CHAPTER 3

Decision Support System for Innovation Managed Quality Circle Programme

3.0. Introduction

The ultimate aim of TQM philosophy is to enhance the customers' satisfaction through continuous quality improvement. Continuous quality improvement is possible only with the active participation of all employees. In this context QCP is viewed as a powerful one, in which opportunity is created to participate all the employees in an organization. Another unique aspect of QCP is that it encompasses systematic problem solving methods, which comprises the following characteristics (Hill, 1996):

- Use of the scientific methods for diagnosing problems (for example, application of Deming's "Plan, Do, Check, Act" cycle)
- Decision making is based on the actual data collected from the organization not by assumptions
- Emphasis on the use of brainstorming sessions and basic statistical tools such as Pareto analysis, histograms, and cause and effect diagram, to organize the data and draw inference from them.

Systematic and effective implementation of QCP will contribute towards the continuous quality improvement in the organization. However, today's competitive world is expecting innovation in products, processes and services rather than just solutions to the problems (Martensen and Dahlgaard, 1996a; 1996b; Denton, 1999; Tucker, 2001; Drejer, 2002). The traditional QCP does not meet these requirements. Since the QCP is found to be acceptable to both management and employees, the existing structure can be improved to make it to offer innovative solutions. In this regard, basic theories of IM principles have been infused with the QCP for bringing out the continuous innovation. Accordingly, a model named as 'innovative quality circle' was
designed. This model was subjected to implementation study in a foundry industry. The experiences gained by carrying out this implementation study indicated that practitioners would require continuous decision support to successfully implement innovative quality circle programme. For this purpose, a DSS has been developed. The above activities formed a module of this doctoral work and the details are presented in this chapter.

3.1 Definition of Innovative Quality Circle

The design of innovative QC has been carried out based on the following definition: "Innovative quality circle is a small group of employees doing similar work who voluntarily meet together on a regular basis to identify not only solutions to the problems but also innovations related to their respective work areas using new idea generation techniques". The above definition has been coined by adopting conventional definition of quality circle (Udpa, 1990) and integrating it with the core principles of IM.

3.2 Organizational Structure

Organizational Structure of the innovative QC has been designed and depicted in Figure 3.1. The authority and responsibilities of the personnel in innovative QC organization are enumerated in the following subsections.

3.2.1 Top Management

Top Management is committed to provide necessary resources and environment, conducive for evolving continuous innovation by generating ideas and stimulating creativity among the members.

3.2.2 Steering Committee

Steering committee is composed of senior management personnel such as heads of departments and other senior functionaries in the central office. Responsibility of this committee is to provide necessary guidelines for bringing out innovative climate throughout the organization and to bring out ideas from the members and inculcate creativity among them.
3.2.3 Facilitator

Facilitator plays a foundational role in an innovative quality circle. He shall be a senior officer of the department. Three to four innovative quality circles can function under one facilitator. The management nominates him. His responsibility is to act as a bridge between the management and members and identify the training needs to the members on new idea generation techniques and creativity. He is required to evaluate the innovative idea on the basis of weightage recommended by the management.

3.2.4 Circle leader

A circle leader is a member of the circle who has the basic responsibility of convening the weekly or fortnightly meetings of the innovative quality circle. Besides while conducting the meetings, he is required to make sure that all members in the innovative quality circle get equal opportunity to take part in discussions. He is also required to identify the triggers that are required to generate creativity and innovative ideas among the members.
3.2.5 Members

Members are the basic elements of the structure of innovative quality circles. Employees working in the same work area or engaged in similar type of work shall voluntarily become members of innovative quality circles and participate in evolving innovations. Members shall possess aptitude for creativity and bringing out innovations.

3.2.6 Non-member

While conducting the proceedings of innovative quality circles, situations may arise to seek the help of experts to evolve innovations. In those situations, such kind of people may be invited to become nonmembers. They will be associated with the innovative quality circles only when their contributions are solicited.

