『原子力開發計劃에 隨伴된 經營 및 産業上槪念의 轉換』

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<要　　旨>

原子力 發電 計劃의 採擇은 現代的인 經營 및 産業上의 槪念에서 얻을 수 있는 利點을 누릴 機會가 되는 것이므로 이러한 槪念들은 發電所의 契約設計 諸 許可 및 建設工事의 제반 과정에서 적용시킬 수가 있는 것이다. 따라서 이러한 現代的 槪念의 適用 대상인 原子力發電所와 다른 工業製品에서 이 두가지 사이의 重要한 差異點은

1. 각 系統間에 複雜한 相互 聯關性이 있다는 것.
2. 安全系統과 그의 解釋에 高度의 信賴性이 要求된다는 것. 그리고
3. 高價의 投資額이 所要 된다는 것에 있다.

이러한 槪念은 일단 採擇 消化된 後에야 原子力發電所 後續機業務와 其他의 産業分野 및 産業經營에 까지 廣範圍하게 有益하도록 적용할수가 있으며 이들의 適用은 生産性의 具體的인 增加를 誘導함으로써 時間과 資本의 投資보상이 개선된다.

여기서는 주어진 時間이 制限 되어 있으므로 이러한 槪念中의 一部만을 골라서 開陳한다.

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以後 原子力 産業界의 금속加工, 製造, 企劃發展 및 商業用 原子爐 事業分野의 要職에서 活躍하고 1969年 古里原子力發電所 계약 初期단계 부터 韓國과 인연을 맺어 왔으며 現在 美웨스팅하우스 古里原子力 발전소 事業擔當理事로서 웨스팅하우스 電氣(韓國)會社의 運營總括 責任者임.

ADVANCED MANAGEMENT AND INDUSTRIAL CONCEPTS INTRODUCED BY A NUCLEAR POWER PROGRAM

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INTRODUCTION

ADOPTION OF A NUCLEAR POWER PROGRAM CREATES OPPORTUNITIES TO BENEFIT FROM ADVANCED MANAGEMENT AND INDUSTRIAL CONCEPTS. SUCH CONCEPTS ARE EMPLOYED IN THE PROCESS OF PLANT CONTRACTING, BESIGN, LICENSING AND CONSTRUCTION. THE IMPORTANT DIFFERENCES BETWEEN NUCLEAR POWER PLANTS AND OTHER INDUSTRIAL PRODUCTS, WHICH ACCOUNT FOR USE OF ADVANCED CONCEPTS ARE (1) THE COMPLEX INTERRELATIONSHIPS OF SYSTEMS(2) THE DEMAND FOR HIGH RELIABILITY SAFETY SYSTEMS AND ANALYSIS AND (3) THE HIGH CAPITAL COST.

THESE CONCEPTS, ONCE ASSIMILATED, CAN BE APPLIED BENEFICIALLY TO SUBSEQUENT NUCLEAR POWER PLANT WORK AND TO A BROAD SPECTRUM OF INDUSTRY AND INDUSTRIAL MANAGEMENT. THEIR APPLICATION CAN LEAD TO MATERIAL IMPROVEMENT IN PRODUCTIVITY AND IMPROVEMENT IN RETURN ON INVESTEMENT OF TIME AND MONEY. TIME PERMITS DISCUSSION OF ONLY A SMALL SELECTION OF SUCH CONCEPTS. I HAVE ATTEMPTED TO SELECT THOSE WHICH MAY YIELD THE LARGEST BENEFITS MOST QUICKLY. THEY ARE IDENTIFIED IN THE SEQUENCE THAT THEY ARE ENCOUNTERED IN A NUCLEAR POWER PROGRAM.

