4. RESEARCH METHODOLOGY
The literature review presented in the previous chapter has demonstrated a number of research gaps which have been identified by the research investigation within SMEs especially automotive suppliers. These gaps have facilitated the development of the goal of this study which is to; development of a continuous quality improvement (CQI) model for small-to-medium scale automotive industries in Gujarat using automotive core tools. Hence, case study (multiple case studies) based research methodology has deemed necessary for the execution of the identified research tasks.

4.1 Research Scope
The scope of this research is the foundation of continuous quality improvement and automotive core tools utilization within the automotive SMEs in Gujarat. The research focuses on the manufacturing SMEs who are engaged in the manufacture of discrete and processed automotive parts / products and who are suppliers of automotive original equipment manufacturers (OEMs).

4.2 Research Hypothesis
The research hypothesis of this research is based on the real life scenario that the continuous improvement of product and processes to compete and survive in growing automotive sector is highly obligatory. All small-scale automotive companies largely depend on the OEMs performance and its requirements which demand the application of automotive core tools as entrance level. To grow in such competitive business situations, it is necessary to show commitment to continual improvement. Customers’ requirements, stated or unstated, must be fulfilled and need to look for more competent methods to provide a product with the highest quality. Continuous improvement of product and services, specifically in the context of values, is essential. The final product acceptance significantly depends on the performance and standardization of business processes. A fundamental issue rose from current industrial scenario and literature review exercised in the previous chapter was the notion that SMEs practitioners are not certain of the
actual benefits of implementing automotive core tools. It was also contended that these SMEs fear that implementing automotive core tools costs much money and time and they will not get good improvements and benefits. The foregone statement thus facilitated the creation of the research hypothesis; whether developing a novel model and framework for implementing automotive core tools to achieve continuous quality improvement (CQI) model would motivate SMEs' adoption.

4.3 Design of Research Methods

The logic which relates the facts to be gathered in the urge of conclusions to the preliminary problems of the study is called as a research design (75). The research project’s “logic” is the hypothesis that assists us to know the communal spectacles (76). The qualitative research and quantitative research are the most prevalent type of the research. Both paradigms outline the method the researcher tracks to understand the problems posed at the start of the research. The qualitative research is demarcated as an analysis process, based on constructing a compound, complete picture, shaped with words, reporting exhaustive opinions on informants, and steered in a normal situation (76). In another way, the quantitative research is an analysis process, based on testing a concept tranquil of variables, measured with data, and analyzed with statistical processes, to search whether the projecting generalities of the concept hold true.

This research concentrates on finding efficacious approaches for implementing automotive core tools to achieve continuous improvement practices. By application of automotive core tools in automotive SMEs, this research endeavors to amalgamate and analyze the methods and tactics that led to efficacious automotive core tools implementation and their consequence on continuous quality improvement. The data for this study are qualitative in nature, therefore a qualitative design will serve best to answer the research question of this study. Table - 6 lists the assumptions and how this research addressed them.
Table 1. Assumptions in Research Design

<table>
<thead>
<tr>
<th>Assumption</th>
<th>Research characteristic addressing assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process oriented</td>
<td>Study of the deployment and implementation of automotive core tools</td>
</tr>
<tr>
<td>Focus on meaning</td>
<td>focus on how automotive core tools helps in achieving continuous quality improvement</td>
</tr>
<tr>
<td>Researcher is the primary instrument</td>
<td>Researcher must review published data, conduct interviews with experienced practitioners</td>
</tr>
<tr>
<td>Involves field work</td>
<td>Implementation training, visits for monitoring and reviews, Data gathering and analysis were executed at selected SMEs</td>
</tr>
<tr>
<td>Descriptive in nature</td>
<td>Purpose is to characterize successful management techniques and strategies addressing deployment barriers and implementation challenges</td>
</tr>
<tr>
<td>Inductive</td>
<td>There is no current theory on how companies have been able to overcome barriers and challenges faced during deployment and implementation</td>
</tr>
</tbody>
</table>

4.3.1 Comparison of Designs

The tactics accessible to the researcher for gathering and analyzing realistic indication are diverse and have merits and demerits. It is a general misapprehension of several researchers that the tactics should be organized hierarchically, generally regulating case studies as an introductory research tactic that cannot be used to define or test intentions (77). When impending design choice “the more suitable opinion of these diverse tactics is a
comprehensive and varied one.” To finalize which tactic to choose, three situations that direct the researcher’s design selection (77):
(a) the type of research question modeled,
(b) the amount of control over actual behavioral actions, and
(c) the gradation of attention on modern as opposite to historical actions.

