ISSN: 0975-5861

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Volume 11
Issue 3
Version 1.0

ENG

Global Journal of Research in Engineering

Global Journal of Research in Engineering

Volume 11 Issue 3 (Ver. 1.0)

Global Association of Research

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Offset Typesetting

Global Association of Research, Marsh Road, Rainham, Essex, London RM13 8EU United Kingdom.

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Global Journal of Research in Engineering
Volume 11 Issue 3 Version 1.0 April 2011
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
ISSN: 0975-5861

Determination of Busy Hour in Mobile Communication in Nigeria

By Osahenvemwen O.A., Emagbetere J.O

Abstract- This paper is focused on determination of busy hour in Mobile Communication in Nigeria, using Lagos as a case study. Busy hour, it is a given period within a day that have the highest traffic intensity. The traffic intensity values obtained within the busy hour are used to calculate the traffic load, capacity of the mobile communication network equipment and to determine traffic performance indicators. Data was obtained from OMC for a period of a year. The OMC is in-built within the mobile communication network, that help to monitor and measure all the entire event in the mobile communication system. The obtained data was analyzed using excel package to determine the busy hour which was observed to be 19:00 (7.00pm) shown in figure 2.1 to figure2.6 the call intensity for various days of the week is as followed, Monday with the highest call intensity, 26,492, followed by Friday with 23,138, Tuesday with 19,080, Wednesday with 17,892, Thursday with 16,467, Saturday with 15,491 and Sunday with 12,119.

Keywords: Operation and maintenance centre (OMC), traffic intensity, peak busy hour, stochastic process.

Classification: GJRE-F Classification: FOR Code: 090602,200102,150305

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Determination of Busy Hour in Mobile Communication in Nigeria

Osahenvemwen O.A.[α], Emagbetere J.O[Ω]

Abstract- This paper is focused on determination of busy hour in Mobile Communication in Nigeria, using Lagos as a case study. Busy hour, it is a given period within a day that have the highest traffic intensity. The traffic intensity values obtained within the busy hour are used to calculate the traffic load, capacity of the mobile communication network equipment and to determine traffic performance indicators. Data was obtained from OMC for a period of a year. The OMC is in-built within the mobile communication network, that help to monitor and measure all the entire event in the mobile communication system. The obtained data was analyzed using excel package to determine the busy hour which was observed to be 19:00 (7.00pm) shown in figure 2.1 to figure2.6 the call intensity for various days of the week is as followed, Monday with the highest call intensity, 26,492, followed by Friday with 23,138, Tuesday with 19,080, Wednesday with 17,892, Thursday with 16,467, Saturday with 15,491 and Sunday with 12,119.

Keyword: Operation and maintenance centre (OMC), traffic intensity, peak busy hour, stochastic process.

I. Introduction

Recent time, the world has witnessed different standards of mobile communication network, ranging from second generation (2G) to third generation (3G) standards. What gave room to this change is human quest to have better coverage quality, Grade of Service (GOS) and capacity (Gunner, 1998).

Despite all these evolution from one stage to another, mobile communication subscribers, still have some difficulties when making calls or initiating calls during some particular period of time. For us to determine the performance of the mobile communication, the grade of service must be determined, firstly the peak busy hour must also be determine, the peak busy hour it is the given period within a day that bears the highest traffic intensity. The 'peak busy hour' traffic is use to determine the equipment quantities of the network. The reason to use busy hour traffic is that this period usually has the highest amount of blocked or lost calls. If the dimensioning of equipment at this period is correct and blocked calls can be minimized, all other non-busy hour traffic should then be handled satisfactorily (Sanjay; 2010).

The operation and maintenance centre (OMC), the OMC-counter is in-built inside the mobile communication system. These OMC-counter is used to measure the traffic variation on the traffic interfaces.

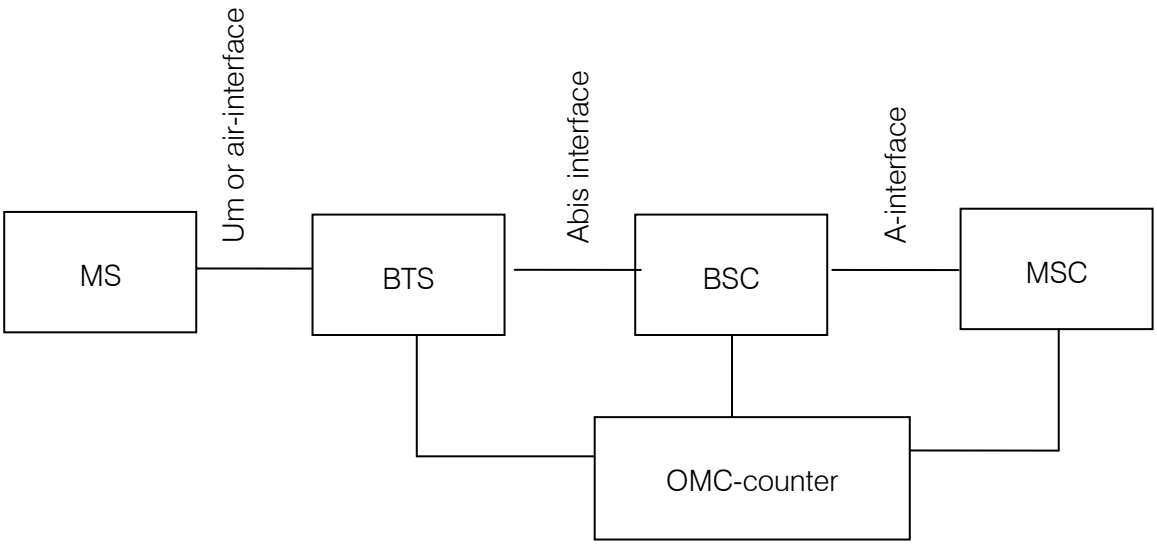

Fig 1.1: Traffic interface architecture

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The operation and maintenance centre is sub-divided into three. They are;

- Fault management
- Configuration management
- Performance management

The performance management unit is responsible for monitoring the performance of all the event (activities). Example are, calls intensity, time duration per call and time duration per hour. Etc. the traffic activities is being handled by sub-section known as (PMR) performance management traffic recording unit (John; 2005).

II. Experimental Procedure

To determine the peak busy hour of traffic saturation in mobile communication network in Nigeria, we can measure traffic by three different methods, they are;

- Driving test
- Protocol analyzer
- OMC-counter (Operational and Maintenance Centre-Counter) (Gunner, 1998).

In this experiment we deployed the use of the OMC-counter for measurement, which is in-built in mobile communication network, measurement have shown, that traffic is characterized by two major components they are;

- Stochastic component
  - ❖ Random generation of calls by subscribers (man)
- Deterministic component (machine)
  - ❖ Structure (hardware)
  - ❖ Operational strategy (software)

(ITU-D, 2006).

Data was obtained from the above mentioned technique for a duration of one- year from the experiment, it was show that traffic has two types of variation associated with the stochastic component. They are;

1. Number of calls variation
2. Services times variation

This variation are the parameters used to determine the peak busy hour (Moltchanor, 2005).

III. Data Presentation

The data obtained from operation and maintenance centre was presented in the following table below:

Table 1.1: Various peak busy hour, on different area and routes

S/NO	AREA	ROUTE ID	PEAK BUSY HOUR	ATTEMPT CALLS
1.	MUSHIN	BSC 0-10 BSC 1-10 BSC 2-10	19:00 19:00 19:00	1092 818 1511
2.	IKOTUN	BSC 0-10 BSC 1-10 BSC 2-10	20:00 19:00 19:00	858 1218 1915
3.	EJIGBO	BSC 0-10 BSC 1-10 BSC 2-10	20:00 19:00 19:00	672 1083 838
4.	APAPA	BSC 0-10 BSC 1-10 BSC 2-10	19:00 15:00 11:00	806 1345 666
5.	ALABA	BSC 0-10 BSC 1-10 BSC 2-10	20:00 19:00 19:00	247 1071 1337
6.	OYINGBO	BSC 0-10 BSC 1-10 BSC 2-10	19:00 19:00 19:00	1185 847 722

The above table have, different areas such are Mushin, Apapa, Alaba, Oyingbo, Ejigbo and Ikotun was consider in this research work due to their population intensity in Lagos.

Each area have a routes incorporated into 3 Base Station Controller (BSC). While 3 routes were consider under one base station controller (IBSC). The attempts calls for 24 hours, in each route are also recorded.

Table 1.2: Call intensity for each day of the week

S/No	Call Intensity	Days of the Week
1.	Sunday	12,119
2.	Monday	26,492
3.	Tuesday	19,080
4.	Wednesday	17,892
5.	Thursday	16,467
6.	Friday	23,138
7.	Saturday	15,491

IV. Result Analysis

The graphics below shows different peak busy hour of call intensity for various routes and six areas in Lagos State from a leading Mobile Communication Network in Nigeria. Data obtained was simulated by Excel package to obtain a resultant graphics.

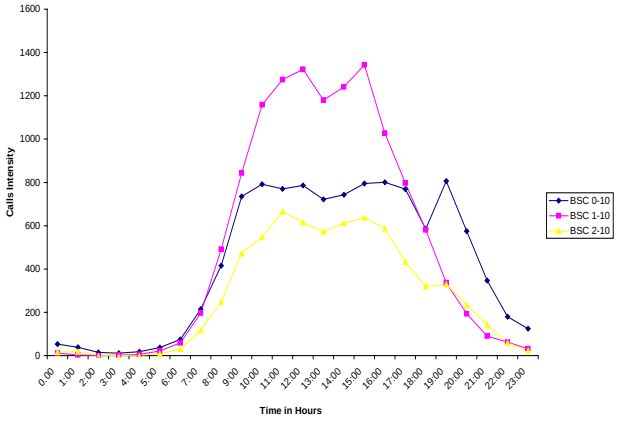


Fig. 2.1: Peak Busy Hour of Route for Apapa

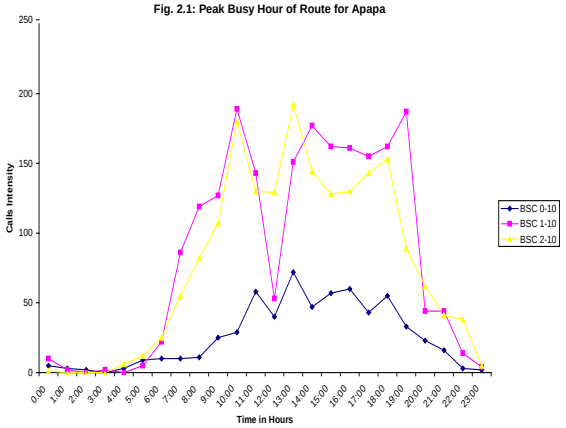


Fig. 2.2: Peak Busy Hour of Routes in Alaba

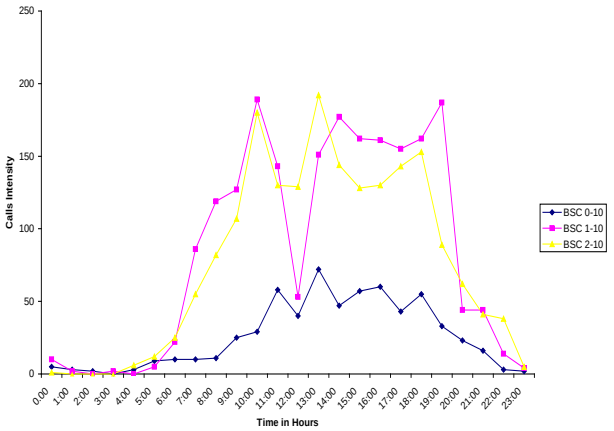
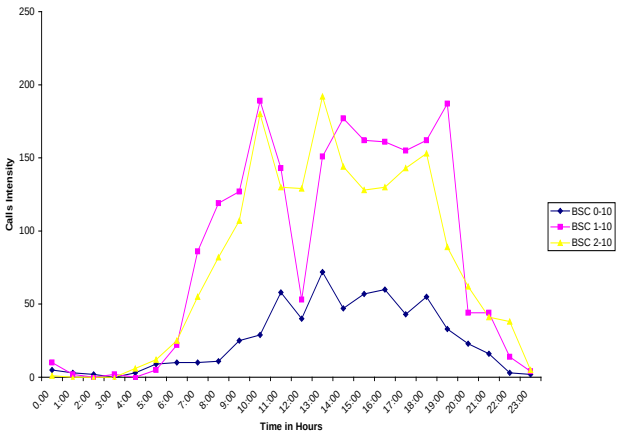