THESE CONCEPTS ARE

(1) FUNCTIONAL SPECIFICATION
(2) SYSTEMS APPROACH
(3) ANALYSIS IN LIEU OF DESIGN
(4) NON-SEQUENTIAL OPERATIONS

1) FUNCTIONAL SPECIFICATIONS

A POWER PLANT CAN BE CONSIDERED TO BE A COMPLEX SET OF INTERACTING SYSTEMS DETAILED DESIGN OF NUCLEAR PLANTS IS NOT YET WHOLLY STANDARDIZED BECAUSE OF CONTINUING IMPROVEMENTS IN TECHNOLOGY, INCREASING DEMANDS FOR SAFETY, PECULIARITIES OF SITE LOCATION AND SPECIFIC CUSTOMER REQUIREMENTS. AS A RESULT IT IS NOT POSSIBLE TO DEFINE DETAILS OF PLANT DESIGN AND CONSTRUCTION BEFORE WORK STARTS. HOW THEN, CAN ONE SPECIFY HIS REQUIREMENTS? THE ANSWER IS BY SPECIFYING FUNCTIONS RATHER THAN COMPONENTS.

IF WE TAKE THE SYSTEM FOR COOLING SPENT FUEL AS AN EXAMPLE, TRADITIONAL

METHODS WOULD SUGGEST THAT QUANTITIES, FLOWS, POWER AND SIMILAR PARAMETERS BE SPECIFIED. THAT, UNFORTUNATELY, WOULD LEAD TO A DIRECT CONFLICT IF SUBSEQUENT DESIGN AND ANALYSIS SHOULD SHOW THAT THE SPECIFIED CONDITIONS WERE INADEQUATE AND WOULD TO WASTEFULNESS IF THEY WERE EXCESSIVE.

THE ALTERNATIVE IS TO SPECIFY THE FUNCTION THE DESIRED END RESULT. FOR EXAMPLE, ONE MIGHT SPECIFY THE MAXIMUM POOL TEMPERATURE WHEN ALL COMPONENTS ARE OPERATIONAL AND WHEN ONE HEAT EXCHANGER IS OUT OF SERVICE. THIS WOULD ASSURE THAT THE DESIRED END RESULT IS ACHIEVED, REGARDLESS OF THE DESIGN DETAILS INVOLED. IT WAS STATED THAT A PLANT CONSISTS OF A SET OF INTERRELATED SYSTEMS. ANOTHER ADVANTAGE OF FUNCTIONAL SPECIFICTION IS THAT THE FUNCTIONAL SPECIFICATION OF A GIVEN SYSTEM CAN, WITHOUT DIFFICULTY, REQUIRE ACCOMODATION OF INTERACTIONS. TRADITIONAL METHODS OF SPECIFICATION CANNOT REASONABLY ACCOMODATE INTERACTIONS BECAUSE THEY ARE NOT WELL KNOWN UNTIL DETAILED DESIGN NEARS COMPLETION.

SYSTEMS APPROACH

FUNCTIONAL SPECIFICATION IS A DIRECT RESULT OF SYSTEMS CONCEPTS AND THE DISCUSSION GIVEN SERVES AS A PARTIAL INTRODUCTION TO THIS SUBJECT. MOST THINGS IN LIFE CAN BE PERCEIVED AS SYSTEMS OR AS PIECES OF SYSTEMS. THAT PERCEPTION, HOWEVER, YIELDS NO PARTICULAR REWARDS UNLESS A SOPHISTICATED ANALYSIS IS PLANNED OR UNLESS THERE ARE COMPLEX INTERACTIONS WHICH ARE OF CONCERN, NUCLEAR POWER PLANTS REQUIRE SOPHISTICATED ANALYSIS AND COMPLEX INTERACTIONS ARE OF CONCERN.

THE ESSENTIAL DIFFERENCE BETWEEN THE ESSENTIAL DIFFERENCE BETWEEN THE SYSTEMS CONCEPT AND OTHER CONVENTIONAL DESIGN CONCEPTS IS THAT IN SYSTEMS THERE IS FEEDBACK. FEEDBACK MAY ORIGINATE FROM WITHIN THE SYSTEM ITSELF OR FROM INTERACTION WITH ANOTHER SYSTEM. AGAIN USING THE EXAMPLE OF A SPENT FUEL COOLING SYSTEM, A CONVENTIONAL APPROACH TO SIZING A HEAT EXCHANGER MIGHT REQUIRE CONSIDERATION OF LIMITING TEMPERATURES, FLOWS AND HEAT TRANSFER COEFFICIENTS ONLY.