3.3 Operational features of Innovative QCs

The operation of Innovative QCs passes through of two phases. Those phases are named as 'Foundational phase' and 'Proceedings phase'. The operational features of innovative QCs are depicted in Figure 3.2.

3.3.1 Foundational phase

As shown in Figure 3.2, foundational phase has to pass through three stages. These stages need not be repeated since they are the foundational elements of innovative QCP, which have to sustain for the prolonged period of time. Even though these activities constitute one time effort, their requirements cannot be underestimated since they play ultimate role in ensuring the success of innovative QCP. To begin with, the management must promote IM awareness programmes throughout the organization over a period of one to two years. During the conduct of these programmes, the
management must commit its interest in receiving innovation which arise from all personnel and other sources of the organization. The success stories of companies, which have adopted innovations, may also be deliberated during the conduct of these programmes. Followed by this, the management shall develop culture and climate for evolving innovations on continual manner. During this stage, the management shall introduce rewards and promotional schemes based upon the innovations evolved by the individual employees or groups (Davis and Moe, 1997; Martins and Terblanche, 2003). The management shall also publish the contributions of those innovative employees by releasing newsletter and special circulars. In order to systematically develop innovative

**Foundational Phase**

| Conduct of awareness programmes on IM principles throughout the organization | Development of culture and climate for evolving continuous innovation | Training on new idea generation techniques, creativity and invention tools |

**Proceedings Phase**

- Implementation
- Presentation to top management
- Idea evaluation / Idea Improvement
- Generation of new ideas with creativity and invention aptitude
- Identification of critical problem
- Analysis of problems
- Identification and selection of Problems

**Figure 3.2 Operational feature of innovative quality circle**
culture and climate on sustained manner, scientific efforts are required to be exerted. For this purpose, employees shall be trained on the new idea generation techniques and creativity and invention tools such slip/card writing, brainstorming, semantic processes etc. (Smith and Ainsworth, 1993; Maxon, 1998; Roffe, 1999)

3.3.2 Proceedings phase

After the completion of the foundational phase, the proceedings phase of innovative QC shall be started. Unlike foundational phase, the activities of proceedings phase are to be cyclic. In other words, the proceedings phase shall be on continual basis and subjected to continuous improvement. As shown in Figure 3.2, one cycle of proceedings phase has to pass through seven stages. The first stage starts with the identification and selection of problems. In the case of innovative QC, the problem to be identified and selected need not be the one that cause disturbances such as production stoppage, increased rejection rate etc. The problems in innovative QC shall be identified and selected based on the higher benchmarks than the existing. During the second stage, the importance of the problems shall be analyzed by referring to the various factors, which may consider the market condition and the company's performance status. During the third stage, appropriate ranking method shall be followed to identify the critical problems. During the fourth stage idea generation techniques shall be deployed to generate new ideas with innovation potential. During the fifth stage those ideas shall be evaluated for their acceptability by the management. If found necessary ideas shall be modified to improve its effectiveness. During the sixth stage the consolidated form of the above ideas shall be presented to the management. During the seventh stage, approval from the management is obtained and the above new ideas generated by conducting innovative QC shall be implemented. This stage marks an important tenet of IM, as innovation calls for successful implementation of new ideas, which leads to the
3.4 Implementation study

The author availed the service of undergraduate production engineering students to study the implementation features of innovative QC principles in a company by name "Raja Steels Private Limited" (hereafter referred to as foundry). This is situated in Coimbatore city of India. Personnel working in the field of foundry came forward to become members of innovative QC. The students contacted the innovative QC members and discussed with them about IM and its effect on quality circle. In the first stage, they explained about the important phases of IM through which innovative QC members came to know about the method of generating innovative solutions. Followed by that, four brainstorming sessions were conducted. The fourth and last brainstorming session was devoted for bringing out innovation. The details of activities, carried out during the four brainstorming sessions are presented in this section.

