Chapter 8: Conclusion

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This concluding section epitomizes a brief sylloge of the main points in this research, salient features of Doctonaut, limitations of the study and indicative areas of further research.

8.1 Conclusion

Previous researches have established that an integrated management model for managing engineering design is indispensably needed to aid design engineers in their design management decisions and to sustain the competitive edge of the company because efficient management of piping engineering design management cycle is indispensable to sustain any company's competitive advantage, thereby preventing time loss, opportunity loss & revenue loss. The companies who do not have effective design management practices/models are much less successful in business than the ones having it.

Previous researchers have established that design management cycle comprises of Three Governing Levels:

Strategic Design Management,

Tactical Design Management,

Operational Design Management

and some other researchers have established that at Each Level, design expertise can be effectively managed to produce an innovative solution through Three Layers:

Enabling Technology Layer,
Solution Layer,
Interface Layer.

The holistic Piping Engineering Design Management Cycle has Six Phases namely:

Establishing a Need Phase,
Analysis of Task Phase,
Conceptual Design Phase,
Embodiment Design Phase,
Detailed Design Phase,
Implementation Phase.

The management of Piping Engineering Design has two interfering Sides:
Design Product Engineering Side,
Design Process Side.

The three governing levels of design management run on both sides (Product Side and Process Side) through each of the six phases of the design management cycle. Multiple issues have been found to be plaguing the design management cycle in each phase, on each side and through each governing level.

From the comprehensive reviews of over three hundred available relevant existing literatures, it has been found that there have been some researches in the broader field of Multidisciplinary Engineering Design Management. There have also been some researches in the Management of specifically Piping Engineering Design. It has been found that these studies have been done for Architecture,

Civil, Construction, Electronics, Transportation industries; they are different among themselves and do not throw any light on the state of design management affairs in the oil & gas industry. Previous studies have also established that, engineering design thinking & corresponding design activities in different industries in differing situations have crucial differences.

Previous studies have established that an integrated management model for managing engineering design is indispensably needed. The previous studies have their respective limitations. Some researchers have focused only on the Product Side of Engineering Design Management and have so far found out three issues challenging the efficient management on engineering design on the Product Side. Whereas some other researchers have focused only on the Process Side of Engineering Design Management and have so far found out four issues challenging the efficient management on engineering design on the Process Side. Existing literature review has evidenced that engineering design management can be effectively managed if the identified issues are catered to. Previous studies for specifically piping engineering design management have focused only from a pure engineering point of view, ensuing a colossal dearth of focus on the management aspects in the product as well as the process sides of design management; the existing studies did neither focus on the piping enginering design management aspects present in both the product sides and the process sides nor into any integrated model for the complete cycle that caters to the management issues of the product as well as the process sides. Further, it has been found that no research has focused on whether there are any issues plaguing the management of engineering design in India. An extensive literature review covering over three hundred relevant available literatures yielded no references of any design approaches & models for oil & gas piping engineering design management in India. The previous studies neither throw any light on the design management in the global oil & gas industry nor on the design management issues of any industry in India. There has been no research to know how design is

being managed in India. The existing studies have identified issues plaguing engineering design management worldwide in other industries & outside India. However, previous studies have established that design management roles, practices and activities significantly & crucially vary from industry to industry and from country to country. Therefore, the applicability of those identified issues to the Indian oil & gas context is uncertain. No study has focussed on their applicability to either the oil & gas industry or on their applicability to India. Moreover, previous researchers have stressed the growing & indispensable need for an integrated design management model and in India no research has focussed on engineering design management. The identified research gaps have not been addressed by any of the previous studies. This present research tries to answer these questions and thus address these dodged research gaps in a bid to improve engineering design management in India.

The business problem has been:

An integrated model for managing engineering design is indispensably needed to aid design engineers/managers in their management decisions and to sustain the competitive advantage of the company.

The research gaps, that this study has addressed, have been:

Extensive literature review yielded no references of any design approaches & models for oil & gas piping engineering design management in India. There has been no research to know how design is being managed in India.

