

Electrical Systems Design

July/August 1988

POWERING

Chrysler's Windsor Plant



Electrical Systems Design

ENGINEER OF THE YEAR
& PROJECT COMPETITION
AWARDS



Ali M. Nasle, P.E.
Chairman
EDSA Micro Corporation

"Electrical Systems Design provides practical information about important subjects relevant to the electrical engineering design process. It provides electrical engineers with instructional information about recent project work. The information presented is both educational and useful to the experienced and inexperienced engineer throughout the design and planning process."

Ali Nasle's most recent electrical project required \$22.5 million of electrical equipment.

Engineering Background:

20 years of experience in electrical engineering specializing in computer application in engineering and construction project work. Designed EDSA, a package of computer programs for electrical distribution system analysis, for mainframe and microcomputers to perform complete electrical design by computer.

Education—Bachelor of Science from Michigan State University and a Master of Science from Wayne State University. Registered professional engineer in Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Maryland, Massachusetts, Michigan, Idaho, Iowa, Oregon, Vermont and Wyoming.

Memberships—Institute of Electrical & Electronic Engineers, Engineering Society of Detroit and the Association for Computer Marketing.

Honors — Inductee to the Engineering Hall of Fame, Wayne State University. Recipient of "4~nding Engineering Achievement Award", Wayne State University College of Engineering.

Selected Project Experience:

Chrysler Windsor Assembly Plant, Windsor, Ontario, Canada
Harper-Grace Hospital, Detroit, Michigan
Methodist Hospital, Indianapolis, Indiana
General Electric Co., Corporate Research and Development Center, Niskayana, New York, U.S. Army Hospital, Fort Carson, Colorado
Sigman Motor Corp., Pretoria, South Africa
Eli Lilly & Co., Biomedical Research Center, Indianapolis, Indiana, University of Michigan Electrical Engineering and Computer Science Laboratory, Ann Arbor, Michigan
Goodyear Tire & Rubber Co., Technical Center, Akron, Ohio
General Motors Corp., Corvette Assembly Plant, Bowling Green, Kentucky
Kajima International, Inc., Telephone Center of New York, Office/Computer Center, Staten Island, New York
Kajima International, Inc., Pacific Duties Technology Center, Office Building, Fairfax, VA

Most Recent Project:

Chrysler Windsor Assembly Plant, Windsor, Ontario, Canada
Type of Project: Industrial
Total Construction Cost: \$400 Million
Total Value of Electrical Equipment Specified: \$22.5 Million
Electrical Equipment Specified: Low and medium voltage conductors and raceway, busway systems, motor controls, secondary unit substations, distribution transformers, wiring devices and lighting.





Winning Entry:

Chrysler Assembly Plant
Windsor, Ontario

Engineer:

Ali M. Nasle, P.E.
Smith, Hinchman & Grylls
Associates, Inc.

Type of Project:

Industrial

Project Description:

The Chrysler assembly plant in Windsor, Ontario, Canada, one of the world's most modern manufacturing facilities, covers an area of 2.5 million sq. ft. Power is provided from the local utility's nearby Essex transformer station to supply the great number of motor loads and manufacturing equipment in this large plant.

Power at 27.6 kV is supplied through three sets of 3000-ft runs of three single 500-MCM conductors to six 5000-kVA, 27.6/4/16-ky, 3-phase, 60-cycle transformers, connected delta-V with primary grounded.

To feed the entire plant load, two pairs of three 750-MCM conductors power a 4.16-ky, 1200-A bus from each 5000-kVA transformer station. All of the resistance welders are supplied from five 3-phase, 60-cycle, 2000-kVA transformer substations, 41 60/480V, connected delta-V with secondary grounded.

Power for welding is supplied through five pairs of three 500-MCM, 5-ky conductors to each of five 2000-kVA transformers grouped as follows:

Substation No. 5—2000 kVA
Substation No. 10—2000 kVA
Substation No. 12—2000 kVA

The estimated initial short circuit duty is 860,000 kVA on the secondary side of each of the six 5000-kVA transformers. The XJR ratio at the same location was given as 5.13.

There are 366 machine welders and 113 robotic resistance welders that are distributed on substations No. 5, No. 10 and No. 12. Substations No. 5 and No. 10 are double-ended substations that supply most of the heavy welding area. Each transformer feeds two runs of 2000-A busways that are protected by 2000-A feeder circuit breakers. The runs are approximately 400 ft to 500 ft long with the outer end of each run connected to the end of another run to form an 800-ft and an 1000-ft loop between two of the 2000-kVA transformers. There are two welding machine busway loops each on substation No. 5 and No. 10 and two radial runs on substation No. 12. This project deals with these three substations feeding the robotic and machine resistance welders.