During the first brainstorming session, the nature of foundry processes was discussed. Followed by that, the departments were visited for one week to get a clear view about the foundry processes. During the second brainstorming session, the technical problems faced by the various departments of foundry were determined. These problems are listed below:

Problem number 1: Difficulty in handling the sand with inconsistent constitution of grain size, moisture, temperature and other critical physical properties.

Problem number 2: Difficulty in efficiently mixing hot sand and bentonite clay. Sand with temperature above 160 degrees Fahrenheit cannot be effectively mixed with bentonite.
Problem number 3: Chunks of sand with high moisture content periodically drops off the walls of the bin and enter the mold. This problem complicates the process of controlling the properties of molding sand and molding.

Problem number 4: Higher scrap rates due to the presence of hot sand used for the molding processes.

Problem number 5: Deviation of laboratory results from the actual results.

Following were identified as the causes of the above technical problems.

Cause for problem number 1: This problem frequently occurs in the foundries operating batch equipment or continuous mixers, which do not have the ability to back-blend the incoming sand.

Cause for problem number 2: This problem arises due to the introduction of hot sand, water, and other additives into the muller.

Cause for problem number 3: When a combination of hot and wet sand enters a bin, free water vapor is always present. The small percentage of vapor, which is above the sand in the bin, can be removed by venting the bin, but a good amount of vapor is trapped down inside the bin in the spaces between sand grains. If the bin walls are cooler than the dew point of the hot water vapor, condensation takes place at the bin wall. Special paints and thin plastic or stainless steel linings do not stop this condensation. As the vapor adjacent to the bin wall condenses, vapor pressure in this area is reduced and vapor from adjacent sand expands to replace that which has condensed.

Cause for problem number 4: When the hot sand does not possess uniform green properties, the molding machine can neither produce an uniformly compacted mold, nor guarantee that the mold will remain intact if correctly formed. Variations in mold hardness are known to cause a wide variety of casting defects (pin holes, dirt inclusions,
washes, rough surface, sand stickiness, broken molds, crushes etc.) especially in molds with critical dimensional tolerances or deep-draw pockets.

Cause for problem number 5: This is due to the fact that, as sand gets hotter and it has a direct effect on the sand properties being tested. If the sand temperature is high and not noted in the testing procedure, the results will be misleading. The results may show a need for longer mulling, where the actual and final solution to the problem is to cool the sand temperature below 120 degrees Fahrenheit.

During the third brainstorming session, the problems were analyzed using the problem-analysis matrix. This matrix is shown in Table 3.1 As shown, the factors which were considered, are

- Ease of solution.
- Resistance to change
- Time allowed for implementing the solution
- Potentiality for quality, productivity, or safety improvement
- Potentiality for return on investment

All the problems were analyzed by referring to this matrix and finally a critical problem was selected at the end of the third meeting for the purpose consideration during the proceedings phase. This problem was defined as the “higher scrap rate due to the presence of hot sand in the molding process”.

During the proceedings phase, participants came out with several innovative solutions. The presence of hot sand is the major reason for the higher scrap rates. So operating the high pressure molding equipment at minimum scrap levels will make formal cooling/preconditioning even more necessary to sustain a consistently high level of sand quality and equipment productivity. In green sand molding lines, there are several types
of equipment used to deliver prepared sand to the molding system. All, however, employ the principle of introducing water into the hot sand, and subtracting heat from the sand through vaporization of the water. By providing this, it is possible to regenerate the molding mixture with optimal strengths on a continual basis. Suggestions to employ the five equipment were considered to be innovative. Each equipment has its own merits and demerits. The salient features of those equipment are described in the following subsections.

