

Chapter 4: Research Design

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This Chapter paints the basic design of the research itself; it depicts the plan including methodologies, rationales & philosophies for application in this study.

4.1 Research Methodology

Researches can be classified into multiple types based on the *research purpose, research process and research approach*.

From a *purpose* viewpoint, researches can be broadly classified into five types –

- (a) *Descriptive*: for fact finding about a present state of affairs,
- (b) *Analytical/Historical/Correlational*: for critical evaluation of already found facts to find relationships,
- (c) *Fundamental/Conceptual*: to create new theory / abstract ideas,
- (d) *Exploratory/Empirical/Experiential/Predictive/Applied*: to clarify/verify already available concepts or assess their applicability,
- (e) *Case Study*: for an in-depth, and detailed examination of a subject of study (the case) relevant under contextual conditions in order to reach the basic causal relations (Kothari, 2004).

From a *process* viewpoint, researches can be broadly classified into four types –

(f) *Qualitative*: based on a phenomenon relating to quality (the researcher is an object of interview/survey),

(g) *Quantitative*: based on measurement of quantity (can be statistical, the researcher is an observer),

(h) *Experimental*: to evaluate whether a concept/program had the intended causal effect on the relevant participants (the researcher carries out the research process and is an observer),

(i) *Action/Participatory*: involving social action to solve an immediate problem or group action for progressive problem solving (the researcher directs & facilitates the research process, the participant is an observer) (Kothari, 2004; Denscombe, 2010).

There are many types of research approaches that are generally specific to the particular purpose &/or the particular process of the research. From an *approach* viewpoint, qualitative researches can be broadly classified into four types –

(j) *Grounded Theory*: to systematically generate theory from data through inductive thinking about a phenomenon of interest (Glaser & Strauss, 1967; Charmaz, 2006; Creswell, 2007),

(k) *Phenomenological/Protocol/Heuristic*: to understand how a phenomenon is subjectively perceived & commonly interpreted by people (Creswell, 2007),

(l) *Ethnological*: to understand the shared patterns of a phenomenon in a common culture group or ethnicity (Creswell, 2007),

(m) *Hermeneutic/Narrative/Discourse*: to interpret narrations by individuals about a particular phenomenon (Creswell, 2007).

Out of these 13 [points 4.1 (a) to 4.1 (m)] broad types of research, it is noted that most researches generally comprise of a combination of these different

methods (Kothari, 2004; Creswell, 2006). These thirteen broad types of research are presented in Table 4.1.

The present research objectives (refer Section 3.7) are to find *facts about the present state of affairs* in Piping Engineering Design Management (PEDM) that **matches with 4.1 (a)**; then, as the research objectives & research questions require to find the existing challenges and how to overcome those, this research calls for an *in-depth and detailed examination of the facts* in order to reach the basic causal relations & as such this **matches with 4.1 (e)**; and a *detailed examination of a phenomenon* (PEDM & its challenges) is the most suitable, thus **matching with 4.1 (f)**; further, in line with the research objective of building an integrated model of PEDM to overcome the identified challenges, the *systematic generation of theory from data through inductive thinking, as in 4.1 (j)*, is the most applicable approach of analysis; hence, categorically the present research required:

4.1 (a) + 4.1 (e) + 4.1 (f) + 4.1 (j) => descriptive qualitative case study with a grounded theory approach

Therefore a *descriptive qualitative case study with a grounded theory approach* has been chosen for this particular research. This mixed approach is further detailed in the subsequent sections.

(Table 4.1 follows in next page)

Table 4.1: Types of Researches

Viewpoint	Tag	Research Type	Description
<i>Research Purpose</i>	a	Descriptive	For fact finding about a present state of affairs (Kothari, 2004)
	b	Analytical/Historical/ Correlational	for critical evaluation of already found facts to find relationships (Kothari, 2004)
	c	Fundamental/ Conceptual	to create new theory / abstract ideas (Kothari, 2004)
	d	Exploratory/Empirical /Experiential/ Predictive/Applied	to clarify/verify already available concepts or assess their applicability (Kothari, 2004)
	e	Case Study	For an in-depth & detailed examination of a subject of study (the case) relevant under contextual conditions in order to reach the basic causal relations (Kothari, 2004)
<i>Research Process</i>	f	Qualitative	Based on a phenomenon relating to quality (Kothari, 2004; Denscombe, 2010)
	g	Quantitative	Based on measurement of quantity (Kothari, 2004; Denscombe, 2010)
	h	Experimental	To evaluate whether a concept/program had the intended causal effect on the relevant participants (Kothari, 2004; Denscombe, 2010)
	i	Action/Participatory	Involving social action to solve an immediate problem or group action for progressive problem solving (Kothari, 2004; Denscombe, 2010)

Viewpoint	Tag	Research Type	Description
<i>Research Approach</i>	j	Grounded Theory	To systematically generate theory from data through inductive thinking about a phenomenon of interest (Glaser & Strauss, 1967; Charmaz, 2006; Creswell, 2007)
	k	Phenomological/ Protocol/Heuristic	To understand how a phenomenon is subjectively perceived & commonly interpreted by people (Creswell, 2007)
	l	Ethnological	To understand the shared patterns of a phenomenon in a common culture group or ethnicity (Creswell, 2007)
	m	Hermeneutic/ Narrative/Discourse	To interpret narrations by individuals about a particular phenomenon (Creswell, 2007)

“The case study method is a favoured method to study practices of design management” (Svengren, 1993) because the research inquiries include a concern for how to integrate design with other business functions, which is a process of change” (Svengren, 1993; Kothari, 2004) and enables an in-depth, and detailed examination of a subject of study (the case) relevant under contextual conditions in order to reach the basic causal relations (Kothari, 2004). Green, Kennedy, & McGown (2002) have researched into the existing four case study based research methods in engineering design namely Protocol Studies, Ethnographic Observation, Historical Analysis & Experiential Analysis and have found that a Multi-Method research approach, that complementarily uses the four methods as per suitability, is best in terms of interpretability & recognition of research (Green, Kennedy, & McGown, 2002). Protocol Studies are concerned with constraining or equalizing variables of the research equation (Dorst, 1995). When designers work for real such rational constructs do not apply leading to the

research being less representative of the actual design process (Dwarakanath & Wallace, 1995; Green, Kennedy, & McGown, 2002). “With the growing recent recognition of engineering as essentially a human activity, Ethnographic Studies, wherein the researcher gains access to companies and working as designers or with designers the researcher gets an inside view of their activities, prove to be more useful in helping to understand how and why design happens” (Wallace & Hales, 1989; Kennedy, 1997; Green, Kennedy, & McGown, 2002). Historical Analysis is used for comparing new design products to past one or learning from past design (Green, Kennedy, & McGown, 2002). Some design researchers have used Experiential Analysis to draw on their own designing experiences to explain the aspects of the design process (Green, Kennedy, & McGown, 2002). French studied engineering design from product side through his experience of design (French, 1992). Pahl and Beitz also put up a similar study (Pahl, Beitz, & (Ed.) Wallace, 1984). “Design researchers are also rightly concerned about the lack of acceptance of their ideas by practising designers” (Cross, 1993; Beitz, 1994; Green, Kennedy, & McGown, 2002). “By *involving designers in the research as equal partners* it is more likely that the outcome of the research will be taken up because of the shared ownership of the knowledge produced by the research” (Green, Kennedy, & McGown, 2002). A Multi-Method research approach combines the advantages of the four methods complementarily to negate the disadvantages of each, thus leading to enhanced recognition of the research (Green, Kennedy, & McGown, 2002). In the study of design process, the adoption of a *qualitative and inductive approach* enables the collection of a vast amount of primary data without any predetermined judgements as to what factors are most pertinent (Charnley, Lemon, & Evans, 2011).