Question #1: How was innovative thinking applied in the electrical design of the project?

Assembly lines with approximately 400 car production capacity per day shift have between 80,000 to 125,000 kVA connected loads. Major loads are in the welding area where reliable and efficient operations have a major impact on the total performance and quality of the product.

In order to create a true picture of the system, it was necessary to mathematically simulate the system and formulate welders' behavior and movement of the parts by application of information theory, standard deviation and probability theorem to study the impact of simultaneous operation and firing of the welding robots on the distribution system.

In applying complex math to large industrial works, one needs to understand the complete relationship of formulas, variables, constants, and the boundaries between theories and facts in the real world. Next, one should truly understand the industrial operation under study. To bring and fit an operation into formulas is not easy; mistakes are expensive. Several years of non-stop operation of the Chrysler plant and post design measurements clearly indicated the precision of mathematical simulation that were applied during the design. In this plant a 12,000 kVA substation feeds almost 100,000 kVA connected load.

Question #2: What problems were identified in the initial electrical systems and how were they solved?

Current surge during the welders' operations is similar to current flow due to a fault. The problem areas to watch were identified as follows:

- A. Sudden impact of welders simultaneously firing on substations;
- B. Sizing of bus ducts to carry the load with minimum voltage drop;

- C. Minimize the dependence of the critical loads on a single service only;
- D. Select and set protective devices to allow welders in rush current to go through, but recognize faults current which differs from the in-rush by only a few hundred amperes and to isolate trouble areas by properly acting and opening the circuit in due time;
- E. Separate clean power needed to operate sensitive moving parts of robots and electronic devices from mixed power needed by welders;
- F. Do all of the above in an overall optimized fashion to minimize cost and keep a high reliability factor for probability of not more than one defect per 10,000 weld.

Question #3:

How did the nominee use state-of-the-art technology to improve electrical operating performance?

Major industrial complexes such as chemical plants and auto assembly plants usually need to operate in 2, 2½ or even 3 shifts to optimize return on investment, meet the market demand and build enough reserves to allow scheduled shutdowns for line changes and modernization.

A one hour unscheduled shut down in an average assembly line means a loss of about \$900,000 in revenue. With this type of figure in mind, one needs to apply the ultimate of the available scientific methods to minimize shut down and damages that may increase product defects and/or delay production schedule.

In this type of operation every phase is 100% dependent on the previous phase, and the total system is similar to a chain that is as strong as its weakest link. Margins of perfect design are very narrow and one has to know how to get inside that boundary and operate within that limited window. Setting the breakers or relays too high will let the fault current get through and cause expensive damages by bringing the total system down for days. Setting the same devices too low will trip the breakers and cause delays, depleted product, and increase overhead due to low production.

One must apply proper mathematics and precise formulations to simulate the steady state conditions of the process, to record and document the variables effective in operation, and identify the upper and lower margins in each area that are critical to total system performance in the use of state-of-the-art technology.

Question #4:

What design methods were used to achieve cost efficiency?

To meet the production goal of not more than one defect in 10,000 weld, and continuous reliable operation, it became necessary to use the primary selective method, double ended substations with loops to minimize power failures and reduce the vulnerability of overloading a line/substation. Keeping the production free from defected parts, a smooth continuous operation to produce quality products as rated speed is the key to maximize cost efficiency. These objectives have been reached through mathematical calculations, accurate simulation, and successful implementation of detailed design planning.

Question #5:

What design methods were used to achieve energy efficiency?

Proper modelling of both robotic and man welder operations and power consumption, simulation of real life operations, sizing the distribution equipment to minimize losses, and application of mathematics in precise calculation of the thermal equivalent currents in the distribution loops, were major elements in the design of an energy efficient system.

Actual test values for equipment power requirements, proper demand, and the adequate diversity factors, were used to create a realistic picture of the total system under normal operational conditions to avoid energy waste and keep the system at the desired level of quality performance.

Question #6:

What techniques were used to improve systems reliability?

Simulations, modelling, and applications of probability theorem were applied to study the system behavior under different conditions (what ifs).

Engineering Background:

Ali M. Nasle is a vice president and director of computer services at Smith, Hinchman & Grylls Associates, Inc., Architects, Engineers, Planners in Detroit. He received a BSEE degree from Michigan State University and a MSEE from Wayne State University. Mr. Nasle has 20 years experience in the U.S. and abroad designing electrical systems for commercial and industrial projects and developing computer applications for electrical engineering. He is a Registered Professional Engineer and a member of IEEE, the Engineering Society of Detroit and the Association for Computer Machinery.