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Automation with TRIZ Technology for Electrical Submersible Pumps

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ABSTRACT

An innovation method is needed in the engineering disciplines which will not only focuses on only problems with past and present condition but also focuses on the future condition of the system also. For that TRIZ is considered the most preferable method for innovation methods. 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 entire operation. Thus the application of submersible pump can be extended to different situations in our country with technology upgradation using the theory of Innovation and problem solving technology, TRIZ.

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INTRODUCTION

In India, in spite of the additions where ever applicable in generation capacity, the growth in demand for power has far exceeded the generation capacity augmentation as a result of which the country is facing both energy markets and faces a chronic 10% electricity shortage and upto 20% during peak periods. India's power demand is likely to cross 300GW in the next 10 years earlier than most estimates (Powering India – The road to 2017). 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 to 10 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, 100GW 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 (Powering India – The road to 2017). 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 and flood removal purposes.

The resulting projections for the pump industry growth in India is shown in Fig.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 sector alone in India is estimated to grow at a rate of 2.4% annually (Powering India – The road to 2017; International Energy Consulting Corporation (IECC) 2011).

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.

I. Pumps connected together – Submersible Pumpset:

The basic parameters of submersible pump include the flow rate and head etc., The main purpose of submersible pump is to lift the water from bore wells. When the pumps are connected in series-

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parallel combination for different circumstances, improving the efficiency of submersible pump has the following characteristics:

Situation.1: Deep water condition. 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.

Situation.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 (Jun Deng, 2010).

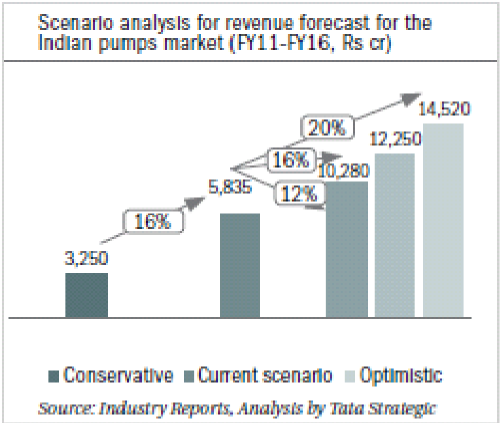

Fig. 1: Forecast for the Indian Pump Market.
Source: Industry Reports, Analysis by Tata strategies

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.

II. TRIZ-Innovation and Problem Solving:

According to TRIZ, this 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 Multi Stage 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 (Jun Deng, 2010) 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 (Jun Deng, 2010; Lijie Feng, 2002).

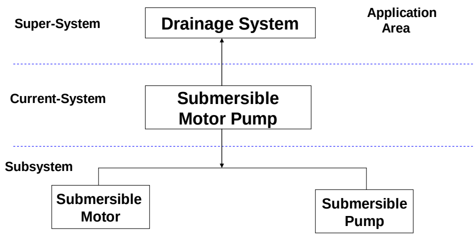

Fig. 2: Multiscreening.

For reasoning, 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 Fig. 2.

C. Multiscreen Approach 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. Innovative 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 the problem of submersible motor pump, it is known that series-parallel conversion in underground situations will consume large amounts of energy and time.

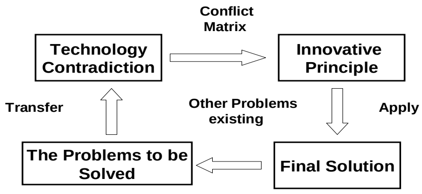

Fig. 3: Innovation by contradiction.

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

E. General engineering parameters:

TRIZ is designed by Altshuller (1999), 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 consumption 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.

Technical contradiction analysis and system improvement with the innovation principle should be used with the conflict matrix table. This is used to solve the technical contradiction by Altshuller for the TRIZ method (Lijie Feng, 2002; Zheng Chengde, 2003).

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 corresponding 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.