Table 2. Strategies in Research Design

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Form of Research Question</th>
<th>Requires Control of Behavioural Events?</th>
<th>Focuses on Contemporary Events?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment</td>
<td>How, why?</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Survey</td>
<td>Who, what, where, how many, how much?</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Archival Analysis</td>
<td>Who, what, where, how many, how much?</td>
<td>No</td>
<td>Yes/No</td>
</tr>
<tr>
<td>History</td>
<td>How, why?</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Case Study</td>
<td>How, why?</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

The case study technique seems to be the best fit for this research. The case study technique tries to find answer empirical, evocative, or illustrative “how” and “why” research questions based on single or multiple case studies (75). The case study does not necessitate control over the action or practice being studied and is concentrated on present events. Auto core tools implementation is a modern event in the industry over which the researcher has no control. The source of facts or data contains analyzing literature and interviews with knowledgeable practitioners. The application of the other methods from above Table 6 would not harvest suitable outcomes. The research is a quantitative method that necessitates the researcher to manipulate the variables of a process to test a theory (76). Because this
research is not challenging a theory and is as an alternative looking for to explain how SMEs implements automotive core tools easily and effectively to achieve continuous quality improvement, the case study method is suitable. Surveys are a quantitative method engaging questionnaires or organized interviews of a sample population for data gathering to simplify across a population (76). A survey study could provide general identification of deployment barriers and implementation challenges. However, as each SME is unique, connecting how each SME succeeded these obstacles and challenges would be challenging. The archival analysis method necessitates the researcher to gather data from verbal, visual, or behavioral forms of communication (78). The history method necessitates that there is no admittance to or control over the occurrence being studied (78). This research emphasis on a modern event, therefore, the history method is not suitable.

Three more research tactics not mentioned in above are ethnography, phenomenological study, and grounded theory study. The ethnography necessitates observations of a complete cultural group taken over an elongated timeframe (76). The phenomenological study also necessitates an elongated timeframe during which a small number of persons are comprehensively studied to cultivate patterns and associations of meaning (76). The research is endeavoring to response a comprehensive, generalizable research question. Investigating a small group of characters would bind the external legitimacy of the research. The grounded theory study recommends originating a concept through the use of multiple stages of data gathering and continuous comparisons and classification. With the understanding of characteristics and benefits of commissioning the case study design, this research will engage the case study method.

4.3.2 Case Study
As specified previously, the case study based research has been carefully chosen for this research because it is the favored method when endeavoring to answer “how” and “why” research questions about modern events over which the researcher has no control (75). The research question in this exertion is “How and why are automotive SMEs not able to achieve
continuous quality improvement by implementations of automotive core tools?” The data for this research will derive from private sector small-to-medium companies with which the researcher is neither employed by nor affiliated.

The case study has four constituents that make up the case study research design: i) the questions and intentions, ii) its unit(s) of analysis, iii) the logic associating the data to the intentions, and iv) the norms for understanding the conclusions (77). The research’s questions, as beforehand deliberated, are grounded on “how” and “why” the phenomenon or event happens; therefore the case study design has been preferred.

The unit of analysis section challenges the problem of describing what a “case” is. Defining the background of the case wants that the study’s questions and plans be well demarcated to guarantee that the scope remains within realistic perimeters. If the “case” is defined as a project, implementation process, or organizational change, there will be difficulties defining the commencement or end points of the “case” (75). Difficulties could comprise dissimilarities in program definition based on perception and program modules that preceded formal program description. This research has addressed these issues using the following definitions:

Unit of analysis: Automotive SMEs that has to implement automotive core tools.

Case timeframe: Begins with the SME’s deployment of automotive core tools in combination.

Program description: Implementation of automotive core tools to study effects on quality improvement.