Among the different established processes to do a research, the qualitative & quantitative research processes are most widely used. The qualitative case study with a grounded theory approach chosen for this research is further

supported by previous researches on qualitative research & its quantitative counterpart, as presented in following Table 4.2 (Maxwell & Loomis, 2003):

Table 4.2: Qualitative vs. Quantitative Research (Maxwell & Loomis, 2003)

RESEARCH FEATURES	QUANTITATIVE RESEARCH	QUALITATIVE RESEARCH
RESEARCH ARENA		
Purpose	<ul style="list-style-type: none"> - Precise measurements & variable comparisons - Relations among variables - Inferencing from sample to population 	<ul style="list-style-type: none"> - Meaning, Context and Process - Discovering unanticipated events, conditions and effects - Understanding of single cases - Induction based development of
Conceptual Framework	<ul style="list-style-type: none"> - Variance theories 	<ul style="list-style-type: none"> - Process theories
Research Questions	<ul style="list-style-type: none"> - Variance questions: truth of proposition, absence or presence, amount or degree, correlation - Testing of hypothesis - Causality: factual 	<ul style="list-style-type: none"> - Process questions: how & why - Meaning - Context: holistic - Conceptual framework works as hypothesis
RESEARCH METHODS		
Relationship	<ul style="list-style-type: none"> - Objectivity / influence reduction: researcher as an extraneous variable 	<ul style="list-style-type: none"> - Use of influence as a tool for Understanding: researcher as a part
Sampling	<ul style="list-style-type: none"> - Probability sampling - Establishing valid comparisons 	<ul style="list-style-type: none"> - Purposeful sampling
Data Collection	<ul style="list-style-type: none"> - Prior development of instruments - Standardization - Measurement / testing: quantitative / categorical 	<ul style="list-style-type: none"> - Inductive development of strategies - Adapting to particular situation - Collection of textual or visual material

RESEARCH FEATURES	QUANTITATIVE RESEARCH	QUALITATIVE RESEARCH
Data Analysis	<ul style="list-style-type: none"> - Numerical descriptive analysis statistics, correlation - Estimation of population variables - Statistical hypothesis testing - Textual data conversion into many categories 	<ul style="list-style-type: none"> - Textual analysis: memos, coding, connecting - Grounded theory - Narrative approaches
RESEARCH VALIDITY		
Internal Validity	<ul style="list-style-type: none"> - Statistical conclusion validity - Construct validity - Causal validity: control of extraneous variables 	<ul style="list-style-type: none"> - Descriptive validity - Interpretive validity - Construct validity - Causal validity: identification and assessment of alternative explanations
External Validity	<ul style="list-style-type: none"> - External generalizability or comparability 	<ul style="list-style-type: none"> - Transferability - Generalizing to theory

To sum up the discussion, a *descriptive qualitative case study with a grounded theory approach* is chosen for this particular research since the research objectives defined in Section 3.7 do get catered only by 4.1 (a): Descriptive (to find facts & challenges on the present state of affairs in PEDM), 4.1 (f): Qualitative (a detailed examination of PEDM & its challenges), 4.1 (e): Case Study (for an in-depth and detailed examination of the facts in order to reach the basic causal relations in challenges); further, in line with the research objective of building an integrated model of PEDM to overcome the identified challenges, the systematic theory generation from data through inductive thinking, as in 4.1 (j): Grounded Theory Approach is the most appropriate method of

analysis for this qualitative research. Moreover, it is noted that this present case (Descriptive Qualitative Case Study with a Grounded Theory Approach) is for reaching the basic causal relations (Table 4.1 point-e: Case Study) leading to theory formulation only and is –

Neither: the verification or testing of generated theory/concepts to ascertain applicability (Table 4.1 point-d: Exploratory or point-h: Experimental),

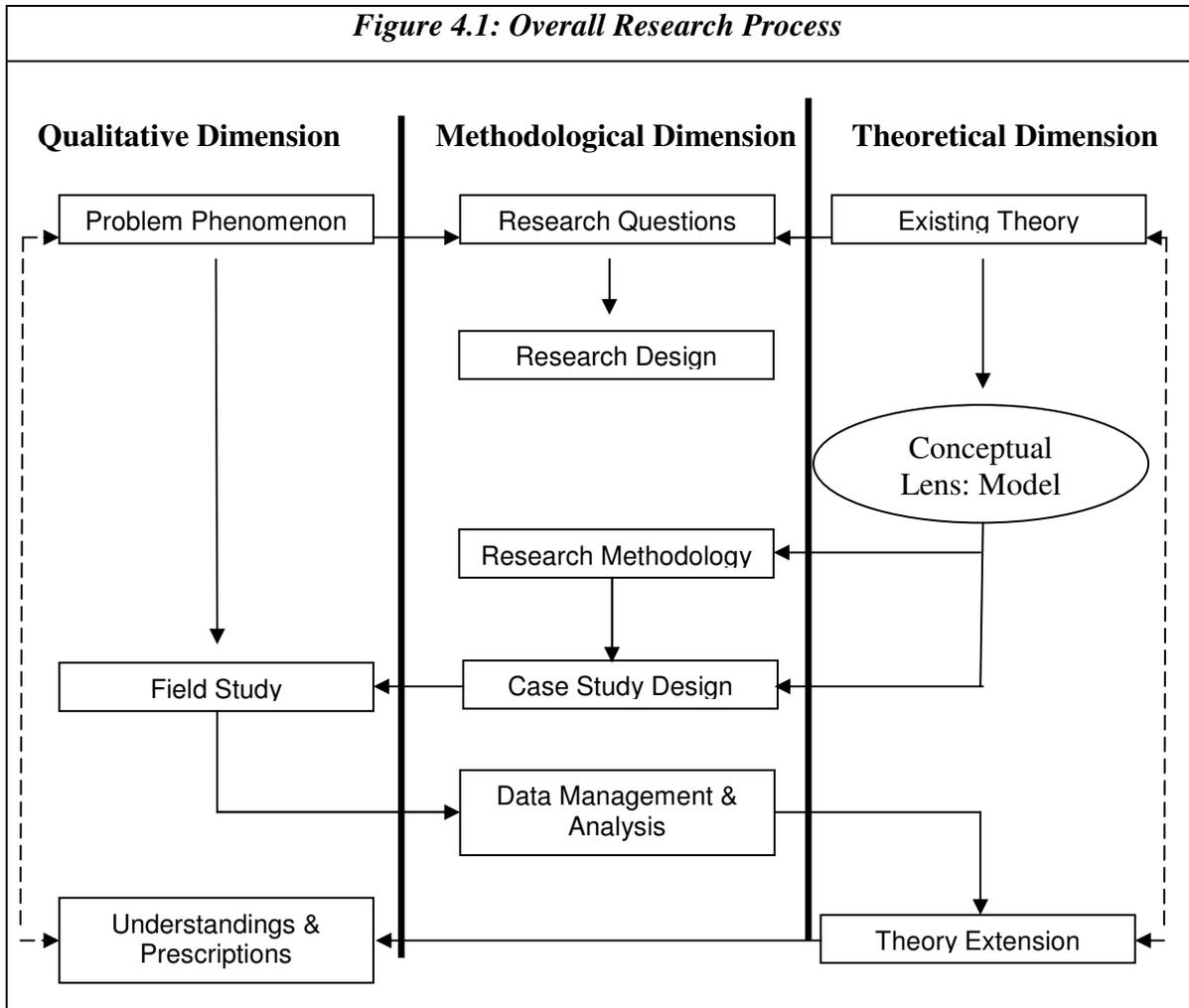
Nor: ‘sample to population’ (Table 4.2 Purpose) or ‘Testing of hypothesis’ (Table 4.2 Research Questions) or ‘External generalizability’ (Table 4.2 External Validity).