Fig. 2.4: Peak Busy Hours of Routes in Ikotun



F.g 2.3: Peak Busy Hour of Routes in Mushin

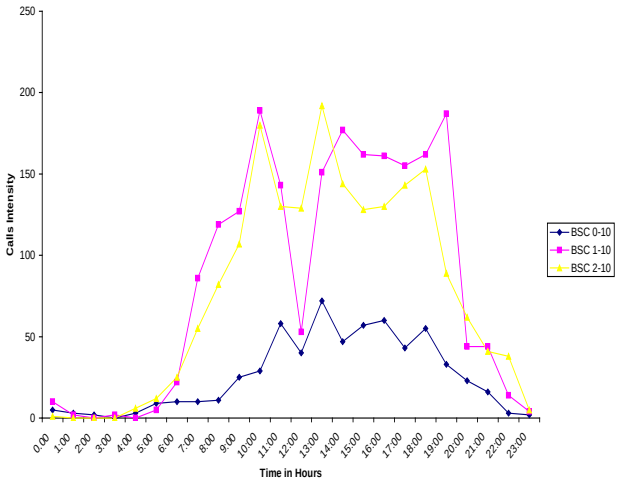


Fig. 2.5: Peak Busy Hour of Routes in Ejigbo

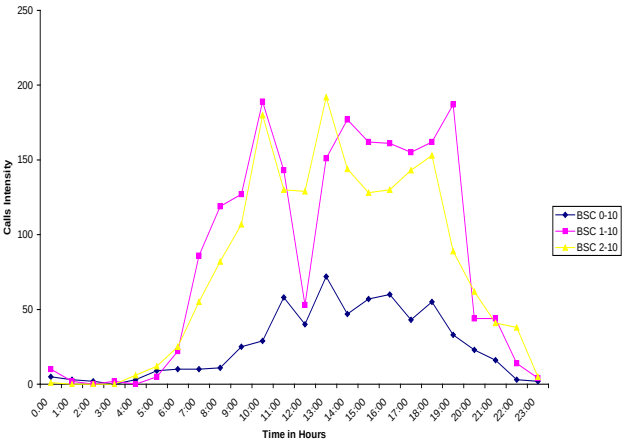


Fig. 2.6: Peak Busy Hour of Routes in Oyingbo

The highest call intensity was also determined for days of the week. From table 1.2 the resultant output shows that Monday has the highest call intensity, followed by Friday, Tuesday, Wednesday, Thursday, Saturday and Sunday. Shown in figure 2.7. For easy comparison the bar chart was used for different days of the week.

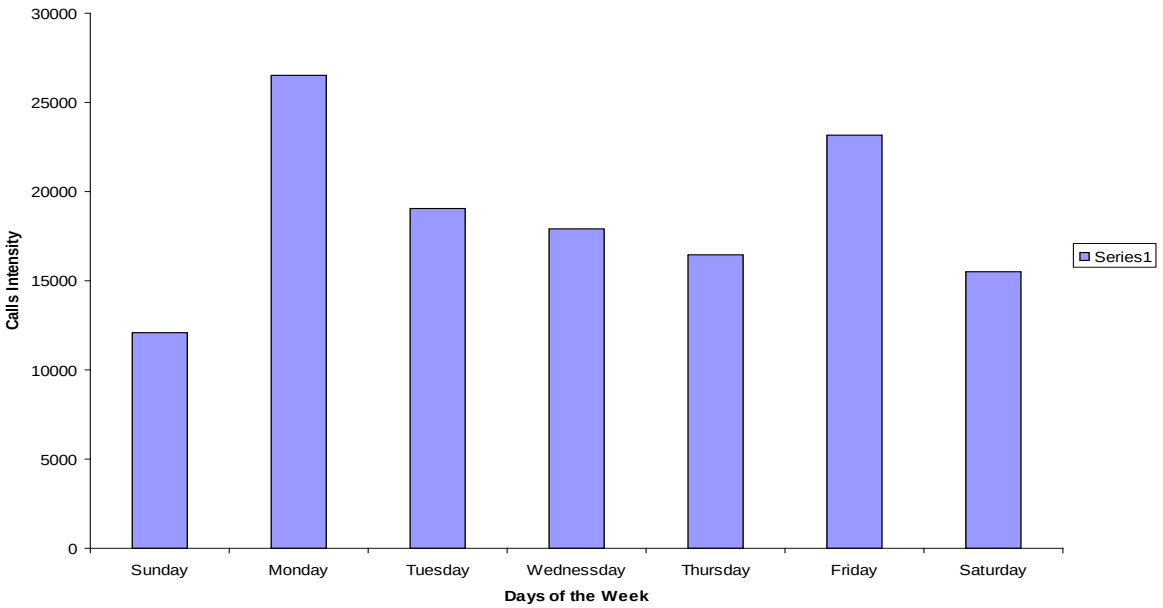


Fig. 2.7: Bar Chart for Total Call Intensity for Days of the Week

V. Discussion

The data obtained are represented in graphys for easy interpretation for various routes in fig. 2.1 to fig. 2.6. It was observed that average routes shown, the busy hour in mobile communication in Nigeria is 19:00 hour (7.00pm) for the performance of various route analyses carried out. The values of busy hour at 19:00 hour can be used to calculate the traffic load, the capacity of network and traffic performance indicator of the network such are offered traffic, carried traffic, block traffic, call completion rate (CCR), busy hour call attempt (BHCA) and grade of service (GOS). The various call intensity was correlated, and represented by bar chart for easy comparative between the various days call intensity as shown in fig. 2.7. Therefore, Monday which have the highest call intensity of 27,567, the value of the busy hour must be used to determine the traffic load and capacity. If the system capacity can handle the highest number of subscriber, therefore it can manage the rest in a good proportion.

VI. Conclusion

From this thesis, the data was obtained from operation and maintenance centre (OMC-Counter). The data obtained was analyzed by Excel package. It was observed that there are two active busy hour, they are 10:00 hr and 19:00 hr. graphical representation of all the routes was shown in fig.2.1 to fig 2.6. The highest busy hour of the average route observed is 19:00 hr (7.00pm). Compared to what is obtained in other countries with their busy hour is at 16:00 (4.00pm). The reason for a radical shift from 4.00pm to 7.00pm in Nigeria time are due to the high business environment, high population and transportation situation in Lagos (Nigeria).

The call intensity for various days of the week was examined. Monday with the highest call intensity 27,567, followed by Friday, Tuesday, Wednesday, Thursday, Saturday and Sunday, shown in figure 2.7.

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Global Journal of Research in Engineering
Volume 11 Issue 3 Version 1.0 April 2011
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
ISSN: 0975-5861

Fuzzy Goal Programming Method for SolvingMulti-Objective Transportation Problems

By K Venkatasubbaiah, S G Acharyulu, K V V Chandra Mouli
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Abstract- The multi-objective transportation problem refers to a special class of vector minimum linear programming problem, in which constraints are of inequality type and all the objectives are non-commensurable and conflict with each other. A common problem encountered in solving such multi-objective problems is that to identify a compromise solution among a large number of non-dominated solutions, the decision maker has to develop a utility function for meeting the desired goal. In this paper, fuzzy membership functions are considered and deviation goals also taken for each objective function. Fuzzy max-min operator is implemented to show the effectiveness of the proposed methodology. LINGO software package is used to solve constrained optimization problem. To illustrate the proposed method, two numerical examples are solved and the results have been compared with interactive, fuzzy and deviation criterion approaches.

Keywords: *Multi-objective Optimization, Transportation Problem, Feasible Ideal Solution, Pareto Solutions, Membership Function, Deviations, Fuzzy Max-Min Operator.*

Classification: *GJRE B Classification: FOR Code: 080309*

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Fuzzy Goal Programming Method for Solving Multi-Objective Transportation Problems

K Venkatasubbaiah[α], S G Acharyulu[Ω], K V V Chandra Mouli[β]

Abstract- The multi-objective transportation problem refers to a special class of vector minimum linear programming problem, in which constraints are of inequality type and all the objectives are non-commensurable and conflict with each other. A common problem encountered in solving such multi-objective problems is that to identify a compromise solution among a large number of non-dominated solutions, the decision maker has to develop a utility function for meeting the desired goal. In this paper, fuzzy membership functions are considered and deviation goals also taken for each objective function. Fuzzy max-min operator is implemented to show the effectiveness of the proposed methodology. LINGO software package is used to solve constrained optimization problem. To illustrate the proposed method, two numerical examples are solved and the results have been compared with interactive, fuzzy and deviation criterion approaches.

Keywords: Multi-objective Optimization, Transportation Problem, Feasible Ideal Solution, Pareto Solutions, Membership Function, Deviations, Fuzzy Max-Min Operator.

I. Introduction

The classical transportation problem is one of the sub classes of linear programming problem in which all constraints are inequality type. Hitchcock (1941) developed transportation model. Because of the complexity of the social and economic environment requires explicit consideration of criteria other than cost, the single objective transportation problems in real world cases can be formulated as multi-objective models. Charnes and Cooper (1961) first discussed on various approaches to solutions of managerial level problems involving multiple conflicting objectives. Ignizio (1978) applied goal programming for multi-objective optimization problems and solved two-objective optimization problem. Some of the authors (see Garfinkl & Rao 1971; Swaroop et al., 1976) have solved the two objective problem by giving high and low priorities to the objectives. Belenson and Kapur (1973) presented two person-zero sum game approach consists of a p x p pay off matrix and solved each objective function individually finally developed best compromise solution using proper weights to the objective functions. Jimmenez and Vudegay (1999) solved a multi-criteria transportation problem using parametric approach by developing auxiliary solutions. Rakesh Varma et al., (1997) used fuzzy min operator approach to develop a compromise solution for the multi-objective problem. Ringuest and Rinks (1987) proposed two interactive algorithms for generating all non-dominated solutions and identified minimum cost solution as a best compromise solution. Gen et al., (1998) solved a bi-criteria transportation problem using hybrid genetic algorithm adopting spanning tree based prufer number to generate all possible basic solutions. Waiel. (2001) developed all non-dominated solutions and defined family of distance function to arrive a compromise solution.

The existing procedures in the literature (see Deb, 2003; Rao, 2003) for solving multi-objective transportation problems can be divided into two categories. First category of those are generating all the sets of efficient solutions (see Ringuest and Rinks, 1987; Gen et al., 1997) and the second category represents the procedure of using an additional criterion to obtain the best compromise solution among the set of efficient solutions (see Rakesh Varma & Biswas, 1997; Gen et al., 1998; Bit et al., 1992; and Sy-Ming Gun & Yan - Kuen Wu, 1999) developed various functions to achieve direct compromise solution without developing and testing all the Pareto solutions.

Although several researchers have been proposed various advances in transportation problems (see Bit et al.,1993; Sinha et al., 2000; Hulsurkar et al.,1997; Pramanik & Roy, 2008; Lau et al.,2009), there are only few researchers (Ringuest & Rinks, 1987; Waiel, 2001; Mouli et al.,2005) have developed methodologies for solving multi criteria transportation problems.

In this paper, authors propose membership functions and goal deviation functions from Pareto solutions for each objective, and these functions are added as constraints. By introducing a max-min operator λ an auxiliary variable, then the equivalent fuzzy interactive goal programming problem is formulated to maximize λ and the solution is obtained by using LINGO software. The remaining of the paper is organized as follows: in section 2 we give a mathematical model of the multi-objective transportation problem (MOTP) and formulation with fuzzy max-min operator and goal deviations. Section 3

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represents proposed methodology; while in section 4 two numerical examples are solved. Finally, in section 5 and 6 we discuss on the results and conclusions.

