Product Design Using Theory of Innovation and Problem Solving (TRIZ) Technology for Induction Machine

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Abstract**—***TRIZ is the design technology that innovates and finds out a solution for problem solving in any engineering disciplines. This innovation method not only focuses on only problems with past and present condition but also focuses on the future condition of the system also. This paper proposes the TRIZ system for Innovation in submersible pump system especially when they are used in series and parallel operations required for drainage and large irrigation purposes. Current system when used in such condition requires a lot of time and large manpower especially when removing and reinstalling the systems. It also conserves large time and reduces the efficiency for another operation. Thus the application of submersible pump can be extended to different situations in our country with technology upgradationy using the theory of Innovation and problem solving technology, TRIZ.*

Keywords: Conflict Matrix, TRIZ, Innovation, Series-Parallel Combination, Product Design, Controversy Solution.

I. Introduction

India's power demand is likely to cross 300 GW in the next 10 years earlier than most estimates. Meeting this demand will require a five hold to tenfold increase in the power of the capacity addition. The profile of planned capacities will also need to be suitably modified to fulfill the peak demands and provide affordable power.

Various studies suggest that if India continues to grow at an average rate of 8 percent for the next 10 years, the country's demand for power is likely to soar from around 120 GW at present to 315 to 335 GW by 2017, 100 GW higher than most current estimates. To fulfill its power requirement of 315 to 335 GW by 2017, India will require a generation capacity of 415 to 440 GW, after adjusting for plant availability and 5 percent spinning reserve [1]. This capacity from the current level of about 140 GW, which in turn translates an annual addition of 20 to 40 GW. One important task to achieve this is to reduce the losses to 15 percent by 2017. Inadequate availability of energy sources affects the economic growth of the country. Studies show that about 40% of electrical energy produced in India are used in Agriculture side especially from irrigation pumps and pumps used for drainage purposes.

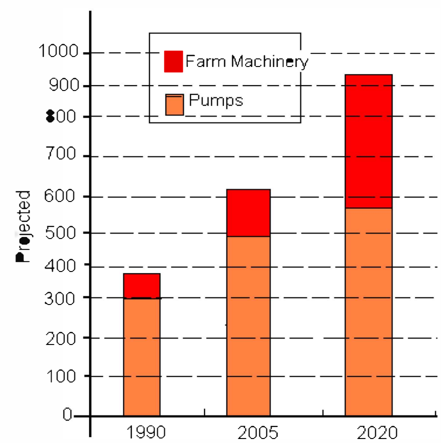

FIG. 1: Projected Energy Consumption from the Agriculture Sector

The resulting projections of energy consumption in agriculture sector for pumping and farm machinery are shown in Figure 1. The largest growth is expected to result from increasing mechanization. Energy use in farm machinery will represent 41% in 2020 compared to 28% in 2005. The total energy consumption in 2020 in the Agriculture secor alone in India is estimated to grow at a rate of 2.4% annually [1,2].

So, by focusing on reducing the losses of the pumps can contribute the demand of such energy requirements. Among this, one of the factors that contribute the inefficiency of the pumping system is when the submersible pumps are used in series and parallel combination for irrigation and as well as drainage and flood removing purposes.

II. Series and Parallel Operation – Submersible Pumpset

The basic parameters of submersible pump include the flow and head etc. The main purpose of submersible pump is to lift the water from bore wells. When the pumps are connected in series-parallel combination for different circumstances, improving the efficiency of submersible pump has the following characteristics:

Condition 1: When there is large flood occurs in narrow tunnel and deep water condition, series operation is well suited. Since it is difficult for high head in the later time of rescuing, there is a need to change parallel operation to series operation resulting in difficulties and time-consumption to install and dismantle pumps in undergrounds. Eventhough this conversion not only affects the efficiency of rescue, it reduces submersible motor pump's efficiency and consumes lot of energy.

Condition 2: Excess water condition. Series operation is not well suited since as the head is high, it is difficult for series operation of double pumps to implement large flow drainage to solve the disaster of water in the initial rescuing. Under this situation, converting series operation to parallel operation consumes time and increases energy consumption[4].