This descriptive qualitative case study with a grounded theory approach is further detailed in the subsequent sections.

4.1.1 Overall Approach

In the case of management research, the research scholar is intrigued with a particular problem / system / phenomenon in practice, that the researcher wants to understand and explore (Maxwell, 1996). After that he/she develops the research questions & a research design to understand systematically this problem / system. In the next step, existing theory is explored and integrated by using the theory development methodology to develop the conceptual lens in order to study the problem. This conceptual lens together with the research questions then lead to the development of qualitative research design and data analysis approach. Next the researcher enters the qualitative world and notes his/her observations in there & collects the data. After that, this data is managed as well as analyzed in accordance with the basic conceptual lens and qualitative research design that leads to findings. These findings then possibly lead to existing theory extension and help to understand and prescribe the identified problem. Figure 4.1 portrays this overall research process design.

Figure 4.1: Overall Research Process



With this background & keeping in view the research questions, as discussed earlier, it has been decided to undertake a process study (*descriptive qualitative case study*) in the piping engineering design management department of the largest oil & gas company in India. This is in contrast to a typical variance study (Crowston, 2000) and implied a focus on how events, organizational members and context interact and unfold (Pettigrew, 1997) rather than on the relationships between dependent and independent variables and subsequent results. In support of this approach, interpretive case study method has been used as research method. The assumptions underlying this choice and the rationale for adopting this approach are described in the following sections.

4.1.2 Philosophical Assumptions & Rationale

All research is based on some underlying assumptions about the nature of reality, what constitutes valid research and which research methods are appropriate (Myers, 1997). These philosophical assumptions consist of a stance toward the nature of the reality (ontology), how the researcher knows what he/she knows (epistemology), the role of values (axiology), the language of research (rhetoric), and the methods used in the process (methodology) (Creswell, 2003, 2007). In the present research all these assumptions have been used and Table 4.3 summarizes these *assumptions* as related to this research, duly highlighting their implications on this research.

Table 4.3: Philosophical Assumptions & Implications (Creswell, 2007)

ASSUMPTIONS	QUESTION	CHARACTERISTICS	IMPLICATIONS FOR THIS RESEARCH
Ontological	What is the nature of reality?	Reality is subjective and multiple, as seen by participants in study	The researcher has used themes in words of participants and provided evidence of different perspectives
Epistemological	What is the relationship between the researcher and that being researched	Researcher attempts to lessen distance between himself and that being researched	The researcher has spent almost two years in the PEDM Department and has worked actively with the team on their projects

ASSUMPTIONS	QUESTION	CHARACTERISTICS	IMPLICATIONS FOR THIS RESEARCH
Axiological	What is the role of values?	Researcher acknowledges that research is value laden and that biases may be present	The researcher has included his interpretations in conjunction with the interpretations of participants
Rhetorical	What is the language of research?	Researcher states in a literary and informal style while using personal voice and uses qualitative terms & limited definitions	The researcher has used first person pronoun in this research, and has tried to provide rich description of the phenomenon
Methodological	What is the process of research?	Researcher uses inductive logic, studies the topic within its context and uses an emerging design	The researcher has described the context of the project teams in detail, and revised the conceptual lens based on the findings from case studies

These *assumptions* cast a particular *stance / paradigm / worldview* that generally researchers make when choosing qualitative research methods. Various authors have suggested various classifications for these paradigms. The present study uses interpretive paradigm as advocated by Orlikowski and Baroudi (1991) because the research objectives & questions (Chapter 3) match with an interpretive stance, mainly since interpretive methods of research are “aimed at producing an understanding of the context of the problem, and the process whereby the problem influences and is influenced by the context” (Walsham, 1995) and, its two processes, discovering & emerging, are understood as covering a meticulous interpretative process in which the resulting concepts and eventually theory is constructed. This approach does not seek the truth as universal and

lasting, but the research product is seen as a rendering or one interpretation among multiple interpretations of a shared or individual reality (Charmaz, 2006). Further details are discussed in the following paragraphs.

Interpretive Paradigm:

Creswell gives four paradigms as postpositivism, constructivism, advocacy/participatory, and pragmatism (Creswell, 2003, , 2007). Orlikowski and Baroudi suggest three categories: positivism, interpretive and critical (Orlikowski & Baroudi, 1991).

Positivism grew and matured in natural sciences research, therefore it has features more suitable for conducting natural science research. Positivists generally assume that reality is objectively given and can be described by measurable properties which are independent of the observer (researcher) and his instruments (Myers, 1997). Positivist studies generally attempt to test theory, which is normally stated in terms of hypothesis, in an attempt to increase the predictive understanding of phenomena. A research can be classified as positivist if there is evidence of formal propositions, quantifiable measures of variables, hypothesis testing, and the drawing of inferences about a phenomenon from the sample to a stated population (Orlikowski & Baroudi, 1991).