II. Mathematical Model

In a typical transportation problem, a homogenous product is to be transported from several origins (or sources) to numerous destinations in such way that the total transportation cost is minimum. Suppose there are *"m"* origins (i=1,2,……,m) and *"n"* destinations (j=1,2,……,n). The sources may be production facilities, warehouses etc and they are characterized by available supplies a_1, a_2,…,a_m. The destinations may be warehouses and sales outlets etc, and they are characterized by demand levels b_1, b_2,….,b_n. A penalty c_{ij} is associated with transporting a unit of product from origin i to destination j. The penalty could represent transportation cost, delivery time, distance, quality of goods delivered under used capacity or many other criteria. A variable x_{ij} is used to represent the unknown quantity to be transported from origin O_i to destination D_j. In the real life, however all transportation problems are not single objective. The transportation problems, which are characterized by multiple objective functions, are considered in this paper. The decision maker would like to minimize the set of K objectives simultaneously; a point will likely be reached where a further reduction of the value of any single objective function may only be obtained at the expense of increasing the value of at least one other objective function. Thus, in general, the objectives will also be conflicting. The mathematical model of the multi-objective transportation problem is written as follows:

$$\text{Min } F^k(X) = \sum_{i=1}^{m} \sum_{j=1}^{n} C^k{}_{ij}\, X_{ij} \qquad (2.1)$$

subject to the

$$\sum_{j=1}^{n} x_{ij} \le a_i \,, i = 1,2,\ldots\ldots\ldots\ldots, m, \qquad (2.2)$$

$$\sum_{i=1}^{m} x_{ij} = b_j \,, j = 1,2,\ldots\ldots\ldots\ldots, n, \qquad (2.3)$$

$$x_{ij} \ge 0, \text{ for all i and j} \qquad (2.4)$$

Where, $F^k(X) = \{F^1(X), F^2(X), \ldots\ldots\ldots\ldots, F^k(X)\}$ is a vector of K objective functions and superscript on both $F^k(X)$ and C^k_{ij} are used to identify the number of objective functions (k=1,2,….,K) without loss of generality it will be assumed in the whole paper that $a_i \ge 0$ and $b_j \ge 0$ for all i and j and $\sum_i a_i = \sum_j b_j$, $c_{ij} > 0$ for all i and j.

a) *Problem Formulation Using Fuzzy Max-Min Operator*

Fuzzy set theory appears to be an ideal approach to deal with decision problems that are formulated as linear programming models with imprecision parameters. Two face fuzzy linear programming models are designated by Sy-Ming Gun & Yan-Kuen Wu (1999) for such problems. In the literature fuzzy linear programming has been classified into different categories, depending on how imprecise parameters are modeled by possibility distributions or subjective preference based membership functions. In this paper the net relative deviation is considered as fuzzy variable and converted into deterministic form using Zadeh's max-min operator as per Zimmermann (1985). We define a linear membership function by considering suitable upper and lower bounds to the objective function as given below.

$\mu[F^k(X)] = 1$, if $F^k(X) \ge U_k$

$$\mu\left[F^k(X)\right] = \begin{cases} \dfrac{U_k - F^k(X)}{U_k - L_k} & \text{,if } Lk < Fk\ (X) < Uk \\ \end{cases} \qquad (2.5)$$

$\mu[F^k(X)] = 0$ otherwise

By introducing a max-min operator λ an auxiliary variable, then, the equivalent fuzzy linear programming problem is as follows.

[X*] = Maximize λ (0≤ λ ≤ 1) where λ ≤ minimum μk [Fk(X)], k=1,2,……,K

subject to the

constraints (2.2) ….(2.4)

where, μk [Fk(X)] is membership of the kth objective function and Lk,Uk are its lower and upper bound solutions.

b) Goal Deviations

The goals for each objective are considered for each objective functions namely under achievement and over achievement goals. Initially, the upper and lower bounds for each objective functions are estimated and then the goals are included as by adding the under achievement and removing the over achievement for each objective on the left hand side of the objectives as variables. After setting goals, an overall fuzzy operator λ has been introduced to identify the minimum value for each function and maximizing it subject to the constraints as per Zimmermann (1985).

III. Proposed Method

For solving MOTP, the proposed method is summarized in the following steps

Step 1: (Initial solution/ideal feasible solution): Solve the MOTP as a single objective transportation problem K times by taking one of the objectives at a time subject to the constraints (2.2) - (2.4).

Step 2. (Pareto solutions): Find the Pareto solutions from the initial solutions and determine upper and lower bounds for each objective.

Step 3 (Membership function): Based on the interaction approach by Waiel (2001) between lower bound and upper bounds L_k and U_k of the K^{th} objective function, membership functions are estimated for all the objective functions $[F^k(X)]$, (k=1,2,…,K) as follows

$$\mu[F^k(X)] = 1, \text{ if } F^k(X) \geq U_k$$

$$\mu\left[F^k(X)\right] = \frac{U_k - F^k(X)}{U_k - L_k}, \text{ if } L_k < F^k(X) < U_k \quad (2.5)$$

$$\mu[F^k(X)] = 0 \text{ otherwise}$$

Step 4. Developing a goal deviation function by setting goals (over achievement and under achievement) for each objective based on the upper bounds (U_k) and lower bounds (L_k) add these goal deviation functions as constraints.

Step 5. By introducing a max-min operator λ an auxiliary variable, then the equivalent fuzzy linear goal programming problem is as follows.

$[X^*]$ = Maximize λ $(0 \leq \lambda \leq 1)$

where $\lambda \leq$ Minimum μ_k $[F^k(X)]$, k = 1,2……..,K.

subject to the constraints (2.2) - (2.4).

Here, $[F^k(X)]$ is membership of the k^{th} objective function and L_k and U_k are the lower and upper bounds for each objective function $F^k(X)$ (k=1,2,……,K).

IV. Illustrative Examples

To illustrate the proposed method, consider the following two examples of MOTP taken from Ringuest and Rinks (1987).

Example 1: The problem has the following characteristics. Supplies: $a_1 = 5$, $a_2 = 4$, $a_3 = 2$, and $a_4 = 9$ Demands: $b_1 = 4$, $b_2 = 4$, $b_3 = 6$, $b_4 = 2$, and $b_5 = 4$.

$$C^1=\begin{bmatrix} 9 & 12 & 9 & 6 & 9 \\ 7 & 3 & 7 & 7 & 5 \\ 6 & 5 & 9 & 11 & 3 \\ 6 & 8 & 11 & 2 & 2 \end{bmatrix} \quad C^2=\begin{bmatrix} 2 & 9 & 8 & 1 & 4 \\ 1 & 9 & 9 & 5 & 2 \\ 8 & 1 & 8 & 4 & 5 \\ 2 & 8 & 6 & 9 & 8 \end{bmatrix} \quad C^3=\begin{bmatrix} 2 & 4 & 6 & 3 & 6 \\ 4 & 8 & 4 & 9 & 2 \\ 5 & 3 & 5 & 3 & 6 \\ 6 & 9 & 6 & 3 & 1 \end{bmatrix}$$

(1) As the first step the feasible ideal solution obtained by solving of each objective function

$$\text{Min } F^k(X) = \sum_{i=1}^{m} \sum_{j=1}^{n} C^k{}_{ij} X_{ij} \quad (2.1)$$

subject to supply constraints according to (2.2)

$$\sum_{j=1}^{5} x_{1j} \leq 5, \sum_{j=1}^{5} x_{2j} \leq 4, \sum_{j=1}^{5} x_{3j} \leq 2, \text{and} \sum_{j=1}^{5} x_{4j} \leq 9 \quad (2.2)$$

demand constraints

$$\sum_{i=1}^{4} x_{i1} = 4, \sum_{i=1}^{4} x_{i2} = 4, \sum_{i=1}^{4} x_{i3} = 6, \sum_{i=1}^{4} x_{i4} = 2, \text{and} \sum_{i=1}^{4} x_{i5} = 4 \quad (2.3)$$

and $x_{ij} > 0$ for all i and j (2.4)

$[X^{1*}]$ = [0,0,5,0,0, 0,3,1,0,0, 1,1,0,0,0, 3,0,0,2,4]

$[X^{2*}]$ = [3,0,0,2,0, 1,0,0,0,4, 0,2,0,0,0, 1,2,6,0,0]

$[X^{3*}]$ = [3,2,0,0,0, 1,0,3,0,0, 0,2,0,0,0, 0,0,3,2,4]

$F^1[X^{1*}] = 102$ $F^2[X^{2*}] = 73$ and $F^3[X^{3*}] = 64$

(2) Determine k objective functions (k Pareto solutions, where k=1,2, ….,K). Identify the its lower and upper bounds as L_k and U_k.F_1 $[X^1] = 102$, $F_1[X^2] = 164$, and $F_1[X^3] = 134$; hence, lower limit L_1=102 and upper limit U_1=164.

F_2 $[X^1] = 141$, $F_2[X^2] = 73$ and $F_2[X^3] = 122$; hence, L_2=73 and U_2=141.

F_3 $[X^1] = 94$, $F_3[X^2] = 90$ and $F_3[X^3] = 64$; hence, L_3=64 and U_3=94.

(3) The membership function of $F_1(X)$, $F_2(X)$ and $F_3(X)$ are determined as follows

$$\mu_1\left[F^1(X)\right] = \frac{164 - F^1(X)}{164 - 102}$$

$$\mu_2\left[F^2(X)\right] = \frac{141 - F^2(X)}{141 - 73}$$

$$\mu_3\left[F^3(X)\right] = \frac{94 - F^3(X)}{94 - 64}$$

(4) The goal deviation functions of $F_1(X)$, $F_2(X)$ and $F_3(X)$ are determined as follows.

$F^1(X) + d_1^+ - d_2^- \leq 164$

$F^2(X) + d_3^+ - d_4^- \leq 141$

$F^3(X) + d_5^+ - d_6^- \leq 94$

where, d_1^+, d_3^+, d_5^+ are over achievements and d_2^-, d_4^-, d_6^- are under achievements of each objective functions $F^1(X)$, $F^2(X)$ and $F^3(X)$ respectively.

Hence, the problem is written as follows: Maximize λ (x_{27}) subject to

$x_1 + x_2 + x_3 + x_4 + x_5 = 5$

$x_6 + x_7 + x_8 + x_9 + x_{10} = 4$

$x_{11} + x_{12} + x_{13} + x_{14} + x_{15} = 2$

$x_{16} + x_{17} + x_{18} + x_{19} + x_{20} = 9$

$x_1 + x_6 + x_{11} + x_{16} = 4$

$x_2 + x_7 + x_{12} + x_{17} = 4$

$x_3 + x_8 + x_{13} + x_{18} = 6$

$x_4 + x_9 + x_{14} + x_{19} = 2$

$x_5 + x_{10} + x_{15} + x_{20} = 4$

$9x_1 + 12x_2 + 9x_3 + 6x_4 + 9x_5 + 7x_6 + 3x_7 + 7x_8 + 7x_9 + 5x_{10} + 6x_{11} + 5x_{12} + 9x_{13} + 11x_{14} + 3x_{15} + 6x_{16} + 8x_{17} + 11x_{18} + 2x_{19} + 2x_{20} + x_{21} - x_{22} \leq 164$

$2x_1 + 9x_2 + 8x_3 + x_4 + 4x_5 + x_6 + 9x_7 + 9x_8 + 5x_9 + 2x_{10} + 8x_{11} + x_{12} +$
$8x_{13} + 4x_{14} + 5x_{15} + 2x_{16} + 8x_{17} + 6x_{18} + 9x_{19} + 8x_{20} + x_{23} - x_{24} \leq 141$
$2x_1 + 4x_2 + 6x_3 + 3x_4 + 6x_5 + 4x_6 + 8x_7 + 4x_8 + 9x_9 + 2x_{10} + 5x_{11} + 3x_{12} +$
$5x_{13} + 3x_{14} + 6x_{15} + 6x_{16} + 9x_{17} + 6x_{18} + 3x_{19} + x_{20} + x_{25} - x_{26} \leq 94$

Simplifying the above three constraints,

$0.055x_1 + 0.073x_2 + 0.055x_3 + 0.037x_4 + 0.055x_5 + 0.043x_6 + 0.018x_7 + 0.043x_8 +$
$0.043x_9 + 0.030x_{10} + 0.037x_{11} + 0.030x_{12} + 0.055x_{13} + 0.067x_{14} + 0.018x_{15} + 0.037x_{16}$
$+ 0.049x_{17} + 0.067x_{18} + 0.012x_{19} + 0.012x_{20} + 0.378x_{27} \leq 1$
$0.014x_1 + 0.064x_2 + 0.057x_3 + 0.007x_4 + 0.028x_5 + 0.007x_6 + 0.064x_7 + 0.064x_8 + 0.035x_9$
$+ 0.014x_{10} + 0.057x_{11} + 0.007x_{12} + 0.057x_{13} + 0.028x_{14} + 0.035x_{15} + 0.014x_{16} +$
$0.057x_{17} + 0.043x_{18} + 0.064x_{19} + 0.057x_{20} + 0.482x_{27} \leq 1$
$0.021x_1 + 0.042x_2 + 0.064x_3 + 0.032x_4 + 0.064x_5 + 0.042x_6 + 0.085x_7 + 0.042x_8 + 0.096x_9$
$+ 0.021x_{10} + 0.053x_{11} + 0.032x_{12} + 0.053x_{13} + 0.032x_{14} + 0.064x_{15} + 0.064x_{16} +$
$0.096x_{17} + 0.064x_{18} + 0.032x_{19} + 0.011x_{20} + 0.319x_{27} \leq 1$

where all $x_i \geq 0$ and integers (i=1,2,……,26) and $x_{27} \leq 1$

The solution obtained as
$[X^*] = [3,0,0,2,0,0,2,2,0,0,0,2,0,0,0,1,0,4,0,4]$ and $\lambda = 0.54$
The corresponding objective functions values are
$F^1[X^*] = 127$, $F^2[X^*] = 104$ and $F^3[X^*] = 76$