Analyzing these two circumstances and considering the above factors, one kind of submersible pump may be used for different conditions and it depends upon how to solve the problem of energy consumption and speed.

III. TRIZ-Innovation Theory

Based on TRIZ, the paper innovatively proposes an idea for an optimized design solution of submersible motor pump which will be able to adapt different working conditions promptly with higher efficiency. Considering the problem in current systems and by viewing the modern design technology, this can be proposed.

A. TRIZ – A Systematic Approach

The design process is divided into three phases: analysis, synthesis as well as evaluation. Thus three steps are repeated in design procedures till a solution is found. TRIZ [4] is a theory of innovation in which the innovative product design is with high quality and less flaws that decrease the system performance.

B. Multiscreen Method of TRIZ

On the basis of system theory, low level systems within the system are called subsystem and high level systems outside system are named as super systems [4,6].

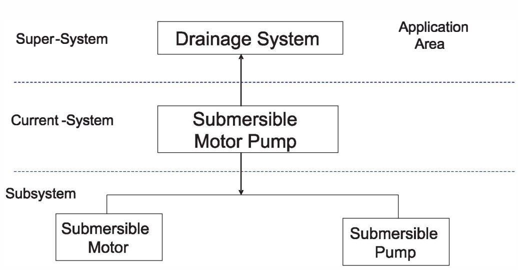

Fig. 2: Multiscreening

For analyzing and solving problems, this multi screen method will consider not only the current system, but also the past and future of subsystem and super-system as indicated in Figure 2.

C. Multiscreen Analysis of Submersible Motor Pump

If we consider the submersible motor pump set as in Figure 2, we can analyse the multi screen map can systematically applied to it. Here, submersible motor and submersible pump are subsystems. Irrigation, drainage, fire protecting are the future systems of the submersible pump. Here, based on this design, a submersible pump that adopts the different conditions mainly depends on subsystems that is with motor and pump attachment.

D. Technology Up Gradation by Considering the Contradictions

This is the restriction relationship of two parameters with in a functioning system. That is improving one parameter or character causes the deterioration of the other parameter or characteristic, which produces contradiction. Thorough analysis of the problem of submersible motor pump, it is known that series-parallel conversion in underground situations will consume large amounts of energy.

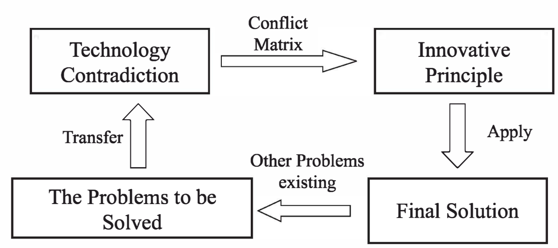

Fig. 3: Up Gradation by Contradiction

Here, in this system, the speed and energy consumption in different circumstances of submersible pump set will be the contradiction techmically. Here, from the Figure 3, a final solution can be found out by considering the contradictions.

E. General Engineering Parameters

According to Altshuller, who designed TRIZ [5], after the analysis of huge amount of latent literatures, there are 39 general engineering parameters that can be analyzed for any product design. Hence, it is sufficient enough to consider these parameters to any engineering contradiction and find out a suitable solution to the contradictory parameters.

In this case, considering the contradictions of submersible motor and submersible pump, the speed and energy consump-ion in different working conditions has the relations of the terms in energy consumption in moving item and the speed.

Contradiction, which has the relation of two engineering parameter: Energy Consumption of moving item and Speed.

F. Conflict Matrix by TRIZ

Technical contradiction analsysis and system improvement with the innovation principle should be used with the conflict matrix table. This is used to solve the technical contradiction by Altshulle for the TRIZ method [6,7].

In the conflict matrix table, the first column, is the name of parameter that needs to be improved in the system and the first line is the name of another parameter to be worse while improving one parameter of the system and figures in each cell-grid denote the number of the most useful innovation principles that solve the corresponding technical contradiction by Triz. Here for analyzing submersible motor pump, the parameter needs to be improved is 9#speed and the corres-ponding contradictory parameter should be worse is 19# energy consumption of moving object.

Based on this, four principles of innovation can be obtained, which are weight compensation, speed, dynamic parameters, parameters that are changed by physical and chemical conditions.