The case study based research involves facilitator to study and work with case-study companies. The intention is to assist companies to overcome the barriers of quality improvement. The role of facilitator shall be to prepare plan, provide training and monitor the project(32). Typically in case studies method multiple source of evidence includes documents, archival records, interviews, direct observation, observation by participant, and physical artefacts. Each of
these different sources requires different approaches to their interrogation, and is likely to yield different kinds of insights (79).

This research has engaged a multiple case study design. The purpose is to determine whether SMEs, having different product range and processes, capabilities, etc., shows the generic process of improvement or not.

4.3.3 Generalisation, Validity and Reliability
A case study may be purposefully selected in virtue of being, for instance, information-rich, critical, revelatory, unique, or extreme or cases selected within a representational sample strategy used in correlational research. If a case is purposefully selected, then there is an interest in generalising the findings (80). Generalisations from case studies are not statistical, they are analytical. They are based on reasoning. There are three principles of reasoning: deductive, inductive and abductive. Generalisations can be made from a case using one or a combination of these principles (81). When a generalisation is based on the deductive principle, the procedure is similar to an experiment: a hypothesis is formulated, and testable consequences are derived by deduction. A second mode of generalisation is achieved through induction. In case studies this is done through inductive theory-generation, or conceptualisation, which is based on data from within a case. The result is a theory normally consisting of a set of related concepts. According to Grounded Theory, this is the way in which generalisations are made (81). The third type of generalisation depends on the principle of abduction. According to the principle of deduction a conclusion is necessarily true from a case and a rule. If the premises are true, the conclusion is also true.

Generalisation can only be performed if the case study design has been appropriately informed by theory, and can therefore be seen to add to the established theory. The method of generalisation for case studies is not statistical generalisation, but analytical generalisation in which a previously developed theory is used as a template with which to compare the empirical results of the case study (82). If two or more cases are shown to support the same theory, replication can be claimed. In analytic generalisation, each case
is viewed as an experiment, and not a case within an experiment. The greater the number of case studies that show replication the greater the rigour with which a theory has been established (77).

Validity and reliability are significant aspects of any research process and should be addressed. Qualitative literature has materialized addressing the concerns of validity and reliability in a qualitative strategy and outlining the perceptions within the procedures (77). Table - 8 refer to approaches and practices applied in this research to address the concerns of validity and reliability.

Four tests have been widely used to establish the quality of empirical research:

- **Construct validity** - establishing correct operational measures for the concepts being studied. This is concerned with exposing and reducing subjectivity, by linking data collection questions and measures to research questions and propositions.
- **Internal validity** (for explanatory or causal studies only and not for descriptive or exploratory studies) establishing a causal relationship whereby certain conditions are shown to lead to other conditions, as distinguished from spurious relationships.
- **External validity**: establishing the domain to which a study’s findings can be generalised. Generalisation is based on replication logic.
- **Reliability**: demonstrating that the operations of a study - such as the data collection produced can be repeated with the same results.

Case studies as a qualitative research process have been applied broadly by eminent researchers in several fields. Case studies, therefore, have become a preferred research methodology. A case study method is an indispensable methodology specifically in a research situation where the realistic exploration of a specific modern-day phenomenon is within realistic situation (83-84). On the other hand, case study process is a stipulation if it is believed research
analysis is ascribed to some practical realistic task. Case study means different things to different people (85).

**Table 3. Case Study Tactics for Four Design Tests**

<table>
<thead>
<tr>
<th>Tests</th>
<th>Case Study Tactic</th>
<th>Phase of research in which tactic occurs</th>
<th>Tactics used in this research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construct validity</td>
<td>Use multiple sources of evidence</td>
<td>data collection</td>
<td>Data collected from literature and implementation / interviews at case companies</td>
</tr>
<tr>
<td></td>
<td>Establish chain of evidence</td>
<td>data collection</td>
<td></td>
</tr>
<tr>
<td>Internal validity</td>
<td>Do pattern-matching</td>
<td>data analysis</td>
<td>Research is exploratory, not causal or explanatory</td>
</tr>
<tr>
<td></td>
<td>Do explanation-building</td>
<td>data analysis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Address rival explanations</td>
<td>data analysis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Use logic models</td>
<td>data analysis</td>
<td></td>
</tr>
<tr>
<td>External validity</td>
<td>Use replication logic in multiple-case studies</td>
<td>research design</td>
<td>Multiple case study design database</td>
</tr>
<tr>
<td>Reliability</td>
<td>Develop case study database</td>
<td>data collection</td>
<td>Case study database through use of word tables / trend charts</td>
</tr>
</tbody>
</table>