Example 2: Let us solve another MOTP having the following characteristics Suppliers: $a_1=8$, $a_2=19$, and $a_3=17$ Demands: $b_1=11$, $b_2=3$, $b_3=14$, and $b_4=16$

$$C^1 = \begin{bmatrix} 1 & 2 & 7 & 7 \\ 1 & 9 & 3 & 4 \\ 8 & 9 & 4 & 6 \end{bmatrix} \quad C^2 = \begin{bmatrix} 4 & 4 & 3 & 4 \\ 5 & 8 & 9 & 10 \\ 6 & 2 & 5 & 1 \end{bmatrix}$$

1) As the first step the ideal solutions obtained by solving of each objective function is
$F^1(X^{1*}) = 143$ and $F^2(X^{2*}) = 167$

2) Determination of Pareto solutions For each objective function the corresponding Parato solutions at each feasible ideal solution and lower and upper bounds are obtained as follows:

$F^1(X^1) = 143$ and $F^1(X^2) = 208$ hence, lower limit $L_1=143$ and upper limit $U_1=208$

$F^2(X^1) = 265$ and $F^2(X^2) = 167$ hence, lower limit $L_2=167$ and upper limit $U_2=265$

3) The membership functions of $F^1(X)$ and $F^2(X)$ are determined as follows:

$$\mu_1[F^1(X)] = \frac{208 - F^1(X)}{208 - 143}$$

$$\mu_2[F^2(X)] = \frac{265 - F^2(X)}{265 - 167}$$

4) The goal deviation functions of $F^1(X)$ and $F^2(X)$ are
$F^1(X) + d_1^+ - d_2^- \leq 208$
$F^2(X) + d_3^+ - d_4^- \leq 265$
Here, d_1^+ and d_3^+ are over achievements and d_2^- and d_4^- are under achievements of each function of $F^1(X)$ and $F^2(X)$ respectively.

Hence, the problem is written as follows
Maximize λ (x_{17})
subject to

$x_1 + x_2 + x_3 + x_4 = 8$
$x_5 + x_6 + x_7 + x_8 = 19$
$x_9 + x_{10} + x_{11} + x_{12} = 17$
$x_1 + x_5 + x_9 = 11$
$x_2 + x_6 + x_{10} = 3$
$x_3 + x_7 + x_{11} = 14$
$x_4 + x_8 + x_{12} = 16$

$x_1 + 2x_2 + 7x_3 + 7x_4 + x_5 + 9x_6 + 3x_7 + 4x_8 + 8x_9 + 9x_{10} + 4x_{11} + 6x_{12} + x_{13} - x_{14} \leq 208$

$4x_1 + 4x_2 + 3x_3 + 4x_4 + 5x_5 + 8x_6 + 9x_7 + 10x_8 + 6x_9 + 2x_{10} + 5x_{11} + x_{12}$
$+ x_{15} - x_{16} \leq 265$

Simplifying the above two constraints,
$0.48x_1 + 0.96x_2 + 3.37x_3 + 3.37x_4 + 0.48x_5 + 4.33x_6 + 1.44x_7 + 1.92x_8 + 3.85x_9 +$
$4.33x_{10} + 1.92x_{11} + 2.88x_{12} + 31.25x_{17} \leq 100$
$1.51x_1 + 1.51x_2 + 1.132x_3 + 1.509x_4 + 1.887x_5 + 3.018x_6 + 3.396x_7 + 3.77x_8 +$
$2.26x_9 + 0.75x_{10} + 1.886x_{11} + 0.377x_{12} + 36.98x_{17} \leq 100$

where, all $x_i \geq 0$ and integers (i=1,2,……..,16) and $x_{17} \leq 1$
The solution obtained as
$[X^*] = [4,3,1,0,7,0,12,0,0,0,1,16]$ and $\lambda = 0.71$
The corresponding objective functions values are $F^1(X^*) = 160$ and $F^2(X^*) = 195$.

The results of the above two examples are summarized and shown below in Table 1 and Table 2 respectively.

Table 1: Comparison of Results

Ideal solution	Proposed Method	Net Deviation Approach Mouli et al., (2005)	Interactive Approach Ringuest and Rinks (1987)	Fuzzy Approach Waiel (2001)
$F^1[X]$ 102	127	127	127	122
$F^2[X]$ 73	104	104	104	106
$F^3[X]$ 64	76	76	76	80
$\sum F[X]$	307	307	307	308
λ	0.54	0.67		

Table 2: Comparison of Results

Ideal solution	Proposed Method	Net Deviation Approach Mouli et al., (2005)	Interactive Approach Ringuest and Rinks (1987)	Fuzzy Approach Waiel (2001)
$F^1[X]$ 143	160	186	186	170
$F^2[X]$ 167	195	171	174	190
$\sum F[X]$	355	357	360	360
λ	0.71	0.7		

V. Results and Discussion

The work reported here for solving MOTP, results a compromise solution in five steps. Initially, a feasible ideal solution is obtained for each objective function, using these feasible solutions, upper and lower bounds values are identified for each objective function. From the upper and lower bounds, membership functions are estimated. Goal deviations are included for each membership functions by introducing under achievement and over achievement variables. By introducing a max-min operator λ an auxiliary variable, then an equivalent fuzzy linear goal programming is formulated and the solution obtained using LINGO software. The feasible ideal solutions obtained for the proposed method is exactly similar to the exiting methods in the literature (see Ringuest & Rinks, 1987; Waiel, 2001; Mouli et al., 2005), and the solutions obtained are compared with those in the literature.

For the example 1, the solution obtained using the proposed method as $\Sigma F(X^*) = 307$ (127,104 and 76) with overall satisfaction level of 0.54. This shows (Table 1), proposed method results exactly similar to the solutions obtained with interactive approach proposed by Ringuest and Rinks (1987), and net deviation approach proposed by Mouli et al., (2005) and better solution than the fuzzy approach proposed by Waiel (2001). For the numerical example 2, the solution for the proposed method obtained as $\Sigma F(X^*) = 355$ (160 and 195) with overall satisfaction level of 0.71. This indicates the solution obtained is much more superior to the existing interactive, net deviation and fuzzy approaches. Also, the fuzzy approach results $\Sigma F(X^*) = 360$ (170 and 190) with 7 number of allocations. The proposed approach generates the same number of allocations with much improved value at $\Sigma F(X^*) = 355$ (160 and 195).

VI. Conclusion

A common problem encountered in solving multi-objective optimization problems is that the decision maker has to identify a problem dependent compromise function among a large number of non-dominated solutions. For the past 20 years, although many researchers have investigated compromise functions, there is still no compromise function among them is generating an optimal solution for all types of problems. In the absence of exact method for solving multi-objective transportation problems a reasonable method has some value. In this paper, a fuzzy goal deviation criterion is developed to determine compromise solution. The effectiveness of the proposed method is tested with fuzzy max-min operator and solved using LINGO software. Two numerical examples are presented and obtained results are compared with those reported in the literature. The results shows a great promise in developing an efficient solution for solving multi-objective optimization problems and this can be extended for all engineering applications in future to achieve global solution.

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Global Journal of Research in Engineering
Volume 11 Issue 3 Version 1.0 April 2011
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
ISSN: 0975-5861

Protective Treatment of Aluminum and its Alloys

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Introduction- Aluminium is a very reactive metal with a high affinity for oxygen. Nevertheless, the metal behaves as resistant to corrosion under most environmental conditions due to inert and protective character of the aluminium oxide film which forms naturally on the metal surface. Thus in most environments, the rate of corrosion of aluminium decreases rapidly with time. These properties exhibited by aluminium are also present in the alloys of aluminium; though the protection given will depend upon the type of alloy and its condition.

1.2 There are however a number of conditions, commonly encountered, under which aluminium gets extensively corroded. The corrosion takes place either through the pores in the oxide film or in the areas from which the oxide film has been removed due to abrasion under normal environmental conditions. Also under certain circumstances, the protective film does not form at all leading to high rate of corrosion.

Classification: *GJRE-C Classification: FOR Code: 090403*

Strictly as per the compliance and regulations of:

Protective Treatment of Aluminum and its Alloys

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I. Introduction

Aluminium is a very reactive metal with a high affinity for oxygen. Nevertheless, the metal behaves as resistant to corrosion under most environmental conditions due to inert and protective character of the aluminium oxide film which forms naturally on the metal surface. Thus in most environments, the rate of corrosion of aluminium decreases rapidly with time. These properties exhibited by aluminium are also present in the alloys of aluminium; though the protection given will depend upon the type of alloy and its condition.

1.2 There are however a number of conditions, commonly encountered, under which aluminium gets extensively corroded. The corrosion takes place either through the pores in the oxide film or in the areas from which the oxide film has been removed due to abrasion under normal environmental conditions. Also under certain circumstances, the protective film does not form at all leading to high rate of corrosion.

The type of corrosion observed on aluminium alloys are as follows:

a) *General Dissolution:* This occurs in strongly acidic or strongly alkaline solutions though there are specific exceptions. Certain inorganic salts (for example, aluminum ferric and zinc chlorides) hydrolyse in solution to give acidic or alkaline reaction and thus cause general dissolution. Lower alcohols and phenols in anhydrous condition do not allow protective layer to form and cause corrosion. Wet freons slightly attack aluminium. Also at temperatures above 90°C, the metal is uniformly attacked by aqueous systems.

b) *Pitting:* This is most commonly encountered form of aluminum corrosion. In certain, near neutral aqueous solutions, a pit once initiated will continue to propagate owing to the solution within the pit becoming acidic and the alumina not able to form a protective film close to the metal. Solutions containing the chlorides are very harmful in this respect particularly when they are associated with local galvanic cells, which can be formed for example by deposition of copper from solution or by particles such as iron unintentionally embedded in the metal surface. As little as 0.02 parts per million of copper in hard water could initiate pitting, although more is required for soft water. Aluminium is corroded by sea water. In alkaline media, pitting may occur at mechanical defects in the oxide. The aluminium alloys weather out-doors to grey colour which deepens to black in industrial atmospheres.

c) *Intercrystalline Corrosion:* This is also electrothermal in nature, the galvanic cell being formed because of some heterogeneity in the alloy structure which may arise from certain alloying elements present.

d) *Stress Corrosion :* This form of corrosion is of limited occurrence with only aluminum alloys, in particular the higher strength materials such as the Al-Zn-Mg-Cu type and some of the Al-Mg wrought and cast alloys with higher magnesium content. The occurrence of stress corrosion increases in these alloys after specific low temperature heat treatments such as stove enamelling.

e) *Bimetallic Corrosion:* Aluminium is anodic to many metals and when it is joined to them with a suitable electrolyte, the potential difference causes a current to flow and considerable corrosion can result. In some cases surface moisture on structures exposed to an aggressive atmosphere can give rise to galvanic corrosion. In practice, copper, brasses and bronzes in marine conditions cause most trouble. The danger from copper and its alloys is enhanced by the slight solubility of copper in many solutions and its subsequent redepositions on the aluminium to set up local active cells. Contact with steel is comparatively less harmful. Stainless steels may increase attack on aluminum notably in sea water or marine atmospheres but the high electrical resistance of the two surface oxide films minimize bimetallic effects in less aggressive environments. With salts or heavy metals notably copper ,silver and gold, the heavy metal deposits on to the aluminum subsequently causes serious bimetallic corrosion.

1.3 Corrosion resistance of aluminum alloys could be improved by cladding these alloys with pure aluminum. In addition to the above, a number of chemical and electrochemical processes are available namely anodizing and chromate treatment, which improve corrosion resistance.