The identified research gaps have not been addressed by any of the previous studies.

The research problems have been:

The Existing Practices/Models of Piping Engineering Design Management that are being used in Oil & Gas Industry in India are unknown, although are indispensably needed to be known in order to sustain the competitive advantage of the company.

The Areas of Improvements or Issues, that are needed to be identified in order to develop a Model of Piping Engineering Design Management, are also unknown.

The research questions have been:

HOW Piping Engineering Design is being managed in oil & gas industry in India?

WHAT are the areas of improvements in the existing practices/models and HOW those areas can be catered to through a Model of Piping Engineering Design Management?

The present research objectives have been:

To Study the Existing Practices/Models of Piping Engineering Design Management that are being used in oil & gas industry in India.

To Identify the areas of improvements in order to develop a Model of Piping Engineering Design Management.

To solve this business problem, address the research gaps, answer the research questions and fulfill the research objectives, the existing practices of piping engineering design management that are being used in the piping engineering design department of India's largest oil & gas company have been studied, issues identified, compared with other researchers' finding, each research step has been deeply thought upon, profoundly analyzed, rigorously verified and an integrated model of piping engineering design management has been proposed as seriated through the following paragraphs.

After careful consideration of established methods & approaches, a descriptive qualitative case study with a grounded theory approach has been chosen as the philosophy of this research owing to the approach being the best suitable research mode for this particular study of the problem through the objectives. This is because the present research purpose has been descriptive (fact finding about a state of affairs), research process has been qualitative (for a phenomenon related to quality) and research approach has been a grounded outlook (to systematically generate theory from data through inductive thinking about a phenomenon of interest). Sample selection has been done in three stages, while decreasing sample size by using the Theory of Elimination and unit of analysis has been critically chosen in line with the research objectives. Detailed case study questionnaire has been developed in three steps so as to enable an appropriate research into the answers to the research questions. Data have been collected and analysed in line with the research philosophy and rationale. All evidences substantiating the case study have been archived and are being maintained with the researcher. The validity of the case study has been verified by employing a number of tactics. To ensure construct validity & internal validity, two tactics have been employed. First, two levels of analyses are undertaken during data analysis – conceptual and detailed. Secondly, the case study reports are reviewed by key informants and then their feedbacks have been incorporated in the final research. This present research study is expected to provide depth and so the study intended to provide an insight into the probable relationships suggested and therefore to generalize beyond this particular research area would require additional confirmation of results that is beyond the scope of this particular research and has been included as a further research scope. Although the research is limited to only one organization that has been selected as a representative of the oil and gas industry in India based on the fact of that company being the largest (in terms of revenue, size as well as market share) among all oil & gas companies in India, however, a point to be noted here is - this research establishes that the seven challenges of design management identified

outside India are applicable to the oil & gas industry in India plus there are some additional five challenges specific to the Indian oil & gas context and therefore, theoretically it can be inducted that most/all of the found out issues and their solution model proposed through this research shall be applicable to the other oil & gas companies as well (the researcher, through his previous work experiences, has also experientally observed these issues to be plaguing design management in some other oil & gas companies in India as well as abroad); further, external validity is beyond the scope of this particular research and is a future research arena. Reliability has been highly ensured through apt instruments, archival of all evidences and use of data analysis software Atlas.ti. This research employed a number of approaches to ensure high reliability while applying procedures for data collection and analysis. First, the case study protocol has been used to guide the research process as the protocol is a major tactic in increasing the reliability of a case study research and is intended to guide the researcher / investigator in carrying out the case study. The protocol has comprised of instruments as well as procedures and general rules that have been followed. This ensured consistency in the areas covered. Secondly, to reduce the likelihood of forgetting or misunderstanding the data and to allow independent data analysis by other researchers, interviews have been taped, transcribed and all original evidences are archived. Thirdly, the use of Atlas.ti qualitative analysis software allowed systematic & consistent analysis of the qualitative data and further increased the reliability of this research because procedures can be repeated. Fourthly, the field notes taken by the researcher have been also transcribed for future reference. Different levels of coding, within case analysis (conceptual & detailed), theory triangulation, employment of case study protocol, use of software Atlas.ti, archival of all evidences, etc. have been carried out to ensure high quality (construct validity, internal validity & reliability) of the study.