G. Contradiction Matrix

Deteriorated parameter / *Improved parameter*	*1.Wt.of dynamic obj.*	*2. Wtofstatic obj.*	*19. Energy Consumption of Moving Objects*	*38. Automation*	*39. Productivity*
1. Weight of Dynamic object			35, 12, 34, 31	26, 35, 18, 19	35, 03, 24, 37
2. Weight of Static object				02, 26, 35	01, 28, 15, 35
9. Speed	02, 28, 13, 38		**08, 15, 35, 38**	10, 18	
38. Automation	02, 27, 35, 11	02, 27, 35, 11	02, 32, 13	05, 12, 35, 26	
39. Productivity	35, 26, 24, 37	28, 27, 15, 03		05, 12, 35, 26	

FIG. 4: DESIGNING CONFLICT MATRIX

H. Analyzing the Technology Conflicts

The main conflicts for analyzing technology contradictions are as follows:

1. 8# Weight compensation principle: The purpose of using weight compensation principle is increasing the quality, but submersible motor pump should be light in weight and the technical characteristics of speed will be worse after increasing the quality of submersible pump. Obviously, weight compensation principle is not suitable to solve this technical contradiction.
2. 38# Strong oxidant principle: oxygen-enriched air instead of ordinary air. The purpose of using strong oxidizer is to make the fuel burning more, so that the device could get maximum thrust. However, for drainage purposes, the submersible pump should be run by electricity in water. As a result, it is not suitable for it.
3. 15# Dynamic principle: segmentation of objects can change the relative positions of their parts: 35# principles of parameter changes by physical or chemical: Changes in temperature, concentration or state of aggregation. In accordance with these two innovations principles, change the internal structure of the submersible pump with pipes and control valves, etc.

IV. DESIGN SOLUTION

The submersible pump system consists of motor assembly and pump assembly as shown in Figure 5. The optimal design of two submersible pumps will be designed by taking into considerations of the above parameters. With control valves, the parallel operation of double pumps is achieved when flow should be two times of the single pump flow. Also, the two pumps can be made into series operation where the submersible pump's lift is increased by one time in the series operation.

The flow analysis with control valves is made by PSIM pump analysis software and with this the flow, head and output performance are simulated for model simulation as in Figure 6 to Figure 8. The parameters used for simulation are given in Table 1 .