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1.4 In addition to the problem of corrosion, aluminum fairs poorly under conditions of wear and abrasion due to its low hardness. It is, therefore not extensively used under these conditions. However hardness could be dramatically improved by "Hard Anodizing" and certain other electroplating processes.

1.5 These processes are widely used in aircraft industries for improvement in corrosion and wear resistance properties of aluminium and its alloys. The following paragraphs highlight the properties of protective films formed by various protective treatment processes and give the uses and limitations of these processes. Though the help has been taken from various references mentioned in para7, the conclusions have been drawn based upon the actual experience of the author in the industry.

II. Anodising

a) General

2.1.1 Anodising of aluminum and aluminium alloys is carried out by chromic and sulphuric acid processes as per Def 151 type II and I or IS 7088-73. These processes produce relatively thick, continuous and adherent oxide film as compared to the naturally formed oxide film, thereby providing increased corrosion protection. It also promotes adhesion of organic protective coatings.

2.1.2 The film produced by anodising largely consists of alumina (Al_2O_3) and a small amount of water. This type of anodic coating is porous as it leaves the bath and is easily stained; but sealing in hot/gently boiling water partially converts the alumina to aluminum monohydrate khown as "Bohemite", which renders the coatings impermeable and non absorptive without any visible change. Thus maximum corrosion protection is provided by sealing the pores of the surface. If the coating is to be coloured for appearance purposes; dyeing precedes sealing because the anhydrous form of coating links more readily with dyes than the monohydrate form. This makes the dyestuff to be effectively held in the film. Such film after sealing cannot be stained by finger marking or leached out.

2.1.3 The type of anodizing is selected depending upon the functional requirements and composition of the alloys to be anodized. In general in aircraft industry, chromic acid anodizing is preferred on all aluminium alloys except for some casting alloys, or parts which have to remain in contact with H_2O_2 after anodizing and also where dyeing of film is required for decorative /identification purposes. The above exceptions must be anodized in sulphuric acid bath. A detailed account of the selection of specific coating is given in para 2.3 below.

b) Properties

2.2.1 Thickness of films: The chromic acid process provides a film of 1 to 6μ depending upon alloy, while the sulphuric acid process builds up anodic film from 7 to 13μ. However it may be noted that the dimension of the component increases during anodizing. The thickness of the surface is 50% below the original surface and 50% above it.

2.2.2 Corrosion and Abrasion Resistance: Both types of anodic films are harder than the base metal . In general, the anodic film produced by chromic acid process is softer than the film produced by sulphuric acid process. However as the coatings are thin, the improvement in abrasion resistance is marginal.

2.2.3 Heat Resistance : Both types of anodic films are resistant up to melting point of base metal. A slight crazing occurs at high temperatures due to difference in rates of expansion of the coating and underlying metal, but this does not appreciably affect the protective properties of the film.

2.2.4 Electrical Insulation: Both types of anodic films provide electrical insulation. The electrical breakdown voltage of anodic film produced by chromic acid process is a minimum of 50V while that produced by sulphuric acid process is a minimum of 200V. Increase in temperature up to 400^{o}C has little effect on this breakdown voltage.

2.2.5 Fatigue : The anodizing referred in this section has little effect on fatigue properties except at holes where a reduction may be caused. Out of the two, the chromic acid process results in lesser reduction in fatigue strength.

2.2.6 Dyeing of anodic films : Film thickness of chromic acid anodic films is of the order of 1 to 6 μ and thus , dye stuff penetration is small, yielding surface of poor color fastness. The clear colors are obtained on sulphuric acid films. The relatively thick films 7 to 13 μ permit sufficient dye absorption to ensure good fastness properties. This process is always recommended for color anodizing and gives most permanent range of colors.

c) Application

2.3.1The chromic acid process is the preferred process for all generally used wrought aluminum and its alloys (bars, forgings, sheets and tubes) and for castings of suitable compositions with the following exceptions:

(a) Casting alloys containing more than 5% copper or more than 7.5% of total nominal alloying elements.
(b) Parts which have to remain in contact with hydrogen peroxide after anodizing.
(c) Where dyeing of film is required.

These alloys are to be anodized by sulphuric acid process. For castings chromic

acid process is preferred because of innocuous nature of electrolyte which could get entrapped in pores of castings. However sulphuric acid process covers wider range of castings. In borderline cases a modified chromic acid process is preferred for castings as per DEF 151, which differs with the standard process only in

temperature and voltage conditions.

2.3.2 For anodising , surface of castings is to be free of blow holes , porosity etc to the extent possible. Gravity die casting or pressure die casting gives good results. Sand castings are least suitable for anodizing. Improved results on castings can be obtained by soaking castings in boiling water after cleaning and before anodizing. This treatment attempts to fill surface voids with water so that voids do not entrap anodizing solution.

2.3.3 Generally anodising of assemblies is to be avoided. In case it is absolutely necessary, the riveted and welded assemblies may be anodized by chromic acid process as the entrapped electrolyte is innocuous in nature.

2.3.4 If interference is required for assemblies accompanied byforce fitting, films produced from chromic acid process are too thin ,too soft and too brittle to overcome abrasion resistance.The coatings may crack or spall due force fitting.

2.3.5 Anodising is not carried out after hard anodizing or plating as the hard anodized surface/plated surface would dissolve by anodic treatment.

2.3.6 Parts produced by chromic acid process are sealed in water at 55-60^{o}C if final coat of paint is required and at 100 ^{o}C if no further treatment is required. Sealing at 100 ^{o}C renders the anodic coating impermeable and non-absorptive.

2.3.7 Films formed by sulphuric acid process are sealed in boiling solution of 5% potassium dichromate. Alternatively, it can be sealed in boiling water or dyed red, green, yellow or black followed by sealin in boiling water. The dichromate sealing, which imparts a yellow colour is used when specially high resistance to corrosion is desired and appearance is less important. The dichromate solution tends to render the effect of residual sulphuric acid less harmful and is therefore less harmful and is therefore helpful. Alloys other than casting alloys which are given sulphuric acid anodizing may be dyed and then sealed in boiling water.

Anodizing is not suitable for composite parts embodying other materials (e.g.steel). It is also not suitable for very thin sheets. In case of blind and threaded holes, film may not form at all in certain areas. Under these conditions chromate treatment is applied. Chromate treatment is also used for the repair of locally damaged anodic films.

III. Chromate Treatment

3.1 General : chromate treatment of aluminium and its alloys is an immersion process and is generally carried out by using salt Alocrom1200/Aledyne 1200. The treatment produces a conversion coat on aluminium and its alloys. The film imparts some resistance to corrosion and offers good paint adhesion. As such it could be widely used on surfaces which are to be painted subsequently. The conductivity for radio frequencies is extremely high resulting in its use for electrical shields and wave guides.

3.2 Properties : The corrosion resistance offered by film usually varies inversely with iron and copper content. The resistance to abrasion and corrosion is much inferior to that provided by anodizing. Temperatures above 150^{o}C on chromate surfaces not protected by organic finishes reduces the corrosion resistance of chromate film. This treatment does not normally impair electrical conductivity and cause negligible dimensional changes.

3.3 Application : Aircraft panels and skin are generally chromate treated before painting. In aircraft accessories field, except on internal where adequate corrosion protection is provided by oil/grease or where it is used in localized application for electrical bonding/repair of damaged films, the process is followed by the application of paint scheme. The treatment is not used for surfaces where rubbing occurs. This treatment is not suitable for , where there are chances for process solution to remain entrapped.

IV. Hard Anodising

a) General

4.1.1 Hard anodizing of aluminium and its alloys is carried out as per DEF 151 type III or IS7088-73. The hard anodic coatings are intended to provide wear and abrasion resistance surfaces with improved corrosion resistance. These coatings are used in such applications as valves,sliding parts,hinge mechanisms,cams,lightly loaded gears, wivel joints, pistons, rockets nozzles,insulation plates, blast shield etc. it is not recommended where rubbing speeds are high or bearings are highly loaded.

4.1.2 This process is also used as a salvage scheme for the building up of undersized/worn out machined surfaces. Hard anodic coatings have good insulation resistance and are used on aluminium formers of solenoid coils. These coatings form an excellent base for most types of paint schemes,adhesives and dry lubricants.

b) Properties

4.2.1 Corrosion resistance : The corrosion resistance of hard anodic films is better than the normal chromic and sulphuric acid anodized coatings ue to its greater thickness.

4.2.2 Hardness : The hardness of hard anodized film is of the order of 500VPN. The top surface of the hard anodized coating is softer than the down surface in the core of the coating towards the base metal. Such coatings may be processed oversize and then lapped or honed down to the final desired dimension . General recommended lapping allowance is 0.012 mm.

4.2.3 Electrical insulation : The hard anodic film provides excellent insulation. The breakdown voltage of 0.05mm thick coating is of the order of 1000V.

4.2.4 Surface Finish: The treated surface finish is inferior to the original machined finish and becomes rougher as the film thickness increases. In case surface finish is important , it is necessary to process such coatings oversized and then lapped ,honed and polished down to final desired dimensions or else ,the finish of part prior to hard anodizing shall be of very high quality.

4.2.5 Fatigue: Fatigue strength may be reduced to 50% by hard anodizing which restricts its use in regions of high dynamic stress. The reduction in fatigue strength can be alleviated by sealing in sodium dichromate at the expense of some softening and loss of abrasion resistance. Hard anodised coatings shall not be sealed if the main function is abrasion or wear.

4.2.6 Growth: Hard anodizing results in dimensional increase of the component. The dimensional increase is approximately equal to one half of total thickness of the coating. Suitable allowance is to be given on the surface to allow the growth of dimensions.

c) Application

4.3.1 Effect of alloying elements: Hard anodizing is generally carried out on alloys having less than 3 % copper and less than 7% silicon. However it is possible to hard anodize alloys having copper content up to 5% though the surface finish would be rougher and abrasion resistance poorer.

4.3.2 Castings : In general hard anodizing of castings is to be avoided. Casings can be anodized provided their composition is within the limits defined above. Porous castings may not be hard anodized as they are likely to entrap electrolyte. Improved results can often be obtained by soaking castings in boiling water after cleaning and before anodizing.

4.3.3 Thickness of coatings : for applications using a hard surface, thickness of 0.025 to 0.075 mm is satisfactory. For purpose of salvage build up etc, hard anodic coating may vary in thickness from 0.013 mm to more than 0.1 mm. However deposits tend to be flaky if the thickness of anodic film s is greater than 0.1 mm. all anodic coatings affect thread dimensions for external and internal threads; the major and minor diameters increases by two times the amount of growth. The pitch diameter for threads having an included angle of 60^{o} increases four times the amount of growth.

4.3.4 Fabrication : Successful use of hard anodic coating depends on proper proper product design. Because of the manner of formation , anodic coatings will develop voids at sharp corner and edges. Chamfering is not used unless sharp edges are radiused. The minimum permissible radius is 0.25 mm but a minimum of 0.75 mm is recommended whenever possible. The coating is allowed to enter holes to a depth of up to 2.5 mm. If force fitting is required for assembly, this may be accompanied by grinding, lapping or otherwise removing the surplus coating. Coatings are brittle and may crack and spall due to force fitting.

4.3.5 Painting : Only external surfaces of the equipment are painted. Prior to painting , wiping , buffing and other mechanical operations on anodized or sealed surface are minimized. This damages the relatively good outside layer of the anodic coating and make paint coat susceptible to subsequent paint adhesion failure.

V. Other Plating Processes

Aluminium and its alloys hard chromium plated or given a electroless nickel treatment for providing greater wear and abrasion resistances. However the difference in electrical potential between these metals and aluminum makes it essential to consider the service environment from the point of view of possible electrolyte corrosion either at the edges of deposit or in the regions of any damage or porosity.

VI. Conclusion

6.1 Pitting and galvanic corrosion are the most commonly encountered form of corrosion in aluminium and its alloys. The corrosion resistance could be improved by artificially creating thick adherent aluminum oxide film on the surfaces by electrochemical process known as anodizing. It could be further improved if the pores in these films are sealed by hot water or hot dichromate solution.

6.2 A dip process is also available to improve the corrosion resistance, though to a lesser extent as compared to anodized films. In this process a passive chromate film is formed on the surface.