Data analyses has been done through grounded theory approach involving process iterations for movements between existing theory and the collected

interview data, observation data & interaction data. The coding approach has involved perspectives of the theoretical framework/lens, the existing constructs and search for any new finding, in tune with the research objectives. The present case data analysis can be represented in three steps or levels. The first step has been open coding, followed by the second & third steps. Both the second and third steps have been focussed/selective coding and used axial focussed as well as theoretical focussed coding techniques. The third step differed from the second step by focussing deeper into the underlying relationships among the codes, categories & concepts; the identified inter-relationships, intra-relationships, cross-relationships and contra/clashing-relationships are linked as a pertinent root causal function. It may be noted that in vivo coding has been used in all three steps. While the first & second steps helped the researcher in exploring & understanding the existing practices of piping engineering design management and the challenges/issues by developing the codes, categories & concepts, the third step helped the researcher understand the relationships of the codes to the challenges/issues that affect the design management output in the existing practices.

The case study has been done through various data collection methods including interviews, observations and interactions with the team members. This study focusses on reality as perceived by the researcher himself, in line with the ideology that reality is what & how we perceive any particular issue and as such, this study is one of the several probable theories of the business management problem. By limiting the study to a single organization, the researcher is able to examine the case in more detail and to thoroughly understand the interrelationships of isolated data; this is more relevant because it focusses on depth of insightful knowledge instead of generality promoted by others. This approach may be criticized as developing localized theory; however, this is still a useful contribution to existing knowledge since it establishes that the issues plaguing the management of piping engineering design in other industries in other

countries, are also applicable to India and there are some additional issues in the Indian oil & gas scenario. Further, the relevance of this specific research in the Indian oil & gas context is bona fide.

The concepts/theories/solutions have been refined in a number of iterative stages leading to natural theory built-ups from the analysis. These refined concepts/solutions have been then again iteratively integrated to synthesise the final refined concepts/theory/solutions.

The existing practices have been described and challenges existing in the present practices have been identified and compared to the issues found by other researchers in other industries; it has been observed that all the seven issues from previous researches are existing and five additional issues are identified to be plaguing the efficient management of piping engineering design in the oil & gas Industry in India. Catering to all the identified issues, a conceptual new model (appositely named Doctonaut) has been proposed to systematically and judiciously manage piping engineering design management.

The research objectives & questions have always been borne in the mind of the researcher throughout the entire research process, with special emphasis during the data collection and analyses stages of the research. As a result, each step has been deeply thought upon, profoundly analysed, rigorously verified and then used in the research. At the later stages, it has been verified whether the findings do indeed answer the research questions and meet the objectives.

Neoteric Knowledge Advancement by this study is gravitated in this paragraph. This study has reviewed pertinent existing research knowledge and has built a new basic conceptual framework; after that data has been collected and analysed as per a critically chosen research design and the previous research knowledge has been compared to the findings; it has been found that all the earlier

identified seven issues are applicable to the Indian oil & gas context and additionally five more issues are found to be plaguing the effective management of piping engineering design. Finally, in line with the research objectives and questions, from the analysed data a brand new model of piping engineering design management, appositely named Doctonaut, has been built encompassing the entire cycle throughout each of the bi-sided six phases; the initially built basic conceptual framework has been suitably modified, augmented and aptly included as a part of this new model Doctonaut through an Operator-Integrator sub-model; this integrated model Doctonaut has been built extensively catering to all the previous seven issues (from previous researches) that are found to be applicable in the present research context as well as the newly identified five issues (from this particular research), catering to a total of all the twelve issues/challenges; thus, this present study substantially adds & advances the existing knowledge in this field of Piping Engineering Design Management.