F.A Conflict Matrix by TRIZ:

G. Contradiction Matrix:

Deterioted parameter / Improved parameter	1.Wt.of dynam -ic obj.	2.Wtof stat-ic obj.	19.Energy consumpti -on of moving objects	38.Automation	39.Pro ductiv -ity
1.Weightof 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.Automa-tion	02,27, 35,11	02, 27, 35, 11	02,32,13	05,12, 35,26	
39.Product-ivity	35,26, 24,37	28, 27, 15, 03		05,12, 35,26	

Fig. 4: Designing Conflict Matrix.

H. Improving 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. Hence, 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 also 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.

III. Design Solution:

The motor assembly and pump assembly is the submersible pump system. 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 at various pressure ranges and with this the flow, head and output performance are analyzed. Fig.8 shows various parameters of the pumps with different conditions.

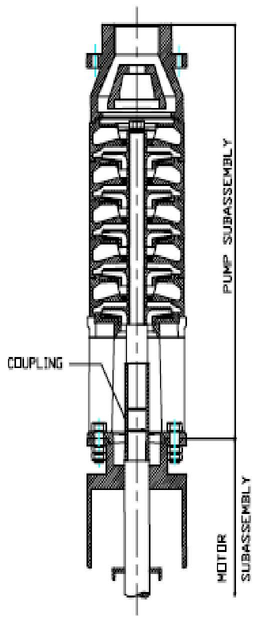

Fig. 5: Motor and subassemblies of submersible pump.

Fig. 6: Pump design with flow control valves.

Fig. 7: Testing Chambers.

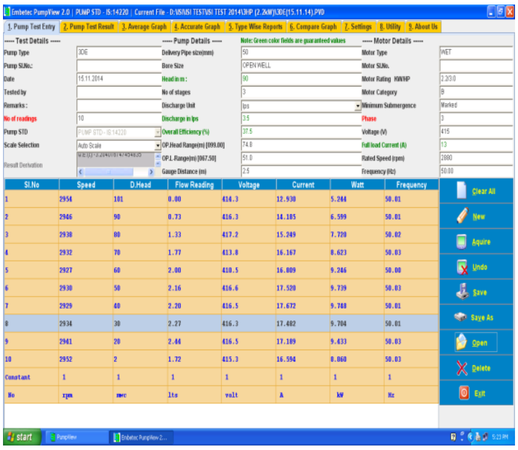

Fig. 8: Pump data, sizing, elevation, static outlet.

Table I: Pump Model Specifications.

Pump Type	3DE
Delivery size(mm)	50.00
Min.Bore size(mm)	OpenWell
No.of stages	3
Motor Rating(kW/HP)	2.2/3.0HP
Voltage(V)	415
Phase	3 phase
Max Current(A)	6.50 Amps
Speed(rpm)	2880
Motor type	Wet
Motor Category	B
Min Submergence(m)	Marked

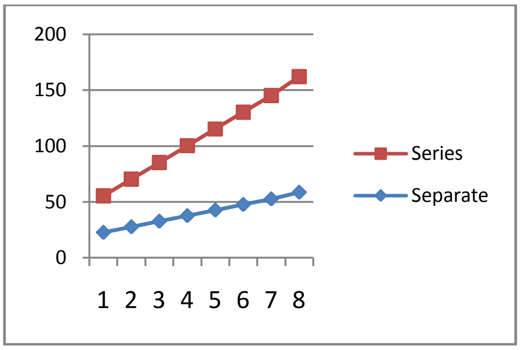

Fig. 9: Head Vs Flow rate.

Fig.9 illustrates the head increases with flow rate for series and separate pumps. The speed plays an vital role in determining the performance of the pumps. This depends upon the specific speed of the pumps and is calculated as per the expression given below

The Specific speed is calculated using the formula,

$N_s = n\ (Q)^{½} / (gH)^{3/4}$

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

IV. Conclusion:

In this paper, a design solution by using TRIZ is analyzed for submersible pumps used in emergency situations for large drainage purposes. 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. When the environmental condition requires the pumps to be operated in series or parallel combination, the automation of the pumps can be made and 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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