WITH A SYSTEMS APPROACH THE HEAT EXCHANGER WOULD BE ONLY ONE ELEMENT OF A SYSTEM WHICH INTERACTS WITH OTHER SYSTEMS SUCH AS (1) EVAPORATIVE COOLING FROM A VENTILATION SYSTEM, (2) HEAT LOADS ON THE SYSTEM WHICH COOLS THE SPENT FUEL COOLING SYSTEM, (3) THE OPERATIONAL OR ACCIDENT STATUS OF THE PLANT AND (4) MAINTENANCE STATUS.

ATTEMPTING TO IGNORE THE SYSTEMS CONCEPT IN DESIGN COULD BE EXPECTED TO RESULT IN (1) EXTREME CONSERVATION WHICH IS ECONOMICALLY UNDESIRABLE, (2) SYSTEM INADEQUACY UNDER VARIOUS COMBINATIONS OF CONDITIONS OR(3) INOPERABILITY. TIME DOES NOT PERMIT A FULL EXPLANATION OF INOPERABILITY. IT MUST SUFFICE TO SAY THAT THERE ARE CASES IN PLANT DESIGN WHERE EXTREME CONSERVATISM WITH RESPECT TO SOME PARAMETER OR COMPONENT WILL RESULT IN A SYSTEM BEING INOPERABLE BECAUSE AN OPPOSING PARAMETRIC LIMITATON HAS BEEN VIOLATHD. STEAM GENERATOR HEAT TRANSFER AREA AND HEAT TRANSFER COEFFICIENT IS AN EXAMPLE OF A CASE WERE EXTREME CONSERVATISM IN ONE DIRECTION LEADS TO AN UNSAFE CONDITION IN THE OTHER DIRECTION.

SO FAR THIS DISCUSSION HAS FOCUSSED

ON SYSTEMS CONSISTING OF HARDWARE, SUCH AS FLUID OR CONTROL SYSTEMS. HAD I PICKED DIFERENT EXAMPLES, IT WOULD HAVE BEEN THAT EXACTLY THE SAME PRINCIPLES APPLY TO DATA OR MANAGMENT SYSTEMS. MANAGEMENT SYSTEMS ARE NORMALLY DEVELOPTED TO FACILITATE CONTROL AND, LIKE OTHER SYSTEMS, HAVE FEED-BADK AS THE ESEENTIAL ELEMENT. QUALITY, COST AND PROGRESS ARE TYPICAL FOCI OF MANAGEMENT SYSTEMS FOR NUCLEAR POWER PLANTS AND FOR ALMOST ANY INDUSTRY.

3) ANALYSIS IN LIEU OF DESIGN

THE TRADITIONAL ENGINEERING CONCEPT TAUGHT IN UNIVERSITIES AND EMPLOYED IN PRACTICE IS THAT ONE DEFINES A PRODUCT BY GOING THROUGH A "DESIGN" PROCESS. TYPICALLY, IN THE CASE OF MECHANICAL DESIGN, *ONE WILL DETERMINE THE DESIRD EN* DRESULT, DECIDE WHAT COMPONENTS WILL BE REQUIRED AND IDENTIFY THE RELEVANT PH ISICAL PROPERTIES OF THE COMPONENTS. THE DESIGN PROCESS THEN CONSISTS OF DETERMINING PHISICAL CONFIGURATIONS (MAK ING DRAWINGS) WHICH ARE COMPATIBLEWITH THE PHISICAL PROPERTIES (SPEICIFICATIONS).

THIS METHOD CONTINUES TO BE EFFECTIVE FOR DESIGNING INDIVIDUAL COMPONENTS AND UNSOPHISTICATED SUB-SYSTEMS OR SYSTEMS. IT RAPIDLY BECOMES IMPRACTICAL WHEN DESIGN OF SYSTEMS IS CONSIDERED. IN FACT, IT IS NOT FEASIBLE APPROACH FOR COMPLEX SYSTEMS OR SYSTEMS WHICH HAVE SUBSTANTAL INTERACTIONS WITH OTHER SYSTEMS. THE POINT IS THAT TRADITIONAL DESIGN METHODS HAVE THEIR LIMITATIONS AND THE CONVENTIONAL CONCEPT OF DESIG N BECOMES OBSOLETE AS THE DEGREE OF SYSTEMS SOPHISTICATION INCREASES. AS THIS SOPHISTICATION INCREASES IT BECOMES DESIRABLE TO PLACE MORE EMPHASIS ON ANALYSIS.