This research work's consistency with the research objectives and questions has been successfully verified. Further, a few salient advantages of the study's findings, especially the new model Doctonaut, have been highlighted in the following paragraphs; for e.g., sustaining & developing the competitive edge of a company, improving the safety of personnel, equipment, environment & other stake holders of the design group, etc. The limitations of the study & the elicited potential areas of future research have also been documented; for e.g. applicability of the new model in other industries, etc.

In short, the previous researches as well as existing practices of piping engineering design management have been analysed and a conceptual new model named Doctonaut has been built that takes the existing knowledge a step further by validating the presence of issues identified elsewhere plus additional issues to

be applicable to the Indian oil & gas sector as well as by integrating inductive solutions systematically into each stage of the entire design management cycle; this has been an indispensable step that the previous researchers have not ventured into and a step that ensures that the full benefits of the research knowledge of this field permeate each step of the entire design management cycle, thus guaranteeing continuous improvement as well as safety of the company's competitive edge, that in turn shall positively contribute directly to the development of the company and indirectly to the country & the world.

8.2 Salient Features of the New Model Doctonaut

A few salient features of the New Model Doctonaut, that edges it over contemporary/in-vogue practices, are enlisted as follows –

- First of its kind product & process sides integrated comprehensive model for the oil & gas industry
- Offers full systematization of the PEDM cycle that so far is being used to be managed by people as per their own experience & thoughts, and thus being prone to subjective managerial decisions affecting the profitability as well as the future of the company
- Real time issues established to be affecting the cycle efficiency, that are mostly ignored, can now be managed easily & effectively through this model
- The New Model can be administered through any custom designed software

- Doctonaut is expected to improve the quality of the design product because the identified challenges are recognized and taken care of; this automatically improves the safety of personnel, equipment, environment and all other direct as well indirect stake holders of engineering design

- The New Model ensures continuous & consistent development, thereby intrinsically & invariably safeguarding and sharpening the company's competitive advantage

- The New Model's features are definitely going to reduce, if not completely eliminate, time loss, revenue loss and opportunity loss of any company practicing it resolutely; success is theoretically guaranteed through the New Model Doctonaut, however, the extent of success may vary from company to company, from people to people owing to human being's inherent unique differences from each other affecting their competencies in administering, operating & controlling the Model

- Many other advantages of the New Model Doctonaut may eventually emanate in terms of improving time, energy & money utilizations, that in turn shall make positive differences in the success of the PEDM cycle and the company

8.3 Limitations of this Research

Albeit this research adds substantially to the existing knowledge in the field of piping engineering design management for the oil & gas industry in India and also envisages quite some critical benefits for sustaining & improving the competitive advantage of the company, the study has the following limitations –

- The research is limited to only one organization that has been selected as a representative of the oil and gas industry in India based on the fact of that company being the largest (in terms of revenue, size as well as market share) among all oil & gas companies in India; however, a point to be noted here is - this research establishes that the challenges of design management outside India are applicable to the oil & gas industry in India; plus there are some additional challenges specific to the Indian oil & gas context and therefore, theoretically it can be inducted that most/all of the found out issues and their solution model proposed through this research shall be applicable to the other oil & gas companies as well (the researcher, through his previous work experiences, has also experientally observed these issues to be plaguing design management in some other oil & gas companies in India as well as abroad); further, as discussed in Section 4.1.3, external validity is beyond the scope of this particular research and is a future research arena

- The New Model Doctonaut that has although been developed through practical findings, has not yet been practically administered in any company and hence is not verified

8.4 Further Research Arenas

This discussed research elicits the following further research arenas in Piping Engineering Design Management -

- To Design a Software for the New Model Doctonaut

- The extent of practical success through Doctonaut-in-use at Oil & Gas Companies in India

- Applicability of the New Model Doctonaut to industries other than Oil & Gas in India

- Applicability of the New Model Doctonaut to other Indian Oil & Gas companies

- Applicability of the New Model Doctonaut to Oil & Gas companies outside India

- Applicability of the New Model Doctonaut to industries other than Oil & Gas outside India