6.3 Aluminum and its alloys have poor hardness and are not suitable for wear and abrasion resistance conditions in untreated form. These properties are improved by hard anodizing and other plating processes which provides a hard and wear resisting surface that could withstand most of the wear and abrasive conditions

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Global Journal of Research in Engineering
Volume 11 Issue 3 Version 1.0 April 2011
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
ISSN: 0975-5861

Highly Secure and Reliable User Identification Based on Finger Vein Patterns

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Abstract- With the evolution of consumer electronics technologies, personal information in consumer devices is becoming increasingly valuable. To protect private information from misuses due to the loss or theft, secure user identification mechanisms should be equipped into the consumer devices. Biometrics based personal identification is regarded as an effective method for automatically recognizing, with a high confidence, a person's identity. A new biometric approach to the personal identification using finger-vein technology. The aim of this paper presents a user identification system framework using finger-vein technology for consumer electronics devices. The finger-vein identification is one of the biometrics sensor technologies, which provides high security and reliability than other identification technology. This paper proposes the Radon transform and Principal component analysis algorithms for the feature extraction and normalized distance measure for classification. The results show that the proposed system achieves good performance in terms of the false rejection rate and the false acceptance rate.

Keywords: *consumer devices, user identification, finger-vein, Radon Transform, Principal component analysis*

Classification: *GJRE-F Classification: FOR Code: 090603*

Strictly as per the compliance and regulations of:

Highly Secure and Reliable User Identification Based on Finger Vein Patterns

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Abstract- With the evolution of consumer electronics technologies, personal information in consumer devices is becoming increasingly valuable. To protect private information from misuses due to the loss or theft, secure user identification mechanisms should be equipped into the consumer devices. Biometrics based personal identification is regarded as an effective method for automatically recognizing, with a high confidence, a person's identity. A new biometric approach to the personal identification using finger-vein technology. The aim of this paper presents a user identification system framework using finger-vein technology for consumer electronics devices. The finger-vein identification is one of the biometrics sensor technologies, which provides high security and reliability than other identification technology. This paper proposes the Radon transform and Principal component analysis algorithms for the feature extraction and normalized distance measure for classification. The results show that the proposed system achieves good performance in terms of the false rejection rate and the false acceptance rate.

Keywords – consumer devices, user identification, finger-vein, Radon Transform, Principal component analysis.

I. Introduction

Recently, due to the increasing demands of the fast-growing consumer electronics market, more powerful mobile consumer devices are being introduced continuously. With this evolution of consumer electronics technologies, personal information in consumer devices also becomes increasingly rich and valuable. For example, cell phones are now used for the payment of goods, bank transfer, stock dealing, and e-mail checking. This convenience also means that it can be a disaster if the cell phone is lost or stolen. To address this problem, secure user identification technologies for consumer devices are being introduced.

Accurate automatic personal identification is becoming more and more important to the operation of our increasingly electronically inter-connected information society. Traditional automatic personal identification technologies to verify the identity of a person, which use "something that you know," such as Personal Identification Number (PIN), or "something that you have," such as ID card, key, or both, are no longer considered reliable enough to satisfy the security requirements of electronic transactions. All of these techniques suffer from a common problem of their inability to differentiate between an authorized person and an impostor who fraudulently acquires the access privilege of the authorized person. Biometrics is a technology which (uniquely) identifies a person based on his/her physiological or behavioral characteristics. It relies on "something that you are" to make personal identification and, therefore, can inherently differentiate between an authorized person and a fraudulent impostor .Biometrics based personal identification is regarded as an effective method for automatically recognizing, with a high confidence, a person's identity.

In contrast to the existing methods, the Finger Vein identification system employs Principal Component Analysis to achieve more accurate matching results. The implemented Principal Component Analysis technique is much more accurate than the previous Singular Value Decomposition technique. The main disadvantage of Singular Value Decomposition is that once a particular image structure is not visible due to the poor choice of basic functions, its presence is unlikely to be seen in future images since the basic functions being used are not tailored to visualizing it and it also takes more memory [14]. To avoid this problem Principal Component Analysis technique are used for instead of Singular Value Decomposition technique.

Finger vein authentication is a biometrics technology based on vein patterns underneath the skin's surface that are unique to each finger and each person. The major advantages for finger-vein identification technique[7],[8] are the following:

(1) High accuracy: Because veins are hidden inside the body, there is little risk of forgery or theft.

(2)Unique and constant: Finger vein patterns are different even among identical twins and remain constant through the adult years.

(3) Contactless: The use of near-infrared light allows for non-invasive, contactless imaging that ensures both convenience and cleanliness for the user experience.

(4) Ease of feature extraction: Finger vein patterns are relatively stable and clearly captured, enabling the use

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of low-resolution cameras to take vein images for small-size, simple data image processing.

(5) Fast authentication speed: One-to-one authentication takes less than one second. Moreover, the authentication device can be compact due to the small size of fingers.

Finger vein authentication thus offers several key advantages compared to other forms of biometrics.

These comparative advantages are collectively shown in Table1

Table1- Comparison of Major Biometrics Method

BIOMETRICS	SECURITY		CONVENIENCE				
	Anti-Forgery	Accuracy	Speed	Enrollment Rates	Resistance	Cost	Size
Fingerprint	I	N	N	I	I	G	G
Iris	N	G	N	N	I	I	I
Face	N	I	N	N	G	I	I
Voice	N	I	N	N	G	N	N
Vein Pattern	G	G	G	N	N	N	N

I=insufficient, N=normal, G=good

For example, Compared to key and password methods, these biometric sensor technologies are more convenient and accurate as well as do not have the danger of password exposure. To protect the information stored in mobile consumer devices, traditional ways are used by passwords or PINs (Personal identification number). Although these ways are easy to implement, passwords or PINs have the risk of exposure, and also being forgotten. Therefore, a more reliable and friendly way of identification needs to offer to user. Recently, biometrics, which is the personal identification technology based on human physiological traits, have attracted more and more attention and are becoming one of the most popular and promising alternative to solve these problems. A number of biometric characteristics such as face[6], iris, palm print [4],[5], finger-vein[1], fingerprint[2],[3] or other biometric other biometrics combination[9] can be used in various user identification systems. Fingerprinting is known for being widely applicable due to the small size of its readers, yet because the fingerprint is a trait found on the exterior of the body, it is not only easily stolen but also has issues with low user enrollment rates, as worn away or sweaty fingerprints cannot be registered. Iris recognition is known for low error rates of authentication, but some users feel psychological resistance to the direct application of light into their eyes. Moreover, as precise positioning of the eyes is required for accurate iris authentication, it becomes necessary either to adopt high-cost position adjustment mechanisms or to place the burden of proficiency onto the user. As for face and voice recognition, they are the means by which humans recognize one another in everyday social interaction and are thus the most natural forms of personal identification; yet impersonation is easily performed, and accuracy rates for these are limited.

However, finger-vein pattern recognition offers high accuracy personal identification that is at the same time difficult to forge, non-invasive, and easy to use, offering a balance of advantages that makes it superior as a form of biometric identification. Moreover, finger-vein patterns are different even among identical twins and remain constant through the adult years [7]. Therefore, identification technique based on finger-vein has become the most favorite and novel biometric method.

The proposed scheme first attempts to exploit Radon transform to derive desirable directional features of finger-vein image. Then PCA applies to Radon space to obtain lower-dimensional feature vector and accelerate the identification speed. Experimental results showed the proposed scheme has good performance in terms of the FAR and FRR.

The remainder of this paper is organized as follows. In sections 2 and 3, briefly review Radon transform and PCA, respectively. In section 4, 5, and 6, describe preprocessing, feature extraction using Radon transform and PCA, and identification measure based on finger-vein identification system, respectively. Experimental results and performance evaluation are presented in section 7. Finally, represented the conclusions and other applications in section 8.

II. Radon Transform

The Radon transform is a useful tool in identification areas [8], [10], [11] because it can effectively capture the directional features in the pattern image by projecting the pattern onto different orientation slices.

Applying the Radon transform on an image $f(x,y)$ for a given set of angles can be thought of as computing the projection of the image along the given angles. The resulting projection is the sum of the intensities of the pixels in each direction, i.e. a line integral. The result is a new image $R(r,q)$. This is depicted in Figure 1 on the facing page. This can be written mathematically by defining,

$$\rho = x\cos\theta + y\sin\theta \qquad (1)$$

after which the Radon transform can be written as

$$R(\rho,\theta) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x,y)\delta(\rho - x\cos\theta - y\sin\theta)\,dx\,dy \qquad (2)$$

where $\delta(.)$ is the Dirac delta function. The $x' - \theta$ space will be referred to as the Radon space. The Radon transform is a mapping from the Cartesian rectangular coordinates (x,y) to a distance and an angel (ρ,θ), also known as polar coordinates.

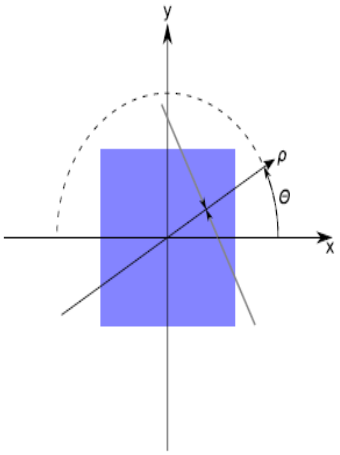

Fig.1. Geometry of Radon Transform

III. Principal Component Analysis

The principal component analysis has been used in the feature extraction of pattern analysis [6]. PCA is a standard technique used to choose a dimensionality reducing linear projection that maximizes the scatter of all projected samples. The basic approach of the PCA is to compute the eigen vectors of the covariance matrix, and approximate the original data by a linear combination of the leading eigen vectors [13].

Principal component analysis (PCA) is a mathematical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of uncorrelated variables called principal components. The number of principal components is less than or equal to the number of original variables. It is a way of identifying patterns in data, and expressing the data in such a way as to highlight their similarities and differences. Since patterns in data can be hard to find in data of high dimension, where the luxury of graphical representation is not available, PCA is a powerful tool for analyzing data. The other main advantage of PCA is that once found these patterns in the data, and compress the data, i.e. by reducing the number of dimensions, without much loss of information. The PCA transformation that preserves dimensionality (that is, gives the same number of principal components as original variables) is then given by:

$$Y^T = X^T W = V\Sigma^T \qquad (3)$$

(V is not uniquely defined in the usual case when $m<n-1$, but Y will usually still be uniquely defined.) Since W (by definition of the SVD of a real matrix) is an orthogonal matrix, each row of Y^T is simply a rotation of the corresponding row of X^T. The first column of Y^T is made up of the "scores" of the cases with respect to the "principal" component; the next column has the scores with respect to the "second principal" component, and so on.

IV. Preprocessing

The size of captured images is 640×480 pixels with an 8-bit gray scale image. The performance of an identification system based on finger-vein depends heavily on the quality of input finger vein images. For this reason, several additional steps are needed to enhance the quality of the finger-vein images before the matching algorithm. Therefore, in the preprocessing stage, it includes four steps: average and Gaussian filter, finger-vein region segmentation, size normalization, gray-scale normalization. After filtering the image normalizes the finger-vein image to accommodate geometric changes in the positioning or angle of the finger in the image is detected and then the entire image is rotated so that the slope of the outline is to be constant. The examples of finger vein patterns are shown in Fig. 2.

Fig.2. Example of finger-vein pattern

V. Feature Extraction Using Radon Transform and PCA

After the finger-vein image preprocessing stage, hence extract important finger-vein features for identification task. Radon transform and PCA are employed for feature extraction in our finger-vein identification system.

This process is essential for reliable authentication while controlling the variation of image data caused by body metabolism or changes in imaging conditions. In particular, unevenness of brightness due to individual variations in finger size or lighting conditions often appears in the vein pattern image, so the system must extract only the vein patterns from such an otherwise unstable image.

In the proposed approach, the finger-vein features are the directional information of finger-vein images. The features are derived by using the Radon projections of a finger-vein image in different orientations. For each projection, a vector, which is the projection of image intensity along a radial line oriented

at a specified angle, is computed. The elements returned in the vector are the sum of intensity values along the x', which is oriented at θ (theta) degrees counterclockwise from the x – axis. The origin of axes is the center pixel of an image. The projection matrix is constructed by first forming a row stacked version of the individual projections, i.e.

$$G = \begin{bmatrix} g_{\theta_1}(1) & g_{\theta_1}(2) & \dots & g_{\theta_1}(N) \\ g_{\theta_2}(1) & g_{\theta_2}(2) & \dots & g_{\theta_2}(N) \\ \dots & \dots & \dots & \dots \\ g_{\theta_M}(1) & g_{\theta_M}(2) & \dots & g_{\theta_M}(N) \end{bmatrix} \quad (4)$$

Where M denotes a total of projection angles, N denotes the number of projection points at angle $\theta_i (i = 1,2,\dots,M)$ Radon space (transform) image for 0-$^{45^\circ}$ orientations is shown in Fig. 3. This has reduced the dimension of feature vector significantly.