Critical research paradigm has the assumption that social reality is historically constituted and that it is produced and reproduced by people. Although people can consciously act to change their social and economic circumstances, critical researchers recognize that their ability to do so is constrained by various forms of social, cultural and political domination (Myers, 1997). The main task of critical research is doing social critique, whereby the restrictive and alienating conditions of the status quo are brought to light. Critical

research focuses on the oppositions, conflicts and contradictions in contemporary society, and seeks to be emancipatory i.e. it should help to eliminate the causes of alienation and domination. This research does not seek to explore the alienation and domination conditions, and because it wants to emphasize the socially constructedness of reality, an interpretive approach is selected for this research.

The philosophical base of interpretive approach is hermeneutics and phenomenology (Myers, 1997). The assumption underlying interpretive research is that access to reality (given or socially constructed) is only through social constructions such as language, consciousness and shared meanings. Typically, interpretive studies try to understand phenomenon through the meanings that people assign to that and interpretive methods of research are “aimed at producing an understanding of the context of the problem, and the process whereby the problem influences and is influenced by the context” (Walsham, 1995). Furthermore, the research study adopts a social constructivist point of view for reality, which implies that reality is socially constructed by the observer (Berger and Luckmann, 1967). The other social point of view can be an objectivist viewpoint. “The focus of the interview and the specific questions asked likely differs depending on whether the interviewer adopts a more constructivist, or more objectivist approach. A constructivist would emphasize eliciting the participant's definitions of terms, situations, and events and try to tap his or her assumptions, implicit meanings, and tacit rules. An objectivist would be concerned with obtaining information about chronology, events, settings, and behaviors” (Charmaz, 2006). While all social studies involve a mix of both viewpoints, a study which has more constructivist viewpoint can be said to have a constructivist grounded theory approach while the other can be said to have an objectivist grounded theory approach (Charmaz, 2006). Specifically, since this research study objectives require more of “participant's definitions of terms, situations, and events and try to tap his or her assumptions, implicit meanings, and tacit rules” (Charmaz, 2006) and less about chronology, settings or behaviors,

therefore this research study employs the adapted version of the grounded theory (Glaser and Strauss, 1967), also referred to as the constructivist grounded theory (Charmaz, 2006). Its two processes, discovering and emerging, are understood as covering a meticulous interpretative process in which the resulting concepts eventually theory is constructed. This approach does not seek the truth as universal and lasting, but the research product is seen as a rendering or one interpretation among multiple interpretations of a shared or individual reality (Charmaz, 2006).

4.1.3 Quality of the Qualitative Study

It may be noted here that this section describes the plan for maintenance of high quality in the study. How these practices have been carried out are detailed in Section 5.1 of the next Chapter.

This study focusses on reality as perceived by the *researcher*, in line with the ideology that reality is what & how we perceive any particular issue and as such, the 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 (Yin, 2003). This approach may be criticized as developing localized theory; however, this is still a useful contribution to existing knowledge (Hughes & Jones, 2003). Further, the relevance of this specific research in the Indian oil & gas context, as already argued earlier (refer to Section 2.1) is bona fide (Sun, Williams, & Evans, 2011). The subject study elicits the “in-vogue scenario of piping engineering design management, directly from the people practising it. This will help present &/or future researchers to get a direct feel of the existing scenario and thus will*

help them in identifying & analysing further ways to improve the present system of managing piping engineering design in the Indian oil & gas industry” (Dutta, Piping Engineering Design Management Scenario in a Top Oil & Gas Company, 2013). Further, the developed model, if put into use, has the potential to overcome the existing identified flaws in the system & thus accelerate the competitive advantage of the company, that in turn can substantially contribute to the country’s economic growth.

As can be seen in Table 4.2, for qualitative research, validity can be established in any one or more of the given approaches, in terms of suitability of that particular approach for the specific research. The different options in context of the present research are discussed in the following paragraphs. Four relevant tests are there for evaluating quality of any research study: construct validity, internal validity, external validity & reliability (Yin, 2003). These are further discussed in the following paragraphs.

Construct Validity:

Construct validity refers to establishing the correct or apt measures for concepts that are being studied (Yin, 2003). The constructs as well as all data & new findings have been analysed through the conceptual lens (discussed earlier in literature review Section 3.8). To ensure construct validity, two tactics are employed. First, *two levels of analyses* are undertaken during data analysis – conceptual and detailed, by triangulation of perspectives (also called theory triangulation) on the same set of data (Patton, 1990). The conceptual analysis findings are intrinsically descriptive whereas the detailed analysis findings are naturally prescriptive leading to solutions (Tsang, 1997) through the multidimensional causal relations, from which the results/theory/solutions naturally emerged. Secondly, the *case study reports are reviewed by key*

informants as advocated by Yin (2003) and their feedbacks are incorporated in the final research. Further details on how the construct validity has been ensured can be found in the pertinent Section 5.1.4, Chapter 5 that is the pertinent chapter for the case study research actions & findings.

Internal Validity:

Internal validity is obtained by “establishing a causal relationship, wherein certain conditions are found to lead to other conditions, as distinguished from spurious relationships” (Yin, 2003). Internal validity includes interpretive and causal validity apart from the validity of other aspects (methods, data transcription, etc.). The problem associated with internal validity is that of spurious effects when there may be other determinative factors apart from those identified in this particular research design. In order to overcome this problem & improve internal validity, a number of tactics have been employed. First, during case analysis the same data set has been *analysed from different perspectives/phases* – on conceptual as well as detailed levels. This is done as one of the methods to improve quality by triangulation of perspectives (also called theory triangulation) on the same set of data (Patton, 1990) through the multidimensional causal relations, from which the results/theory/solutions naturally emerged. The conceptual analysis findings are intrinsically descriptive whereas the detailed analysis findings are naturally prescriptive leading to solutions (Tsang, 1997). Secondly, the key participants have been requested to appraise, *review & comment on the case reports and their comments are incorporated in the final research*. All these steps ensured the identification & assessment of alternative explanations in order to ensure the causal validity. To ensure internal validity the researcher has been focused on the understanding as well as the interpretation of the processes that can be represented as causal relationships between concepts: one concept (or a cause) leads to another concept

(or an effect). Moreover, review by the respondents and incorporations of their comments have ensured elimination of any flaws in the detection & analyses, thus up-keeping the interpretive validity. Further details on how the internal validity has been ensured in this study are described in the next Chapter.

External Validity:

External validity is the ability to extend the research findings to a more general Case (Yin, 2003). This present research is intended to provide an insight into the probable relationships suggested. As discussed in Section 4.1, a case study methodology is expected to provide depth and not external generalizability. This research should then lead to additional valid research to confirm the relationships using measures that provide the necessary confidence in the results for generalizing. 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* in the concluding chapter. As such, external validity is beyond the scope of this particular research and is a future research arena.