3.10.1 Rotating Cooling Drums

The cooling drum has great appeal to the foundry industry because of its relative simplicity. However, the inefficiencies of the equipment far outweigh the apparent benefits. In the cooling drum, sand is fed into one end of a rather large, inclined rotating drum. Often the downhill side of this drum incorporates a rotary screen. Air is pulled through the drum from end to end by an exhaust fan. Due to the slow movement of sand through the equipment, a major requirement for effective sand cooling is totally ignored. Furthermore, due to the slow movement, the sand actually moves through the drum as 'slug' and uniform mixing of ingredients with sand is not achieved. Sand leaving cooling drums exhibits inconsistent properties in terms of temperature, moisture content, etc.

3.10.2 Stationary Cooling Drums with Rotating Paddles

Like the rotary drum, sand enters at one end of an inclined stationary drum and is advanced through the unit by lifting paddles or shelves rotating around a central shaft. Air is pulled through side openings in this type of drum cooler and exhausted through the top. This equipment has similar performance as that of the rotating drums.

3.10.3 Sand Cascades

Hot sand is elevated to the top of cascade towers, from which point it either falls by gravity through a series of baffles or is plowed off stacked shelves, dropping from
one shelf to the next lower one.

3.10.4 Vibrating Fluid Bed Coolers

Fluid bed coolers also enjoy a degree of popularity in the foundry industry. However, a number of factors limit the effectiveness of a fluid bed cooler. In a fluid bed cooler, sand is fed onto the inlet end of a double-deck-vibrating conveyor. The upper deck consists of a plate perforated with many small holes or a small opening screen mesh. The sides and lower deck of the conveyor form an air plenum under the upper deck. Air is blown under pressure into the air plenum and passes up through the upper deck as many small high-velocity jets.

3.10.5 Cooling in the SIMPSON Muller

In this system, the multi-cooler is equipped with controls to add a measured amount of cooled and tempered water to ensure discharging of cooled sand within a controlled moisture range on a continual basis. Multi-mull (or batch muller) receives the sand from the multi-cooler and facilitates in adding required quantity of water to build the sand mixture with optimal strength on a continual basis. Because of its unique back-blending feature, the multi-mull is able to deliver sand with near constant properties, providing a far more uniform product than batch mixing equipment. The addition of a multi-cooler into the system allows the sand preparation plant to prepare sand of optimum quality. The multi-cooler makes it possible to place sand of uniform moisture and temperature into the sand system ahead of the critical mixing stage.

After rating all the five equipment, the best innovative solution was defined. Such best innovative solution was “replacing the conventional batch mixing equipment with Simpson multi cooler and Simpson multi-mull”. The members implemented this innovative solution and received the appreciation from their customers. Finally they accepted that, it was an innovative solution which helps not only to
overcome the problem but also to increase the value of their product. The successful conduct of this implementation study indicated the practical feasibility of innovative QCP. However, it was discernable that high quality decision support is imperative to sustain the implementation of innovative QCP. Hence, the theoretical design details of innovative QCP and the practical experiences gained by conducting this implementation study were used to develop a DSS. The details of developing and working of this DSS are illustrated in the next section.

<table>
<thead>
<tr>
<th>Problems</th>
<th>Ease of solution</th>
<th>Resistance to change</th>
<th>Time allowed for solution</th>
<th>Potentiality for quality, productivity, or safety improvement</th>
<th>Potentiality for return on investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difficulty in handling the sand with different inconsistent constitution</td>
<td>Easily solved (1)</td>
<td>Acceptance (2)</td>
<td>Moderate time pressure (2)</td>
<td>None (1)</td>
<td>Some (3)</td>
</tr>
<tr>
<td>Difficulty in efficiently mixing hot sand and bentonite clay</td>
<td>Difficult (3)</td>
<td>Some resistance (4)</td>
<td>Urgent (3)</td>
<td>Some (3)</td>
<td>None (1)</td>
</tr>
<tr>
<td>Over wet chunks of sand periodically drop off the walls of the bin</td>
<td>Difficult (3)</td>
<td>Neutral (3)</td>
<td>No time pressure (1)</td>
<td>Some (3)</td>
<td>Some (3)</td>
</tr>
<tr>
<td>Higher scrap rates due to the presence of hot sand used in the molding process</td>
<td>Highly difficult (5)</td>
<td>Great resistance (5)</td>
<td>Very urgent (4)</td>
<td>Some (3)</td>
<td>Considerable (5)</td>
</tr>
<tr>
<td>Deviation of laboratory results from the actual results</td>
<td>Difficult (3)</td>
<td>Neutral (3)</td>
<td>Moderate time pressure (2)</td>
<td>Some (3)</td>
<td>Some (3)</td>
</tr>
</tbody>
</table>

