER/LMES developed an equivalent circuit model for NEMA design B three phase induction motors. The model is automatically generated from information found in the nameplate of a motor and only requires a measurement of motor speed (by stroboscope) to calculate motor operating efficiency and load. The software developed processes measured waveform data of voltage and current and computes the efficiency loss or motor de-rating that may be required due to voltage imbalance and/or harmonic distortion. The model and data analysis software was written in ANSI standard C++.

Subsequently, PdMA incorporated the equivalent circuit model into a portable computer equipped with the signal acquisition hardware needed to acquire the three phase current and voltage inputs from a motor. In addition, PdMA generated a prototype user interface for the unit.

The prototype unit was tested at LMES' Electric Machinery Test Facility by a team of PdMA and LMER investigators. The capabilities of the prototype to perform each of the design functions were verified. The assessment of

the prototype's accuracy has been limited and at present must be considered tentative.

How the work done under this CRADA benefitted the DOE

In its production facilities, DOE is a major user of motor drives. The work done under this CRADA constitutes a benchmark in the on line analysis and evaluation of motor condition and performance. The work accomplished under this CRADA will be of significant benefit to DOE in the efficient and reliable operation of their production mission, as well as all other programs that use motors, such as heating and air conditioning, manufacturing, etc.

Technical discussion of the work accomplished.

The software was developed by LMER using ANSI C++ and the CodeWarrior compiler system in the Macintosh operating system. PdMA ported the software to the Windows95 operating system. At first the CodeWarrior compiler was used as it seemed the logical choice. Unfortunately, CodeWarrior for Windows95 was found to be defective and thus the final implementation was performed using Microsoft's Visual C++ 5.0.

The software runs in a portable computer outfitted with a PCMCIA card which performs the analog-to-digital conversion of preconditioned voltages proportional to the three phase currents and phase-to-phase voltages seen at the terminals of the motor while it runs.

Data from two different 2-pole Y-motors, one rated at 7.5 HP and the other at 50 HP were taken. The 7.5 HP motor is a 12-lead motor that was wired in a fixed Y configuration to provide access to the stator's neutral point common to the three phases. This motor was loaded by means of a generator that provided a minimum high inertia load of about 22% of rated with zero excitation voltage. Consequently, all so-called no-load tests for the 7.5 HP motor correspond to about a 22% load on the motor. The rotor speed and load torque were measured by an in-line torque cell. Measurements at no-load, 25, 50, 75, and 100% rated load were taken with balanced voltages at rated and off rated voltage levels. Data were also taken at full load unbalanced voltage conditions.

The 50 HP motor was tested using a dynamometer to load it. The dynamometer provided low-inertia load of about 2% of rated load with zero excitation voltage. Measurements at no-load, 25, 50, 75, and 100% rated load were taken with balanced voltages at rated and off-rated

voltage levels.

The measured data was compared to the computed predictions by the modeling software in-situ on the first set of data. Initial evaluation showed an agreement within 5 per cent of the efficiency and current magnitude predictions. Further analysis revealed a 0.5 degrees to 2.3 degrees difference between the phase angle of the voltages and currents as measured by LMES versus that of the CRADA project. The full analysis of the data is currently in progress. In addition, the need for minor software adjustments was identified in the algorithms predicting the energy savings if the motor were to be operated under the same load conditions but with clean, balanced voltages.

The results of the full analysis of the data will be reported and published in a trade journal once it is completed.

Discussion of new inventions during the CRADA.

No new inventions were made or reported.

Assessment of commercialization possibilities

The technology developed in this CRADA is at the cutting edge of a highly competitive and growing field of motor diagnostics and performance analysis. We anticipate that it will be commercialized rapidly by PdMA. The commercial product will have the ability to corner the market of on-line motor diagnostics because of its ability to evaluate the effect of unbalanced conditions on the motor and to provide an assessment of motor performance.

Plans for future collaboration.

We hope to work with PDMA extensively in the future in developing this technology and its "daughter products". We have both the technical experience and competence to assist in the commercialization process, and the testing facility to evaluate the accuracy of the completed prototypes.

Conclusions

This CRADA has been successful in transferring a technology to the private sector and will result in a product which will have a significant benefit to both the DOE and to US Industry.