Reliability:

Reliability test in a case study research implies that if any other research scholar does the same procedures, as employed by the previous researcher for conducting the same case study, he/she shall arrive at the same findings & conclusions (Yin, 2003). In this particular research a number of tactics have been employed to ensure consistency while applying the data collection & analyses procedures. First, the case study protocol has been used to guide the research process. The *protocol is a major tactic in increasing reliability* of a case study

research and is intended to guide the researcher in the carrying out of the case study (Yin, 2003). The protocol comprised of instrument (i.e. the *interview questions in line with the research objectives*), as well as procedures and general rules that are followed. This ensured the consistency in the covered areas. Secondly, to reduce the likelihood of misunderstanding or forgetting the data and to allow independent analysis of data by other investigators, the interviews have been *taped, transcribed and all original evidences are archived (refer Appendix A)*. Thirdly, the *use of Atlas.ti qualitative analysis software* allowed systematic and consistent analysis of qualitative data (Weitzman, 2000) that increased the reliability of research because the procedures can be repeated (Yin, 2003). Fourthly, the field notes that are taken by the research scholar have also been transcribed for future reference.

This Section 4.1.3 depicts the design for ensuring high quality of the study; further details of how these design measures have been employed are described in pertinent Sections 5.1.4 & 5.1.5 of the next Chapter.

4.1.4 Purview of this Research Work

This specific research is limited to addressing the identified Research Gap (Section 3.4) and the Research Problems (Section 3.5); as such, this research is bound to answering the earlier defined Research Questions (Section 3.6) in line with the set out Research Objectives (Section 3.7). Hence, the purview of this research work is bound only to find how piping engineering design management is being managed in the Indian oil & gas sector, what are the areas of improvements or challenges (including whether the challenges match with those of other sectors or are there some additional issues) and how those challenges can be improved upon through a model for PEDM. As discussed earlier it is echoed here that this present case (the Descriptive Qualitative Case Study with a

Grounded Theory Approach) is for reaching the basic causal relations (Table 4.1 point-e: Case Study) leading to theory formulation only and is neither the verification/testing of generated theory/concepts to ascertain applicability (Table 4.1 point-d: Exploratory or point-h: Experimental) nor ‘Testing of hypothesis’ (Table 4.2 Research Questions) / ‘sample to population’ (Table 4.2 Purpose) / ‘External generalizability’ (Table 4.2 External Validity). Limitations of this research work and findings through this research that are beyond this defined purview have been included as limitations and further research scope at the concluding section.

A study of the design process employing a *qualitative and inductive approach* enables the collection of a vast amount of primary data without any predetermined judgements as to what factors are most pertinent (Charnley, Lemon, & Evans, 2011). Researchers have found that the qualitative case study method is a favoured method to study & analyze practices of design management (Svengren, 1993).

Earlier researches have proved that a research, wherein the researcher gains access to companies and works as designers or with designers, gives the researcher an inside view of their activities; these inside-viewed activities have been found to be more useful in helping to understand how & why design happens, and teamwork in design teams (Wallace & Hales, 1989; Kennedy, 1997; Baird, Moore, & Jagodzinski, 2000; Green, Kennedy, & McGown, 2002). Yin (2003) advocated use of qualitative Case Study for investigating contemporary phenomena in real-life context, especially when the boundaries between phenomenon & context are not clearly evident. In this research case, since the existing practices are unknown, the boundaries are not evident & hence, it has been decided to use a **descriptive qualitative Case Study** approach in a large oil & gas company in India. This led to the case selection discussed hereinafter.

4.1.5 Case Selection & Rationale

Sample selection has been done in three stages: this Section 4.1.5 consists of the first stage where the company has been selected and the following Section 4.1.6 consists of two more stages - the sample pertinent to the cause of this research has been selected and lastly, the selection has been narrowed down to a focus group identified as being the key people in developing the model. Theory of Elimination has been used in each stage by relating to its relevance in this specific research.

This research is bound 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* (the company is the oldest Indian oil & gas company, however the company's name is not mentioned here in order to protect that company from possible ignominious effects). It is the largest oil & gas company involved in petroleum refining, marketing, distribution and R&D in India. Therefore, the practices of piping engineering design management in that company is a perfect case for this study.

This has been the first stage of sample selection. The second and third stages, although further detailed in the following paragraph, are briefed here as follows. In the second stage, the researcher identified all employees who, by virtue of their knowledge, skills and experience, are being directly/indirectly involved or associated with piping engineering design management (PEDM). These people have been then examined through general screening questions (Appendix B) in order to identify their potential usefulness in finding the answers to the research objectives & questions discussed earlier. The employees ranged from many fresh engineers to many general managers in charge of PEDM in that particular location of that company, throughout the whole company. In the third

stage, the sample has been narrowed down to a unit of employees who are the most relevant people in answering the research questions and in providing the key inputs to develop the model. Then the qualitative case study (in line with the overall approach discussed in Section 4.1.1 earlier) has been done in that piping engineering design department of the company. The data has been collected from the team members through a pre-defined instrument (i.e. case study questions derived from research questions). Then the data collected (all evidences referenced in Appendix A) has been analysed as per pre-designed data analysis strategy & rationale subsequently discussed (Section 4.3). After that the researcher proposed a new model based on the findings in order to answer the research questions.