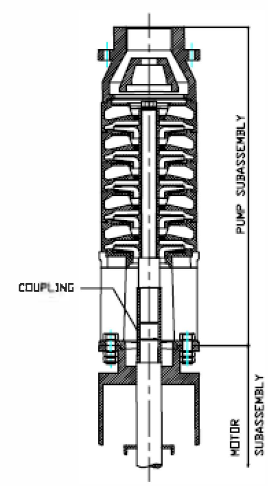

FIG. 5: MOTOR AND SUBASSEMBLIES OF SUBMERSIBLE PUMP

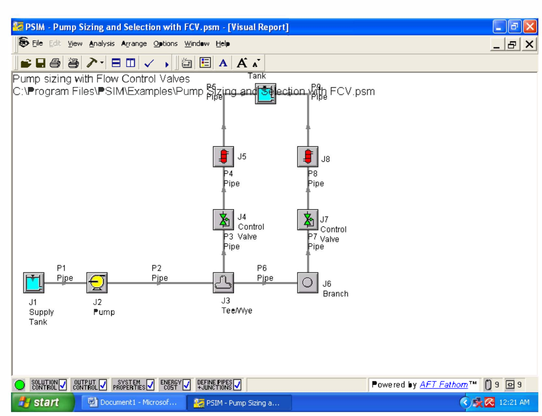

FIG. 6: PUMP LAYOUT WITH FLOW CONTROL VALVES

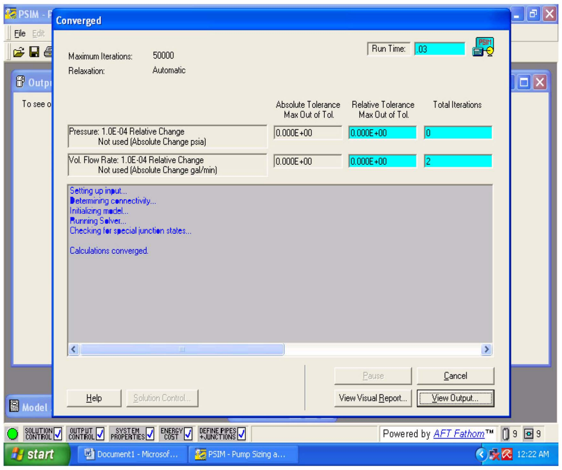

FIG. 7: REPORT CALCULATION

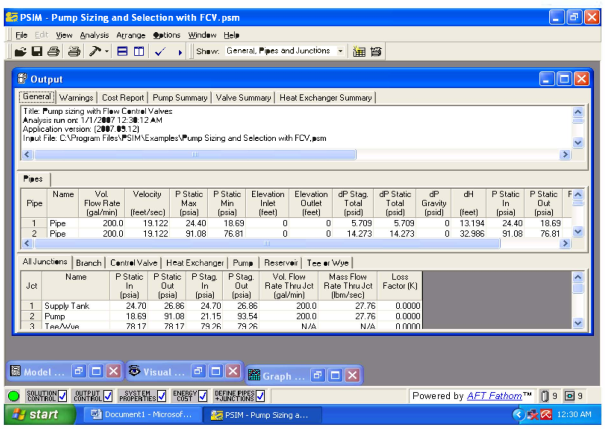

FIG. 8: PUMP DATA, SIZING, ELEVATION, STATIC OUTLET

TABLE 1: PUMP MODEL SPECIFICATIONS

S. No.	*Parameter*	*Value*
1	Atmospheric Pressure	1 atm
2	Gravitational acceleration	1 g
3	Max. Fluid Temperature data	212°F
4	Temperature	70°F
5	Density	62.30841 lbm/ft^3
6	Viscosity	2.36004 lbm/hr-ft
7	Vapor pressure	0.36154 psia
8	No of pipes in the model	9
9	No of joints in the model	9
10	Pipe inner diameter	2.067 inches
11	Pipe material	Steel
12	Absolute roughness	0.0018 inches
13	Fittings and losses assumption	0
14	Pipe lengths may vary	

The speed plays an vital role in the efficiency of the pump design. Figure 9 illustrates the specific speed rate to the pump efficiency. The parameters which are taken for model consideration are: pump rotational speed, flow rate, total head and acceleration due to gravity as illustrated below.

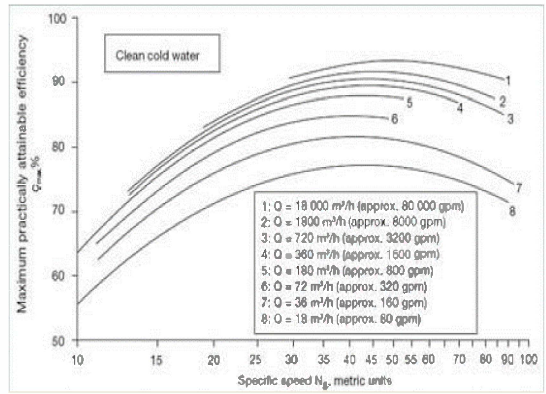

FIG. 9: THE MAX ATTAINABLE EFFICIENCY WITH SPECIFIC SPEED

The Specific speed is calculated using the formula,

$$N_s = n\,(Q)^{1/2}/(gH)^{3/4}$$

where,

N_s = Specific speed
n = Pump rotational speed (rpm)
Q = Flow rate in cubicmeter per sec
H = Total head per stage in meter
g = Acceleration due to gravity in mtr per sec per sec.

V. CONCLUSION

In this paper, TRIZ which is the Theory of Innovation and problem solving is illustrated to design a product with contradiction matrix. This also gives an optimal solution according to designer's choice. A submersible pump system which automatically changes in to series and parallel operation can be designed and implemented for the specified field of application. Hence, when the environmental condition requires the pumps to be operated in series or parallel combination, the jump on different conditions of submersible motor pump can be achieved by considering the contradiction factors and reducing them instead of removing or reinstalling the pumps. This will result in reducing the labor costs, time, material reserve and moreover the increase in efficiency.

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