PCA analysis is applied to this projection matrix G, and then singular values can be gotten. Arrange these values with descending order to compose a feature vector , then the feature vector is unique, and also describe uniquely finger vein image. So the proposed approach can be applied to finger vein identification system.

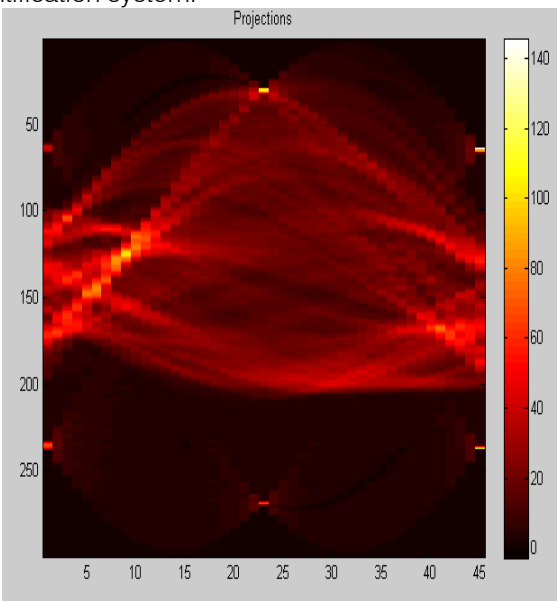

Fig.3. Radon Transform using 180 projections

VI. Finger-Vein Identification

After the finger-vein feature extraction stage, the proposed system measures the similarity between the input finger-vein features and the previously enrolled ones. To measure the similarity, defining a normalized distance between the two feature vectors sets as follows:

$$D = D(A, A_i) = \left\| \frac{A}{|A|} - \frac{A_i}{|A_i|} \right\|_F \quad (5)$$

Where A is the feature vector which is obtained from the input finger-vein image, A_i the feature vector which is obtained from the enrolled finger-vein image. $\|.\|_F$ is Frobenius norm and $|.|$ is amplitude of vectors. A smaller value of $D(A, A_i)$ means that the two feature vector sets are more similar. It is noted that D is between 0 and 1. The distance for perfect matching is zero. If the correlation value is higher than a pre-defined threshold value, the input vein pattern is authenticated. The vein pattern image and the extracted feature pattern are ultimate personal information. Fig. 4 shows the block diagram of the proposed finger-vein identification system.

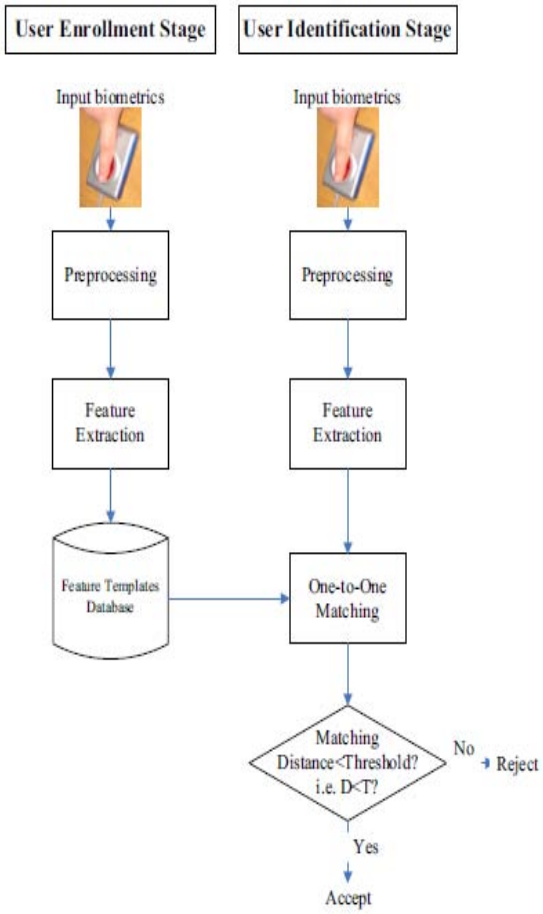

Fig.4. Block diagram of the proposed finger-vein identification system

VII. Performance Evaluation

To evaluate the effectiveness of the proposed finger-vein based identification scheme, performed simulation experiment by Matlab 7.0 on a Intel CORETM 2 Due CPU 2.40 GHz processor with 2.0 GB RAM.

The finger-vein database in the experiment collected a total of 100 images which were organized by acquiring 10 images for the forefinger of right hand from 10 testers through our capturing device. The size of captured images is 640×480 pixels with an 8-bit gray-scale image. Radon transforms are used to reduce

the dimension of feature vector. It used two performance measures, namely the false rejection rate (FAR) and the false acceptance rate (FRR). FAR refers to the acceptance rate of unauthorized users and FRR refers to the rejection rate of the legitimate users. In both of the measures, a lower value implies better performance[2].

Table 2 shows the FAR and FRR of the proposed finger-vein identification scheme with different distance measure threshold. As can be seen from the table, the identification system shows the best performance when the distance measure threshold is 1. FAR and FRR are 0.008 and 0.000, respectively.

Table 2- Performance Evaluation in terms of FAR and FRR

Distance Threshold	FAR	FRR
0.80	0.048	0.000
0.90	0.050	0.090
1	0.008	0.000

VIII. Conclusions

In this paper, a new finger-vein based user identification system for personal consumer electronic devices. The system provides effective and efficient features using Radon transform and PCA. The Radon transform has been used to derive desirable directional features of finger-vein image. The PCA has been applied to Radon space to obtain lower-dimensional feature vector. The experimental results showed the proposed scheme has good performance in terms of the FAR and FRR.FAR and FRR are 0.008 and 0.000 at the distance measure threshold 1. Finger-vein based identification technology has high security and reliability compared to the traditional authentication mode.

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Global Journal of Research in Engineering
Volume 11 Issue 3 Version 1.0 April 2011
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
ISSN: 0975-5861

Effects of the Controller Performance of DFIG on its Inertia Response

By Ramin Tayebi Derazkolaie, Heidar Ali Shayanfar, Babak Mozafari
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Abstract- Inertia response is the first reaction of the generator to the frequency disturbance in power system that is so important for the grid. Conventional synchronous generators have a high inertia response inherently and therefore the power system by these generators has a high Inertia response. Recently, using the wind turbines by DFIG generators are become popular, consequently, investigation the Inertia response of DFIG is important. At this work the inertia response of a DFIG that is connected to an infinite bus investigated and it is observed that DFIG has a very low inertia response, because its controller takes the slip of machine within fix range. In this paper for studying on effect of the operation speed of the DFIG controller on its inertia response, several different times took for its controller speed.

Keywords: *Inertia response, DFIG, DFIG controller.*

Classification: *GJRE-F Classification : FOR Code: 090601,090602*

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Keywords- *Inertia response, DFIG, DFIG controller*

I. Introduction

Frequency of power system increases by adding a big load or by disconnecting a big generator. When frequency is proportional by rotor speed of generator and they are electrically couple, by dropping of power system frequency, rotor speed will decrease (from ω_1 to ω_2). By knowing that every rotational mass has stored kinetic energy that is given by (1), released energy by dropping in rotor speed will calculate by equation (2) [1], [2].

$$E = \frac{1}{2} j\omega^2 \quad (1)$$

$$\Delta E = \frac{1}{2} j(\omega_2^{\,2} - \omega_1^{\,2}) \quad (2)$$

Where, E, j and ω are kinetic energy, moment of inertia and angular speed respectively. In generators, this released energy will inject in the power system and it will be cause of sudden increasing in output power of generator that is named inertia response [2, 3]. Importance of this increasing in output power is that additional power in all generators of power system in dropping frequency supply some of demand of system and therefore frequency will drop smoother. Having good inertia response in power system, cause that system has not sudden change in frequency in misbalance of supply and demand.

In conventional synchronous generators when system frequency decreases because of sudden connecting a big load or sudden disconnecting of a big generator in power system, stator rotational field speed will decrease (according to the equation (1)). Considering the existence of coupling between rotational fields of the stator and rotor, speed of the rotational field of the rotor will decrease by decreasing of speed of the rotational field of the stator. Therefore kinetic energy will release in this situation. Based upon above descriptions conventional synchronous generators will have very good inertia response.

$$f_s \quad \frac{n_s p}{120} \quad (3)$$

In which, f_s, n_s and p are system frequency, speed of the rotational field of the stator and number of poles respectively.

Usual induction generator same as SCIG (squirrel cage induction generator) has good inertia response. Therefore increasing of these generators in power system doesn't change inertia response of power system out of normal range. Nowadays DFIG uses in wind power systems. Therefore by increasing of this generator in power system, investigation of its inertia response is important [4].

In this paper inertia response of a DFIG that is connected to an infinite bus investigated. Then by forcing different times for operation speed of the DFIG controller and comparison their result to each other, it is concluded that increasing in speed of the DFIG controller cause to decrease in inertia response of DFIG.

II. Inertia Response of DFIG

In DFIG, the rotor winding is connected to the controller through slip rings that control the voltage amplitude and rotor frequency due to demanded applications.

Hence the appropriate performance of the machine is obtained for specific and constant slip and electromagnetic torque with respect to change in wind speeds, the controller injects specific voltage to change the electrical speed of rotor field to prohibit effect of change in mechanical speed of rotor (change of wind

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speed). Therefore it makes constant total rotational speed of rotor field (n_r) through the equation (4).

$$n_r = n_{re} + n_{rmech} \quad (4)$$

Where, n_{re} is electrical and n_{rmech} is mechanical rotational speed of rotor.

This causes the slip to be constant hence the output electromagnetic torque become constant approximately. On the other hand, with this type of control, when the grid frequency decrease and therefore n_s decrease, the controller makes the slip and electromagnetic torque constant by changing the rotor field speed.

According to equation (7), rotor speed is not change and Kinetic energy is not release. So during changes in grid frequency, generator doesn't sense any of that and the inertia response of the machine doesn't change. Of course because of the delay in controlling system, generator has a small inertia response with respect to the delay time. In this interval (delay time), DFIG behave like as a SCIG. So DFIG in the time of grid frequency changes has a small inertia response that is undesirable [5].

Table I: parameters of simulated DFIG

parameter	Value	Unit
P_{out}(rated power)	2×10^{6}	W
R_S(stator resistance)	1.748×10^{-3}	Ω
R_r(rotor resistance)	3.253×10^{-3}	Ω
L_s(stator inductance)	2.589×10^{-3}	H
L_r(rotor inductance)	2.604×10^{-3}	H
L_m(mutual inductance)	2.492×10^{-3}	H
V_s(generator output voltage)	690	V
j(moment of inertia)	1.39×10^{3}	Kg/m
T_{in}(input mechanical torque)	2×10^{4}	N.m
P(number of pole)	6	----
f_s(frequency)	50	Hz

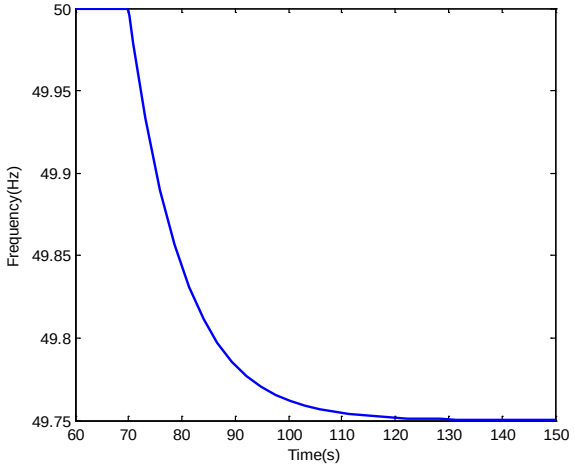

Fig.1. grid frequency

In the simulation according the tabulated parameters values in table I, fault is take effect as a dip in grid frequency which was shown is figure 1. Till 70th second grid frequency was 50 Hz and the generator has a rotor speed 100 rad/s while give 2MV active power to the infinite bus.

By taking 1 second for delay time of controller, rotor speed decreased from 100 to 99.988 rad/s. in this decrease of rotor speed as shown in figure 2, kinetic energy of rotor decreased from 6950 to 6948.332 KJ. Therefore only 1.6 KJ kinetic energy released. Because of releasing this energy, output power of DFIG as shown in figure 3, increased from 2 to 2.0005 MW that its change is too small.