4.1.6 Unit of Analysis & Rationale

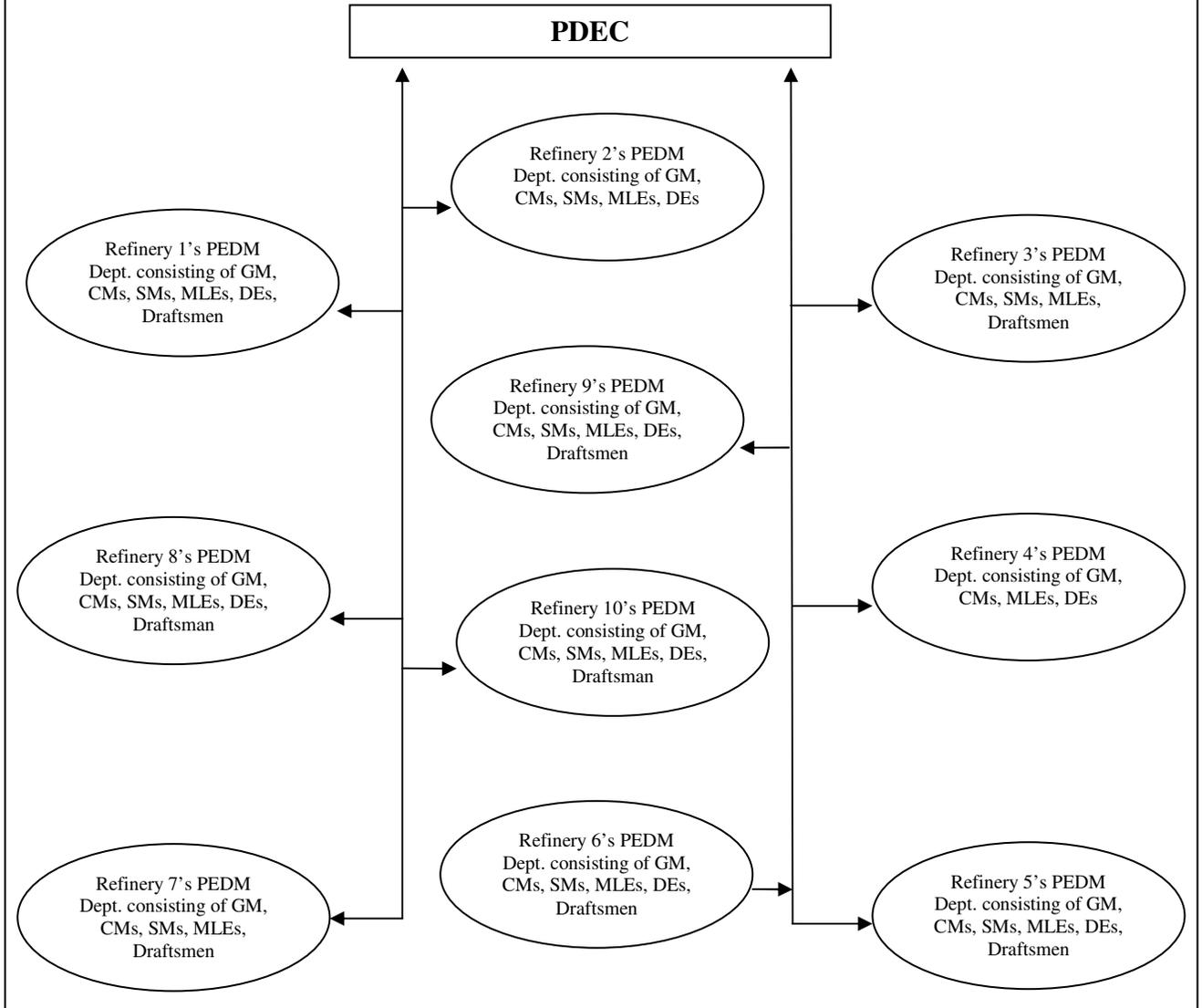
The chosen particular company (the largest oil & gas company in India in terms of revenue, size & market share) has ten refineries all around India wherein each refinery has a piping engineering design management (PEDM) department. As initially the researcher has not known who all the pertinent people (sample) can be so he has started with all the PEDM departments throughout the whole company; it has been found that collectively, there are eighty two people working in different levels (from General Managers to Design Engineers to Draftsmen level) of PEDM including all the ten refineries throughout that company. Each of these people have been then examined through general screening questions (refer Appendix B) in order to identify their roles & potential usefulness in finding the answers to the research objectives & questions discussed earlier. Based on their answers, only if they qualified to be a useful or potential useful source in proving information for answering the research questions and in developing the model, they have been considered in the core study, while the remaining have been eliminated using the Theory of Elimination since their roles have been found to be

non-pertinent to this particular study's requirements. It has been found that, each of the refinery's PEDM department is only involved in some recuperative/retrofit designs that are needed in the maintenance activities of that refinery and sometimes indirectly in the constructions of final design outputs that they receive from a common governing department named PDEC (elucidated subsequently). The individual refineries' PEDM departments have been found to be involved in only a very limited role in just carrying out the execution of the PEDM product (design output received from PDEC) in that refinery, some maintenance driven recuperative/retrofit design constructions and do not govern or have any pertinent role in the actual piping engineering design management cycle. Out of these eighty two people (refer Figure 4.2) who are in directly/indirectly associated with PEDM activities, six best of the experts, by virtue of their pertinent roles, super-skills, in-depth knowledge and experience superior to the other seventy six people, have been found be having the authority to govern all piping engineering design management activities throughout all locations of the company (all evidences referenced in Appendix A). These people are working in a specialized department named PDEC (Process Design Engineering Cell), which is a unique special cell with the Vision "To become world class Process Design Engineering group to carry out Front End Design & Engineering in Petroleum Sector" (for data source details see Appendix Ref. No. 1). These six people are authoritative and are empowered to act as the head authority for all PEDM activities throughout the company. As such, these six people of PDEC, comprising one General Manager (GM), one Chief Manager (CM), one Senior Manager (SM), one Lead Design Engineer (MLE) and two Design Engineers (DE1 & DE2) are the governing authority for all PEDM activities in all refineries across whole India. *These six people are designing improvement projects, developing the front end engineering design (FEED), basic engineering design, detailed engineering design as well as verifying, modifying and approving design change or minor projects requested from the different refineries (refer Figure 4.2); all these activities are not being done by the other seventy six PEDM related people at the*

different refineries; those seventy six people are only doing some construction related detailed engineering or some recuperative/retrofit designs as and when they needed in the maintenance or project activities of that refinery but are sending their designs to PDEC for review and approval prior to starting any job. Therefore these six employees have been found to be the most relevant & key people in answering the research questions and in providing the key inputs to develop the model since their roles are the governing levels controlling the PEDM cycle; thus they comprised the core study focus. This head body PDEC's philosophy has been to use its team members' existing knowledge in projects and also gain world class expertise in their respective fields. As a governing body for PEDM, PDEC has delivered quite a number of PEDM projects across many refineries of this company as well as for external Clients outside the company. All of these information have been obtained through the collected data and sources of evidences have been substantiated in Appendix A.

(Figure 4.2 follows in next page)

Figure 4.2: PEDM Stakeholders in the Company (source: Appendix A)



As discussed in the preceding paragraph, there are eighty two people (Appendix A) directly or indirectly involved in PEDM, six people in PDEC and seventy six in the different refineries. The Figure 4.2 shows how these seventy six people in the different refineries, across all levels, are depending upon the governance of the specialized cell PDEC for any piping engineering design management activity. Although these seventy six people across the refineries are