**4.3.4 Multiple Case Study Approach**

A multiple case study method intensifies the exterior validity of the research through the obscure “replication logic” intrinsic in its design (75). This “replication logic” is equivalent to that used by numerous researchers in that when a noteworthy conclusion from a single research is revealed the effort is made to instantaneously reproduce this conclusion in another research. This
research exertion implements Yin’s process of studying transformed companies through the use of “cross-case synthesis.” Companies, small-to-medium size, have been carefully chosen for the due to their necessity for automotive core tool implementation.

4.3.5 Data Collection

There is several research techniques employed in data collection by researchers within the premise of qualitative. These can be described as literature review, observations and interviewing.

(i) Literature Review

A literature review can be treated as a key data collecting technique since it is being extensively used in qualitative research designs. The fundamental point of conducting literature review is the conveyance of the established knowledge on the relevant domain, to the other interested parties. Literature review spurs the genre of the researcher not only as a means of exploring the prevailing theories but rather to determine new ideas (86). A literature review is an organized process for recognizing, appraising and understanding the prevailing body of recorded work formed by others in certain discipline (87).

Although literature review is one of the significant data collecting techniques in the qualitative research design, it is crucial that researchers observe a number of pitfalls that can limit the realization of good data collection. The review should be broadened to capture relevant subject domain in order to generate an evaluative critique.

(ii) Interviewing

Interviewing is another important aspect of data collection within qualitative research. Interviewing has a high preference within the research community as a data collecting method (88). This is based on the premise that interviewing process generates interactive dialogues amongst interested stakeholders. This could engage personal dialogues (face-to-face), electronic forums (e-mail, telephone) and paper based mediums (posted questionnaires). Interviewing mediums play pivotal roles in determining the reliability of the
results of data gathering within qualitative research designs. Much of the qualitative data gathering needs numerous interviews so as to cover various ranges of issues involved (89).

(iii) Observing
The art of observing the occurring activities within an identified setting for qualitative research design is not a new phenomenon within academia. Observation is one of the major techniques for data gathering within qualitative research. A methodological discussion about the role of observations as a research method has been the cornerstone of qualitative research (90). Observation as a data collection mechanism facilitates the accomplishment of the goal of attaining an insider's knowledge of the field. This is conducted through the researcher's continuous attachments as part and parcel of the field being investigated.

4.4 The Selected Research Methodology
This research project has employed a qualitative research methodology – case study in its investigation. This included a combination of different research approaches discussed in the previous section. Specifically, the research methodology adopted a process which encompassed the use of techniques such as literature review and case study based. Moreover, the research process was composed of five phases as demonstrated in Figure 7.

4.4.1 Phase 1: Identification of the Research Process
The objective of the phase one of the research process was to ascertain the most suitable research approach for the entire research investigation. This activity encompassed the examination of both the quantitative and qualitative research approaches. The insightful analysis enabled the evaluation of their strengths and weaknesses. Consequently, a decision was made to adopt the qualitative research approach.
4.4.2 Phase 2: Literature Survey
The second phase of the adopted research methodology constituted a background review of the contemporary work on the relevant subject areas. These areas included literature on automotive core tools (ACTs) in detail and their importance as well. In addition, the implementation methods and technologies for automotive core tools were also reviewed. The progression of continuous quality improvement (CQI) has been outlined from its initial roots in manufacturing to the more refined practices that can be used in any business, and that encompass a wide-ranging toolbox for continuous quality improvement. Even though much research has been steered on the discrete continuous quality improvement practices and quality management, many tools have been established to conclude the advancement and profits of the continuous quality improvement initiative for large enterprises but diminutive attention has been directed to development of a framework and model that would empower a small and medium organization to recognise continuous quality improvement practice. It is significant to note that, the literature review
accompanied comprehensively at the early phases of this research investigation, confirmed the presence of gaps in knowledge. In particular, the review did not provide specific information for implementation of auto core tools and their effect on continuous quality improvement within SME companies. Thus a thought-provoking subject to hunt in the field of continuous quality improvement is how to conclude the suitable continuous quality improvement approach and model for SMEs to implement automotive core tools to accomplish successful improvements.