The numerals given in brackets refer to preference values

Table 3.1 Problem analysis matrix
3.5 Constitution of DSS

The DSS for innovative QC has been developed using Microsoft Access as back end and Visual Basic version 6.0 as front end. The DSS has been named as IQCP. The following are the constituents of this IQCP.

- Input and storage of company names
- Creation, deletion and modification of the departments
- Form for entering the employee names
- Dynamic form for entering selection criteria, weighting factor and preference values for problem analysis
- Dynamic form for screening innovative ideas by choosing the factors and weightage
- Entering and viewing the existing failures of a product for a specific department
- Form for analyzing the critical failure
- Form for entering the innovative ideas to solve the problem by applying 1M principles.
- Form for identifying the best innovative idea

IQCP also provides the option for modifying the data, if found necessary. This feature is important in the sense that if the data were to be modified, then the computation is done within few seconds. Manually, it would be a time consuming and laborious task.

3.6 Execution

IQCP for innovative QCP is annexed as an executable file in the CD attached with this report under the name ‘IQCP’. IQCP starts working by displaying the title form. After entering login name (temporarily, login name is given as ‘admin’) and password (temporary password is ‘admin’) in the title form, IQCP displays the main
menu consisting of three modules namely ‘Master’, ‘Problem’ and ‘Solution’. On invoking ‘Master’, the following entries can be made:

- Information related to company (‘company’ to be selected)
- Information related to department (‘department’ to be selected)
- Information related to employees (‘employee’ to be selected)
- Fixing the parameters for problem analysis (‘selection’ to be selected)
- Fixing the parameters for best innovation (‘perfect’ fit to be selected)
- Option for another login for different user (‘login’ to be selected)
- Exit Option (‘exit’ to be selected)

By invoking ‘problem’ module, following operations can be carried out:

- Recording the generated problems
- Analyzing the problem according to the weightage to find out the critical problem

By invoking ‘solution’ module, following operations can be carried out:

- To record the innovative ideas for the selected critical problem.
- To find out the best innovative solution

3.7 Sample Run

The activities carried out to test the implementation of Innovative QCP were referred to carry out the sample run of ‘IQCP’. Figures 3.3-3.12 show the displays of important screens of this sample run. Figure 3.3 shows the entry of company details. Figure 3.4 shows the entry of departments details. Figure 3.5 shows the entry of employee details. Figure 3.6 shows the process of choosing the selection criteria of problem analysis. Figure 3.7 shows ‘perfect fit master’ through which the innovative ideas are evaluated. Figure 3.8 shows the problem listing. As shown this screen displays department, problem code and problem name. The problems have to be chosen and saved.
The listing will be added. Figure 3.9 shows the screen using which problem is analyzed. As shown, the problem and preference must be chosen. After that, the score will be displayed. Followed by that, the listing will be updated automatically. Listing can be sorted either by score (in descending order) or problem code (in ascending order). Figure 3.10 shows the screen through which solutions are generated. Against each employee’s names the solution suggested by him/her will be entered. Figure 3.11 shows the screen using which best innovative solution can be attained. As shown, against each problem chosen, solution will be listed. Against each criteria, scores are entered. On pressing best innovative solutions, screen shown in Figure 3.12 will appear. As shown the best innovative solution against the problem considered will be displayed in decreasing order of their scores. Thus IQCP provides decision support to the user (who will be normally a middle level managerial personnel) for successfully implementing innovative QCP. In order to enable the reader to view the sample run of computer screen outputs reported in this chapter the concerned details have also been saved in the CD. For this purpose the reader can enter 02 against employee ID. After this the employee name will appear as G.Kamalkumar. The word ‘kumar’ has to be entered against the password. With this the reader will be able to view the computer screen outputs shown in this chapter.