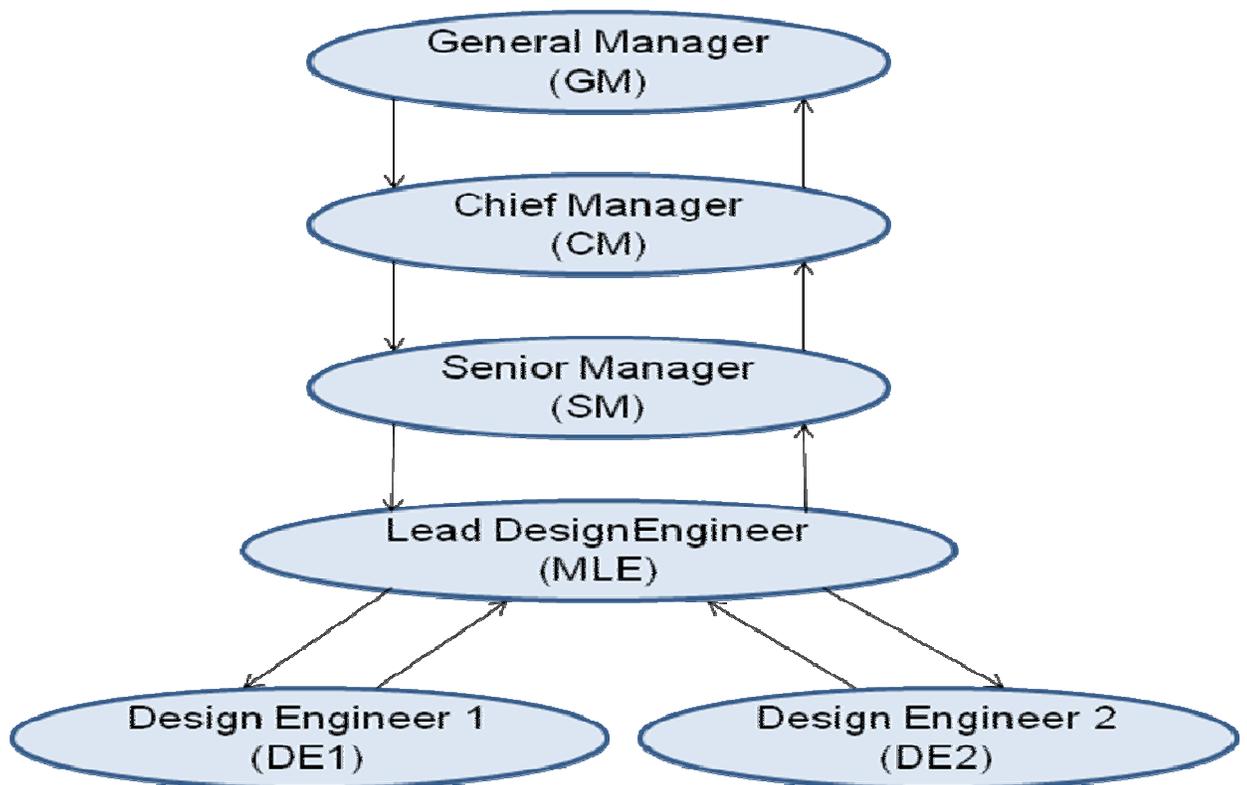
directly/indirectly doing some PEDM work, however, these six experts of PDEC, acting as the main governors of PEDM across all refineries, have been found to be the key PEDM people for meeting this research's objectives & developing this research model since their roles are the governing levels controlling the entire PEDM cycle in all locations throughout the whole company; thus they comprised the core study focus and hence it has been decided to take these six experts only as the core unit of analysis; this sample selection is also in line with the philosophy discussed earlier in Section 4.1.3 as it enables the researcher 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 (Yin, 2003)¹.

Thus, the overall unit of analysis is the governing **Piping Engineering Design Management Team PDEC in the largest oil & gas company in India.**

1: The following has been comprehensively detailed in the forthcoming sections & pertinent chapters of this thesis, however an abridgement is noted here for maintaining an overall ligature: This approach may be criticized as developing localized theory; however, this is still a useful contribution to existing knowledge (Hughes & Jones, 2003), as discussed in subsequent sections. Further, the relevance of this specific research in the Indian oil & gas context, as already argued earlier (refer to Section 2.1) is bona fide (Sun, Williams, & Evans, 2011). The subject study has elicited (depicted in the next Chapters) the in-vogue scenario of piping engineering design management, directly from the people governing it through all refineries of that company in all locations across the whole of India. This has helped the researcher to get a direct feel of the existing scenario, in identifying & analysing the challenges for improving present system of managing piping engineering design in the Indian oil & gas industry. With reference to the earlier discussed research gaps (Section 3.4) this selected sample comprised a perfect core case for research in PEDM for the oil & gas industry in India. Further, the developed model, if put into use, has the potential to overcome the existing identified flaws in the system & thus accelerate the competitive advantage of the company, that in turn can substantially contribute to the country's economic growth.

The subject piping engineering design management (PEDM) team's structure is represented in following Figure 4.3 (refer Appendix A for source of this organogram).

Figure 4.3: PEDM Team Structure at PDEC (Appendix A)



With the growing recent recognition of engineering as essentially a human activity, an approach wherein the researcher gains access to companies and working as designers or with designers the researcher gets an inside view of their activities, prove to be more useful in helping to understand how and why design happens (Wallace & Hales, 1989; Kennedy, 1997; Green, Kennedy, & McGown, 2002). The inside view of the designers' activities are researched upon by being with the team during the case study. This helped the researcher understand the

existing practices & the issues corresponding to the areas of improvements in depths that cannot be uncovered through other means.

4.2 Data Collection Plan

Data, as it is commonly known, is a collection of facts & information that is recorded for reference or analysis. Standard methods have been employed to collect data in this study as follows. Any research process calls for two types of data collection –

- a. **Primary Data:** Primary data is the data that is directly collected by the researcher during the core research or case study; this is data that is analysed by the researcher for addressing the research questions & objectives; examples include records of interviews, transcriptions, etc. (Kothari, 2004); thus all data collected & analysed by the researcher during the case study is primary data.
- b. **Secondary Data:** Secondary data is data that is first collected by someone else apart from the researcher; this is data that may have been used by the other person for some other reason but the researcher uses some of those findings/knowledge in his/her present study as per relevance; examples are published research papers, pertinent journals, published books, official records/documents, etc. (Kothari, 2004); thus, the existing literature on the subject as well as official records collected by the researcher is secondary data.

Most of the secondary data collection has been done from published books, published research papers, journals, etc. as discussed earlier in Section 3.1. Secondary data was collected with the help of online or internet-based as well as

physical libraries, athenaeums, etc. Further secondary data like official records, documents, etc. have also been collected by the researcher from the company's databases. In order to maintain clear distinctions, primary data in this present study is classified as *explicit primary data* (data collected during the case study through interviews, interactions, observations) and official records & documents collected are classified as *ancillary secondary data* (data collected during the case study through from company's documents). The data collection methods designed for this research are discussed in the subsequent sections. The term *data* is hereinafter is designated to mean both explicit primary and ancillary secondary data collected during the case study only. It may be noted here that this subsection enlists the data collection plan at a high level only. Further details have been discussed in the Case Study Protocol employed in the research, given in the next Chapter.

4.2.1 Explicit Primary Data Collection Design Methods

The researcher has done *in-depth Personal Interviews, Observations and Interactions with the team members* to collect & document Explicit Primary Data (refer Appendix A for details) for each stage of the design process, in order to understand the activities of the holistic piping engineering design management cycle.