ANALYSIS CAN BE PERCEIVED AS A PROCESS WHICH IGNORES THE REASONS THAT CONFIGURATIONS COME TO BE AS THEY ARE. IT ADDRSSES THE QUESTION OF WHETHER THE SELECTED CONFIGURATION WILL DO THE JOB AND THE QUETION OF WHAT HAPENS WHEN THAT 'CONFIGURATION IS SUBJECTED TO CERTAIN EXTERNAL CONDITIONS. AS AN EXAMPLE, ONE GEN ERALLY DOES NOT DESIGN A BUILDING TO WITHSTAND SPECIFIC SEISMIC CONDITIONS. ONE DESIGNS A BUILDING TO CONTAIN EQUIPMENT AND TO SUPPORT CERTAIN LOADS AND THEN PERFORMS AN ANALYSIS TO DETERMINE THE EFFECT OF SEISMIC EXCITATION. THE EXPERIENCED DESIGNER WILL HAVE DESIGNED THE BUILDING SO THAT THE SEISMIC ANALYSIS WILL YIELD AN ACCEPTABLE RESULT. THE INEXPERIENCED DESIGNER MAY FINDIT NECESSARY TO MODIFY HIS DESIGN TO OBTAIN AN ACCEPTABLE ANALYSIS. THE IMPORTANT POINT NEITHER DESIGNER ACTUAL LY USED THE TRADITIONAL DESIGN PROCESS WITH SEISMIC EXCITATION AS A SPECIFIC A ND DISCRETE INPUT. BUILDINGS TEND TO BE LESS SOPHISTICATED THAN MANY SYSTEMS. AS *THE LEVEL OF SOPHISTICATION INCREA*SES, EMPHASIS SHIFTS FROM RIGOROUS DESIGN TO RIGOROUS ANALYSIS. CONVERSELY, I TSHOULD BE NOTED THAT AS EXPERIENCE INCREASES, KNOWLEGE OF THE EFFECT OF DESIGN DECISIONS ON THE RESULTS OF ANALYSIS IMPROVES. THE RESULT IN THE NUCLEAR INDUSTRY IS THAT AS TIME PASSES, THE PRECISION OF DESIGN INCREASES AND EMPHASIS ON ANALYSIS SHOULD (BUT DOES NOT) DECREASE.

ONE OF THE "UNIQUE" CHARACTERISTICS OF THE NUCLEAR INDUSTRY IS THAT IN THE COURSE OF DESIGN AND CONSTRUCTION OF A POWER PLANT ONE SEES MANY TRULY MASSIVE REPORTS OF ANALYSES (FOR EXAMPLE THE SAFETY ANALYSIS REPORTS) BUT FEW

DESIGN REPORTS. IN FACT, IF YOU STUDY REPORTS WHICH HAVE THE WORD "DESIGN"INTH E TITLE, YOUWILL USUALLY FIND THAT THE CONTENTS REPORT THE RESULT OF ANALYSES RATHER THE PROCESS OF DESIGN ITSELF.