3.11 Conclusion

QCP is the oldest TQM technique, which has been dominating the organizations of any type and size, situated throughout the world. The unique feature of the QCP is that it is welcomed by both management and employees. Till today QCP is being employed to solve quality related problems. Besides QCP has facilitated in bridging the gap existing between various levels of employees. The aggressive competitive situation, which has been happening during the past one decade has forced the organizations to offer innovations, coupled with quality. Hence interest was evoked to
study the possibility of deploying QCP in this direction. An overview on literature of
QCP and IM indicated that no model, which would incorporate both, these principles
have been brought out. In order to fill this gap the module of the research work reported
in this chapter was carried out. The main contribution of this work was the design of
innovative quality circle model. A case study was conducted to study the practical
feasibility of applying this model. Though this case study revealed the feasibility in this
regard, it was clearly discernable that practitioners are not mature enough to implement
this model on their own. In order to overcome this situation a DSS called IQCP was
developed. This research module was the second major contribution of this research
work. At the outset, it is claimed that the discussions, observations, results and running of
DSS reported in this chapter, will provide broader guidelines for the manufacturing
enterprises to implement innovative QCP successfully and evolve innovations coupled
with quality.
Figure 3.3 Company details entry screen of IQCP
Figure 3.4 Departments details entry screen of IQCP
Figure 3.5 Employee details entry screen of IQCP
Figure 3.6 Selection criteria master of IQCP
Figure 3.7 Perfect fit master of IQCP
Figure 3.8 Problem listing of IQCP
Analysis of Critical problem

Department: Moulding
Problem Code: 04
Problem Name: Higher scrap rates due to hot sand

<table>
<thead>
<tr>
<th>Selection Criteria</th>
<th>Weighting Factor</th>
<th>Preference</th>
<th>Value</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ease of Solution</td>
<td>5</td>
<td>Highly Difficult</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>Potential for quality, productivity or safety improvement</td>
<td>3</td>
<td>Considerable</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Potential for return on investment</td>
<td>3</td>
<td>Considerable</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Resistance to change</td>
<td>5</td>
<td>Great Resistance</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>Time allowed for solution</td>
<td>4</td>
<td>Immediate action necessary</td>
<td>5</td>
<td>20</td>
</tr>
</tbody>
</table>

Total Score: 100

List of Analysis and selection of critical problem

<table>
<thead>
<tr>
<th>Problem Code</th>
<th>Problem Name</th>
<th>Critical score</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Handling the sand with inconsistent constitution</td>
<td>45</td>
</tr>
<tr>
<td>02</td>
<td>Mixing of hot sand and bentonite clay</td>
<td>52</td>
</tr>
<tr>
<td>03</td>
<td>Over wet chunk sand drop</td>
<td>53</td>
</tr>
<tr>
<td>04</td>
<td>Higher scrap rates due to hot sand</td>
<td>100</td>
</tr>
<tr>
<td>05</td>
<td>Deviation from actual results</td>
<td>30</td>
</tr>
</tbody>
</table>

Figure 3.9 Problem analysis display of IQCP
Figure 3.10 Solution generation screen of IQCP
Figure 3.11 Screen of IQCP displaying the perfect fit score for the innovative solution
Figure 3.12 Screen IQCP displaying best innovative solution with employee numbers and scores