4.4.3 Phase 3: Implementation - Case Study

The third phase of the research approach demanded the implementation and gathering of data from case companies. The selection of companies was the vital part. The selected companies are SMEs and the suppliers to automobile OEMs. The selection of companies was done ensuring that each company has to be different in the category of product produced, processes and technology used, the number of employees and facility. It was necessary to select such companies to have unbiased research results and which can be applicable to all SMEs. The four SMEs were identified to implement auto core tools to measure continuous quality improvement and its effect.

It was envisaged the research would include a practical research element of the implementation of automotive core tools – APQP, PPAP, FMEA, SPC, and MSA to the different product small scale industries of the automotive sector. Issues and benefits of implementation would be investigated based on actual data to conclude impact on SMEs and development of continuous quality improvement model and framework.

The first step in this was to study & analyze current processes of the company which resulted in opportunities to improve & standardize processes which in turn has improved productivity and quality. Next step was to provide training to the employees on automotive core tools to educate them to improve implementation process following that cross functional team preparation. Next step was the application of FMEA (Failure Mode Effect Analysis) tool on each manufacturing process & preparation of control plan for potential failures. It
helped to identify potential failures and their mitigation plans have been prepared in advance. Furthermore manufacturing & quality data have been recorded during production of each product at each company. Based on result data, process capability was checked using SPC tool (Statistical Process Control). i.e. Cpk value. For making process capable enough Measurement system is playing very important role, hence for all measurement systems MSA tool was implemented and checked for errors pertaining to it. All above data along with manufacturing data were sent to the customer (Automobile Manufacturer) for approval through Production Part Approval Process (PPAP) & customer approval was taken. The outcome of each ACTs implementation had emerged as potential improvement opportunity and each improvement points were recorded and considered as an improvement project. The improvement of processes and products were monitored through the selected KPIs (Key Process Indicators) e.g. Cost of Quality, Reduction in in-process rejection, Reduction in customer return, etc. Comparative data of improvement along with trend chart was prepared & analyzed to conclude the impact of automotive core tools on small scale manufacturing unit. Based on the above process and results, unique CQI model along with framework was developed for easy implementation and measurement of the impact & effectiveness of the automotive core tools on continuous quality improvement. Next key step was to validate the developed unique model.

All of the above activities engaged company visits, where interviews, research meetings, training, monitoring and review of processes, review of manufacturing and quality data, etc. were conducted for the formalization of the research knowledge. The purpose of these activities was for data collection from companies involved. Interview sessions were facilitated through the aid of semi-structured questionnaires, observation data collection sheets, etc. Moreover, correspondences between the researcher and the collaborating partners were fostered through the use of electronic mediums such as; telephone and e-mails.
4.4.4 Phase 4: Development of unique model & framework (TO BE Model)

The fourth phase of the research methodology involved the development of the Model. This particular phase was classified in twofold. The first part entailed the development of the model, whereas the second phase involved the development of a framework. Both of these activities engaged company visits, where interviews and research meetings were conducted for the formalization of the research knowledge. However, in the case of model and framework development, the researcher involved qualitative data collection methodology that was utilized in the previous phases. These approaches also included the use of interviews and extensive observations. The model and framework were developed based on the implementation procedure and result data collected.

4.4.5 Phase 5: Validation of the unique model & framework

In the final phase of the research methodology, validation of the model was carried out through case studies approach (91). The approach has been elected since the research desired to assessment the advantages and disadvantages of the framework and the established model. Carefully selected case studies were sought as illustrated in forthcoming chapters. Moreover, the formation of these validation workshops and case studies necessitated both company and their management involvements. Hence, the validation exercises were conducted by giving companies detailed model and framework along with necessary training. The validation of the model and framework sought based pattern matching (trend analysis) of the KPIs results of case studies companies (77) as well as each case study company feedback results.