ALL ACTIVITIES SUFFER FROM RESOURCE LIMITAIONS. IN THE CASE OF DESIGN ANALYSIS THE LIMITING RESOURCES ARE MANPOWER AND, FREQUENTLY, COMPUTER CAPABILITY. ETH NUCLEAR INDUSTRY HAS TYPICALLY FOUND THAT THE MOST DESIRABLE RESULTS AND MAXIMUM PRODUCTIVITY ARE ACHIEVED BY SHIFTING EMPHASIS FROM DESIGN TO ANALYSIS. THE CONCEPT HAS APPLICATION THROUGHOUT INDUSTRY WHERE THE PRODUCT IS COMPLEX AND THE DESIGN IS REASONABLY WELL KNOWN. IT IS SIGNIFICANT THAT ANALYSIS GENERALLY SEEMS TO REQUIRE A HIGHER LEVEL OF TALENT THAN DESIGN. WHEN CARRIED TO EXTREMES, DESIGN IS FREQUENTLY DEPENDENT ON IMPLEMENTING A SET OF RULES THAT ARE GENERALLY TAUGHT IN UNIVERSITIES. ANALYSIS, IN THE OTHER HAND, REQUIRES MATHEMATICAL MODELING AND APPLICATION OF ANALYTICAL TECHNIQUES WHICH ARE LESS WELL KNOWN. THERE IS DANGER IN TRYING TO CONVERT A DESIGNER INTO AN ANALYSIST BECAUSE DIFFERERENT LEVELS OF CAPABILITY ARE REQUIRED. WHEN THERE IS A SUFFICIENT SUPPLY OF HIGH CALIBER PEOPLE IT MAY WELL BE POSSIBLE TO GAIN A SUBSTANTIAL IMPROVEMENT IN PRODUCTIVITY BY SHIFTING EMPHASIS FROM DESIGN TO ANALYSIS.

4) NON-SEQUENTIAL OPERATIONS

IN TERMS OF SHORT-RUN ECONOMICS THE CONCEPT OF NON-SEQUENTIAL OFERATIONS IS PROBABLY THE MOST ROWERFUL CONCEPT, IN FACT, THE CONCEPTS OF FUNCTIONAL SPECIFICATION AND ANALYSIS IN LIEU OF BESIGN ARE IMPORTANT NOT ONLY IN THEIR OWN RIGHT BUT ALSO BECAUSE THEY ARE DEVICES TO FACILITATE PARALLEL OPERATIONS. IT WAS STATED THAT CAPITAL INTENSIVENESS IS ONE OF THE "UNIQUE" CHARACTERISTICS OF A NUCLEAR POWER PROGRAM, THIS CHARACTERISTIC IS IMPORTANT BECAUSE INTEREST DURING CONSTRUCTION MAKES A VERY SUBSTANTIAL CONTRIBUTION TO THE TOTAL COST OF POWER, ESPECIALLY WITH TODAY'S INTEREST RATES, DIRECT AND SUBSTANTIAL ECONOMIES CAN BE ACHIEVED BY MINIMIZING DESINE AND CONSTRUCTION TIME, THE FIRST AND MOST OBVIOUS WAY TO SEEK SUCH ECONOMY IS TO ASK WHAT OPERATIONS TRADITIONALLY DONE IN SEQUENCE CAN REASONABLY BE DONE NON-SEQUENTIALLY? I.E. IN PARALLEL.

IT IS VERY IMPORTANT TO RECOGNIZE THAT SEQUENTIAL OPERATIONS ARE TRADITIONALLY THE MOST CONSERVATIVE. THAT IS, THERE IS LEAST LIKELYHOOD OF LATER DISCOVERY THAT "THINGS" SHOULD HAVE BEEN DONE DIFFERENTLY. IN A COST INTENSIVE PROJECT, THIS FORM OF CONSERVATISM CARRIES AN EXTREMELY HIGH PRICE TAG. IN THE NUCLEAR INDUSTRY AN ATTEMPT IS MADE TO BALANCE THE COST OF THIS FORM OF CONSERVATISM AGAINST THE COST OF MODEST AMOUNTS OF REWORK OR REDESIGN WHICH RESULT FROM STARTING AN OPERATION BEFORE ALL FINAL INPUTS ARE AVAILABLE.

CONCEPTUALLY, THE SYSTEMS DESIGN ANALYSIS SEQUENCE IS TO PERFORM A ROUGH SYSTEMS DESIGN, WHICH GENERALLY CONSISTS OF ADAPTATION OF A PREVIOUSLY ANALYZED DESIGN, TO PERMIT SPECIFICATION OF EQUIPMENT. WHILE EQUIPMENT PROCUREMENT PROCEEDS FURTHER DESIGN DETAILS ARE DEVELOPED AND ANALYSES ARE PERFORMED. WHEN EQUIPMENT TESTS ARE COMPLETE THEY ARE CONFIRMED AGAINST THE

ASSUMPTIONS USED IN THE ANALYSIS. OBVIOUSLY, THE ELAPSED TIME IS MUCH LESS THAN IT WOULD BE IF PROCUREMENT WAS NOT STARTED UNTIL DETAILED DESIGN WAS COMPLETE AND IF ANAYLSIS WAS NOT STARTED UNTIL PROCUREMENT WAS COMPLETE.

