Optimization System for Electromechanical Design Based on FEA and Distributed Calculations

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Abstract — An optimization system for electromechanical design based on Finite Element Analysis and batch system is developed. The concept of the system is that the desktop on the engineer's computer can be provided with a virtual machine. The advantages are that the system is flexible, easy-to-use and stable. In fact, the system can be adapted to the optimization design for interior permanent magnet motor in terms of the high efficiency, and the validity of the solution is verified.

I. INTRODUCTION

Faster computer performance and developing numerical techniques make an electromechanical design by a digital engineering solution increasingly popular. One of the representative numerical techniques is a Finite Element Analysis (FEA) and it is required to figure out the physical phenomena precisely and instantly. The optimization function is also demanded in order to efficiently come up with better designs, such as a trade-off relationship between the design factors. In addition, to adapt to the design process, it is necessary for the system to be flexible, easy-to-use and stable. A conventional solution runs the FEA on a preconfigured system and repeats as needed in a strictly sequential manner. Our system consists of three parts, one is the FEA software in a virtual machine, the second is a batch system and the third is the optimization system. Our solution can solve any number of optimizations in parallel.

The system that can resolve the current challenges is proposed in this paper. The system can be realized using VMWare [1] for the virtual machine. The advantages of the system are that the engineer can place all the needed tools into the virtual machine. Our system has the FEA in a virtual Windows machine which the batch system distributes to Linux execute nodes. We chose a known Windows environment for our solution, however any engineering environment could have the same technique applied.

The design of the electrical motor has been worked out by using the system and the validity of it has been verified.

II. SYSTEM SUMMARY

A. Proposed Solution

The system configuration of a proposed solution is shown in Fig. 1. The optimization system generates the appropriate design parameters to calculate, inserts it into a virtual machine image that Windows system with installed JMAG, has the batch system schedule the job to run on an available resource with VMWare and extracts the resulting optimization after the job runs.

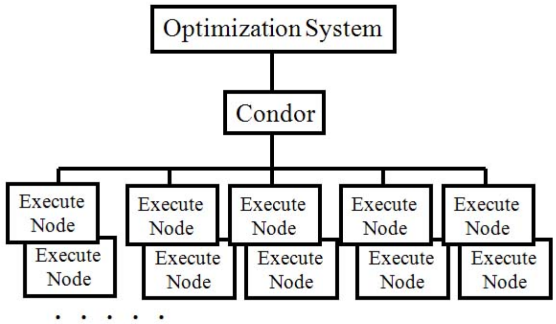

Fig. 1. System configuration

1) Condor

Condor is a specialized workload management system for compute-intensive jobs. Like other full-featured batch systems, Condor provides a job queueing mechanism, scheduling policy, priority scheme, resource monitoring, and resource management. Users submit their serial or parallel jobs to Condor [2] as the batch system, Condor places them into a queue, chooses when and where to run the jobs based upon a policy, carefully monitors their progress, and ultimately informs the user upon completion. Condor was developed by University of Wisconsin-Madison Computer Science Department over 25 years.

2) Finite Element Analysis

The characteristics of the electromechanical machine are evaluated by FEA. The JMAG [3] is integrated into the system as an FEA software. The JMAG is a comprehensive software suite for electromechanical equipment design and development and it has over 25 years of use in this field.

3) Optimization System

The various kinds of the optimization methods are available for the system, such as the genetic algorithm, the simulated annealing, and so on. In the case of the proposed system, the genetic algorithm is used and it is implemented on Matlab [4].

B. Conventional Solution

The party trying to solve the problem must either find a system with a suitable application like JMAG ready to run the optimization or must install such an application meeting all of its dependencies. It is difficult to remove all of the various kinds of dependencies that each computer has, such as the operation system, version, conflicts with the other software, and so on.

III. TEST CASE

The interior permanent magnet (IPM) motor [5] has been developing for the various kinds of applications, such as the traction motor for hybrid and electric vehicle, the compressor for the air conditioner, and so on. To reduce the energy consumption, the high performance and the down sizing need to be addressed. The prediction for the iron loss [6] is one of the key techniques to realize the high performance.

Therefore, we work on the optimization design for high efficiency and we achieve to come up with good design by using the system.

The specifications of both motor and inverter are shown in Table I and Table II respectively. The motor model is shown in Fig. 2. As a result of the calculation, the efficiency shown in Fig. 3 is resolved.

TABLE I
SPECIFICATION OF IPM MOTOR

Pole	4
Number of Slots	24
Stator Diameter (mm)	150
Inner Diameter of Stator (mm)	80
Gap Width (mm)	1.5
Stack Length (mm)	50
Turns (turns/coil)	32
Phase Resistance (Ohm)	0.46
Core Materials	35H360 (Lamination factor: 98%)
Permanent Magnet	N39UH

TABLE II
SPECIFICATION OF INVERTER

DC Voltage (V)	200 - 300
Current Value (A)	20
Current Phase Angle (deg)	0 - 90
PWM	Comparison method of the triangular waveform
Current Control Period (rad/sec)	100 - 500
Ld (mH)	5
Lq (mH)	11
Magnetic Flux of Magnets (Wb)	0.24
Carrier Frequency (kHz)	2 - 15
Dead Time (micro sec)	4
Speed (r/min)	1800

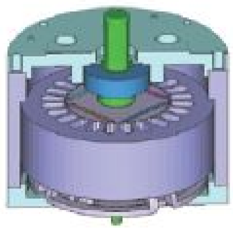

Fig. 2. FEA model of IPM motor

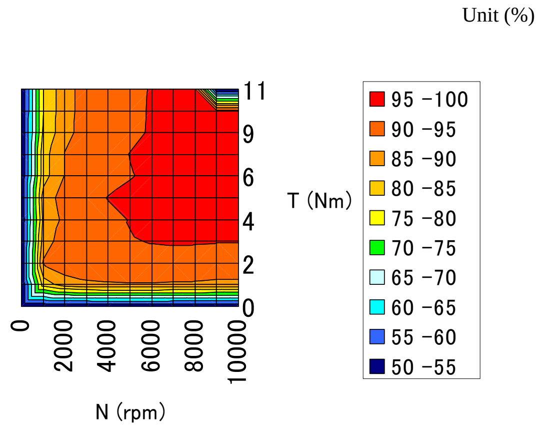

Fig. 3. Efficiency map

IV. FUTURE WORKS

To design the IPM motor, the temperature, the vibration and the noise problems are also considerable [7]. The system can be adapted to the other physical fields, such as thermal analysis, mechanical analysis and those coupling analysis.

V. CONCLUSION

The optimization system for the electromechanical design is proposed. The advantages of the system are that it is flexible, easy-to-use, and stable. In fact, the validity of the system is verified by applying to IPM motor design in terms of the high efficiency.

VI. REFERENCES

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