4.2.2 Ancillary Secondary Data Collection Design Methods

As & when required, the researcher has collected Ancillary Secondary Data (refer Appendix A for details) from the *Company's Design Standards/Philosophies, Reports, Policies, etc.*

4.3 Data Analysis Strategy & Rationale

The researcher has done Textual Data Analysis ¹ using Grounded Theory approach (Charmaz, 2006) to find what are being done, what are the areas of improvements & how to improve those. Why the grounded theory approach (Charmaz, 2006) has been chosen has been detailed in earlier Section 4.1. Data analyses through grounded theory approach involves process iterations connecting movements between existing theory and the interview data, observation data & interaction data (Charmaz, 2006). It may be noted that grounded theory approach is a systematic generation of theory from data that contains both inductive and deductive thinking (Strauss & Corbin, 1990, 1998; Charmaz, 2006). It is most applicable when the researcher wants to - *formulate hypotheses based on conceptual ideas, to discover the main issues and how to resolve them*; the questions the researcher repeatedly asks in grounded theory are – *what is going on, what are the main problems & how these can be resolved*; these questions get answered by the core issues & their properties in due course of the research (Charmaz, 2006). Since in this research, the researcher has wanted to know, what are the existing practices going on, what are the issues & how these can be improved, *hence, this grounded theory approach is best suited in this case*. Accordingly and inline with the reasearch questions discussed earlier, the *case study questions have been derived on what is going on, how that is going on, how the activities are connected, what are the problem areas, why do the respondents consider that as a problem area, how these can be improved, etc. (the basic main questions and the further probing questions that are given in Section 5.1.3).*

1: Textual data analysis refers to profoundly investigating each word, line or segment of data in tune with the research objectives; coding of data using textual data analysis is an integral part of grounded theory approach that has been employed throughout the entire process of this study; the data analyses executions & outcomes have been extensively described in Section 5.1.4 of Chapter 5 (Case Study: Actions & Findings).

Through this grounded theory approach, structured interviews have been carried out and each subsequent interview has been adjusted based on the findings and interpretations from each previous interview, with the purpose to develop general concepts or theories through data analyses. The researcher has analysed how the different PEDM activities start, flow and end, the types, why and when of the activities, the interaction subjects, pathways & causes, the quality management practices, issues/challenges, etc. (all findings detailed in Section 5.2); then it has been analysed whether the identified issues or areas of improvements are matching with the issues that have emerged from literature review or there are any other issues plaguing the management of oil & gas piping design in India. Based on the findings, the researcher has developed theory through induction from data in order to propose the model. The researcher has also cited limitations & further scope of research. The collected data has been analysed (open coding, focussed coding, networks, families, links, dependencies, in-depth analyses, etc.) with the help of Atlas.ti software as one of the means for improving reliability (Section 4.1.3) as subsequently detailed.

Keeping in mind the scope of this research (Section 4.1.4), let us discuss a bit more here on why the grounded theory method (GTM) approach has been adopted in this case analysis. There are quite a lot of reasons for that. The grounded theory method of analysis has been already established as very effective in qualitative analysis by previous researches (Charmaz, 2006; Urquhart, 2013). GTM encourages the researcher to take a closer look at the data, the micro-phenomena; coding line by line or at the paragraph level encourages this close relationship with the data and this is what leads to new concepts as it encourages more analytical thought and all the constructs in a grounded theory are well grounded in the observations (Charmaz, 2006; Urquhart, 2013). The GTM facilitates slices of relevant data to be directly collected from the lowest level in order to build a substantive theory. The philosophical base, as discussed in earlier Section 4.1.2, uses constructivist grounded theory (Charmaz, 2006). Its two

processes, discovering and emerging, are understood as covering a meticulous interpretative process in which the resulting concepts, and eventually theory, are constructed. This approach does not seek the truth as universal and lasting, but the research product is seen as a rendering or one interpretation among multiple interpretations of a shared or individual reality (Charmaz, 2006). Further details on how the grounded theory approach has been employed during the case study can be found in Section 5.1.4, Chapter 5 that is the pertinent chapter for the case study research actions & findings.

4.4 Conceptual Lens & Constructs

From the review of existing literatures (discussed earlier in Sections 3.1 & 3.2) the basic theoretical framework (Figure 3.1) has been derived by the researcher as chronicled earlier in Section 3.2. The Figure 3.1 framework can be treated as a built-up *conceptual lens which has been deployed in the research process*. The conceptual lens has been used in the study through the steps discussed in preceding Section 4.1.1 & Figure 4.1. The challenges/issues that have been identified through the reviews of existing literatures formed the constructs (Table 3.1) for the second objective (Section 3.7) alongwith the search for any new finding. The Table 3.1 constructs of seven issues, consisting of three on product side and four on process side, have been already described earlier in Section 3.2. Further details on employment of the conceptual lens & the constructs in the present research process has been appositely described in Sections 5.1 & 5.2 of Chapter 5 that is the pertinent chapter for the case study research actions & findings.

Researches in many countries, none of which has focused on India, so far have identified that *an Effective Model for integrated Design Management can be built if these three issues on product side & four issues on process side are taken*

care of. However, previous research has proven that engineering design thinking & corresponding *design activities in different industries in differing situations have crucial differences* (Visser, Design: one, but in different forms, 2009) as discussed with examples in earlier Chapters and therefore, the earlier discussed design management studies, undertaken in other industries, are uncertain in terms of their applicability to the oil & gas industries and no research has been done on their applicability to the oil & gas industries. Further, previous research has proven that *design management roles & practices vary from country to country* (Sun et al., 2011) as exemplified in earlier Chapters. From the existing literature review, it has been found that no research has focused on whether there are any issues plaguing the management of engineering design in India. The existing studies have identified issues plaguing engineering design management worldwide in other industries & outside India. Moreover, design management practices 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 a *comprehensive design management model* and in India no research has focussed on engineering design management.

This is the median point of the chapters in this thesis and hence, in order to maintain ligature continuum, a brief peek into the ensuing chapters is digested in this paragraph as follows: After the issues in Table 3.1 have been derived, the research has been designed (as detailed in the preceding sections) and the case study including data collection & analysis have been executed; the case study actions and results are discussed in the following chapters. The researcher has analysed if the areas of improvements are matching with the issues that emerged

from literature review or there are any other issues plaguing the management of oil & gas piping design in India. Based on the findings, the researcher has developed theory through induction from data in order to propose the model. The researcher has also cited limitations & further scope of research. The collected data has been analysed (open coding, focussed coding, networks, families, links, dependencies, in-depth analyses, etc.) with the help of Atlas.ti software as one of the means for improving reliability (Section 4.1.3) as chronicled successively.

In this Chapter the plan for doing this research study has been designed. The proceeding Chapter 5 describes the specific actions taken in this study on the selected sample as well as the findings and as such, is the constructive employment of the Chapter 4 research design into the particular study.