CONSTRUCTION AND ERECTION WORK ON-SITE ARE ANALOGOUS TO SYSTEMS AND EQUIPMENT WORK EXCEPT THAT THE TIME SAVINGS ARE SUBSTANTIALLY GREATER. THE MOST BASIC DESIGN-LAYOUT- CANNOT TRULY BE COMPLETED UNTIL AFTER EACH SPECIFIC PIECE OF EQUIPMENT HAS BEEN DESIGNED BY ITS PARTICULAR VENDOR. DUCT WORK CANNOT BE FULLY DEFINED UNTIL AFTER ALL DETAILS OF PIPE RUNS AND ELECTRICAL CABLEWAYS HAVE BEEN DETERMINED. OBVIOUSLY, AGAIN, THE TIME REQUIRED TO DO THESE PIECES OF DESIGN IN SEQUENCE WOULD BE UNPALATABLE.

IN MOST INDUSTRIAL ACTIVTIES, AND ESPECIALLY IN CAPITAL INTENSIVE PROJECTS, IT IS IMPORTANT TO APPLY THE CONCEPT OF NON-SEQUENTIAL OPERATIONS TO APPROACH AND OPTIMUM BALANCE BETWEEN THE TIME COST OF MONEY AND THE COST OF REDOING WORK THAT IS LATER FOUND TO REQUIRE CHANGE BECAUSE IT WAS STARTED BEFORE ALL DETAILED INPUT INFORMATION WAS AVAILABLE.

CONCLUSIONS

WHEN THE DECISION IS MADE TO EMBARK ON A NUCLEAR POWER PROGRAM, VARIOUS CONCEPTS WILL NECESSARILY BE EMPLOYED BY THE ORGANIZATIONS INVOLVED IN DESIGN AND CONSTRUCTION. SOME OF THESE CONCEPTS WILL BE NEW IN THAT THEIR DEVELOPMENT WAS NOT NECESSARY TO COPE WITH PRIOR PROBLEMS. HOWEVER, ONCE THESE CONCEPTS ARE DEVLOPED, FOR WHATEVER REASON, IT CAN REASONABLY BE EXPECTED THAT THEY CAN BE PROFITABLY APPLIED IN UNRELATED INDUSTRIAL AND MANAGEMENT FIELDS.

FUNCTIONAL SPECIFICATION IS A BROADLY APPLICABLE DEVICE TO SHIFT RESPONSIBILITY AND THE BURDEN OF DETAILED DESIGN ONTO A VENDOR.

THE SYSTEMS APPROACH IS A DEVICE FOR MAKING BENEFICIAL USE OF FEEDBACK AND FOR HANDLING INTERACTIONS WHICH ARE TOO COMPLEX TO BE HANDLED EFFICIENTLY BY TRADITIONAL METHODS.

ANALYSIS IN LIEU OF DESIGN IS A DEVICE TO FACILITATE EFFICIENT USE OF EXISTING DESIGN AND ANALYSIS INFORMATION AND TO PROVIDE MAXIMUM ASSURANCE OF A SUCCESSFUL RESULT WITH MINIMUM INVESTMENT IN DESIGN TIME AND COST.

NON-SEQUENTIAL OPERATIONS IS, VERY SIMPLY, A DEVICE TO GAIN TIME AT THE EXPENSE OF MONEY AND, THEREFORE, TO PERMIT LEAST TOTAL COST WHENEVER THE COST OF MONEY IS SIGNIFICANT.

THESE CONCEPTS ARE TOOLS WHICH ARE AVAILABLE FOR USE BY ALL. I URGE YOU TO USE THEM TO YOUR ADVANTAGE.

THANK YOU.