Because of feedback in the controller, the rotor speed after 1 second delay, return to its previous speed so during this returning period, kinetic energy and output power of the generator decrease for a moment.

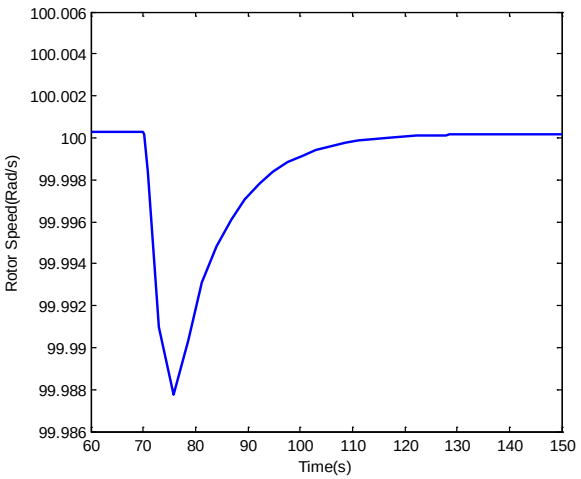

Fig.2. rotor speed of DFIG

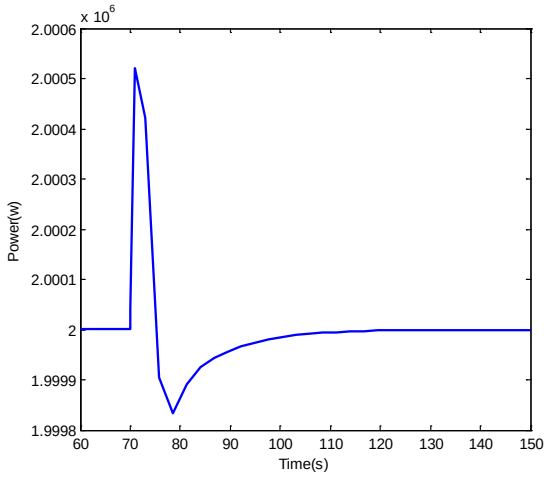

Fig.3. Output power of DFIG

III. Inertia Response of DFIG in Different Times for Controller Speed

Till the controlling system has delay, the DFIG acts as a usual induction generator like a SCIG. In SCIG by decrease in grid frequency, n_s decreases too. So slip that calculates by equation (5) decreases. Since the case study in this paper is in steady state situation, slip is very small and the approximate electromagnetic torque equation for DFIG is given in (6).

As it was mentioned in the last section the value of the delay in controlling system of DFIG has an influence in inertia response of it. In this section, the comparison is made between the different delay times.

It is clear that increasing the slip cause the electromagnetic torque increases. According to equation (6), in normal situation when output electromagnetic torque is equal by input mechanical torque, $d\omega_r/dt$ is zero so the generator works at a constant speed. But if the torque increases for any reason, $d\omega_r/dt$ becomes negative and therefore the rotor speed decreases which cause releasing the kinetic energy from rotor and therefore increasing in output of generator.

So the faster the DFIG controller acts the faster it prevents changes in slip and because of it, the inertia response will decrease [7, 8].

$$S = \frac{n_r - n_s}{n_s} \quad (5)$$

$$Te = \frac{3SV_{th}^{\ 2}}{R_r \omega_S} \quad (6)$$

$$\frac{P_{mech}}{\omega_r} - T_e = j\frac{d\omega_r}{dt} \quad (7)$$

In above equations, S, T_e, V_{th}, P_{mech}, ω_s and ω_r are slip, electromagnetic torque, equal voltage, input mechanical power, stator electrical angular velocity, rotor electrical angular velocity respectively.

In the DFIG that simulated, in order to show the effects of the speed performance of the control system on inertia response, different times took for control system performance speed that the results of it will explain.

Figure 4 shows electromagnetic torque difference with delay times of 0.1, 1, and 2 seconds respectively in performance speed of controller system of DFIG. Note that, in these figures, td and tq are time constants of DFIG controller in Direct and quadrature axis component [1].

It can be seen that electromagnetic torque decreases in the fault by increasing the speed of the controller.

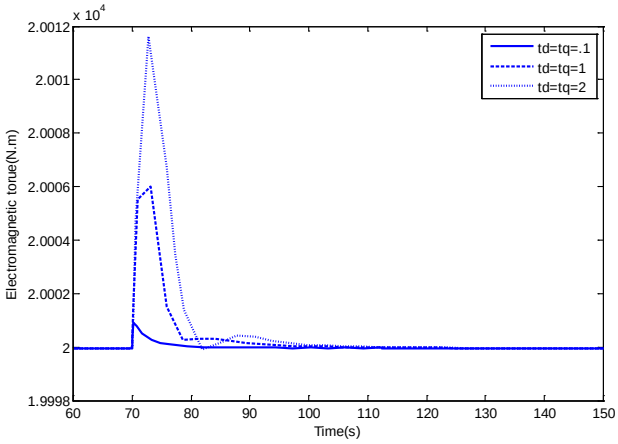

Fig.4. electromagnetic torque of DFIG in different time of controller speed

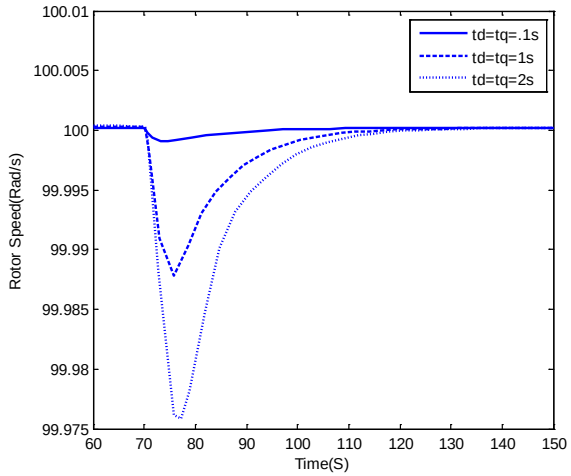

Fig.5. rotor speed of DFIG in different time of controller speed

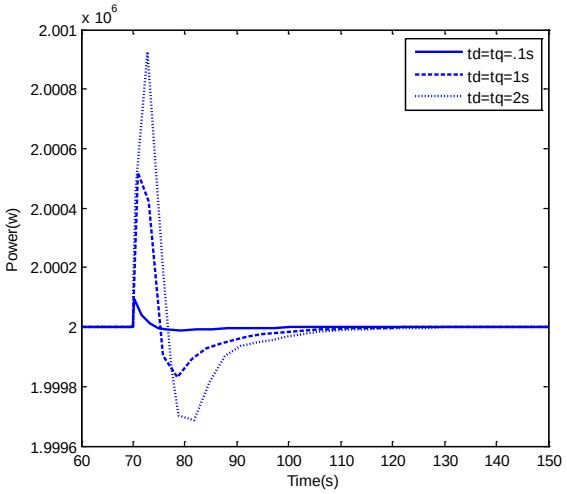

Fig.6. Output power of DFIG in different time of controller speed

Also, Figure 5 shows the rotor speed difference with mentioned delay times. It can be seen that for 2 seconds delay time in comparison to the 1 second delay time, the rotor decreases 2 times more. But for the 0.1 second delay time, the rotor speed is approximately not change. So by decreasing the delay time dip in the rotor speed during grid frequency changes will be less. As it can be seen in figure 6 at this point rotor provides less kinetic energy that causes the active power of the generator to increase less than other situations.

IV. Conclusion

Conventional synchronous generator has appropriate inertia response due to the coupling with grid frequency. So in the grid that most of its generator is synchronous, frequency change doesn't cause any perturbation. Recently contribution of the wind turbines in power generation has been increased and in some case situated for the thermal power plants.

SCIG was the first popular generator used in wind turbines that almost has the same inertia response like synchronous generators.

Nowadays DFIG become the most popular generators used in wind turbines. But this generator doesn't take affect from the grid frequency (because its control system) and it hasn't an appropriate inertia response. Due to delay time till since the control system doesn't work operation of these generators are like Conventional induction machine and has inertia response. By increasing in speed of control system, generator changes in slip modifies sooner which cause the inertia response to decrease.

V. Acknowledgment

The Authors would like to thank Mr. Ali Ebadi and Mr. Mohammad Rezanezhad for their great helps.

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Global Journal of Research in Engineering
Volume 11 Issue 3 Version 1.0 April 2011
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
ISSN: 0975-5861

Energy Optimization in Wireless Sensor Network Using Sleep Mode Transceiver

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Abstract- Energy efficiency is a central challenge in sensor networks and the radio is a major contributor to overall energy node consumption. These Wireless Sensor Networks have severe resource constrains and energy conservation is very essential. The aim of this project is to reduce the energy consumption in wireless sensor networks. This paper proposes adaptive radio low-power sleep modes based on current traffic conditions in the network. It provides an analytical model to conduct a comparative study of different MAC protocols (BMAC, TMAC, SMAC, DMAC) suitable for reduction of energy consumption in wireless environment. This technique exposes the energy trade-offs of different MAC protocols. It first introduces a comprehensive node energy model, which includes energy components for radio switching, transmission, reception, listening, and sleeping for determining the optimal sleep mode and MAC protocol to use for given traffic scenarios. The model is then used for evaluating the energy-related performance of our recently proposed RFID Impulse protocol enhanced with adaptive low-power modes, and comparing it against BMAC under varying data rates. The comparative analysis confirms that RFID Impulse with adaptive low power modes provides lower energy consumption than the BMAC and DMAC in low traffic scenario. The evaluation also yields the optimal settings of low-power modes on the basis of data rates for node platform, and provides guidelines and a simple algorithm for the selection of appropriate MAC protocol, low-power mode, traffic requirements of a sensor network application.

Keywords: *RFID, wake-up radio, sleep mode, adaptive, energy efficiency, MAC protocols, routing protocols, energy model, sensor networks.*

Classification: *GJRE-F Classification: FOR Code: 090601,090602*

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Index Terms- RFID, wake-up radio, sleep mode, adaptive, energy efficiency, MAC protocols, routing protocols, energy model, sensor networks.

I. Introduction

Energy efficiency is a central challenge in sensor networks, as battery replacement is costly and often difficult in inaccessible deployment regions. Several efforts have addressed energy efficiency in sensor networks, through the design of energy saving MAC protocols, such as duty cycling protocols [7] or low-power wake-up radio protocols [12], and routing protocols, such as [11].

Radio energy consumption is a major component contributing to the overall energy consumption at each node. Current MAC protocols put the radio in sleep mode while there is no data to send or receive, in order to minimize energy consumption.

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Although most radios for sensor networks support multiple sleep modes, the radio sleep mode in current MAC protocols is static. Choosing a static low-power mode involves an energy and delay tradeoff.

The deepest sleep mode, which turns off the oscillator and voltage regulator, provides the lowest current draw of all low-power modes. However, it also involves the highest energy cost and the longest latency for switching the radio back to active mode. In contrast, the lightest sleep mode provides a transition to active mode that is quick and energy inexpensive, but it has a higher current draw. In a low traffic scenario, it is better to use the deep sleep mode as nodes spend more time sleeping than switching back and forth between sleep mode and active mode. In a high traffic scenario, a lighter sleep mode is more suitable as the cost of switching the radio frequently into deep sleep mode would exceed the energy saving of the deep sleep mode's low current draw.

To address this trade-off, this paper proposes adaptive radio power modes that dynamically change according to current traffic conditions in the network. To demonstrate the benefits of adaptive sleep modes, we incorporate them into our recently proposed RFID Impulse mechanism [15], [2],and compare its performance against the popular BMAC [7] protocol. The performance evaluation of proposed protocols generally considers the radio energy consumption, including receiving, transmitting, listening, and sleeping energy consumption components, but it disregards the switching energy component [16] that is appreciable for any protocol that switches nodes between active and sleep modes in low traffic conditions.

In order to determine how to adapt low-power modes in RFID Impulse and to compare the MAC protocols, this paper presents a sensor node energy consumption model that includes switching energy. The model enhances existing models [7], is generalizable to any MAC protocol, and serves as the basis for evaluating the energy consumption of sleep mode configurations for given traffic loads and for determining the optimal protocol/sleep mode configuration and for comparing the protocols through a custom-built Matlab simulation model [2].

The comparison of the protocols under different traffic loads yields guidelines for selecting appropriate MAC protocols for specific traffic requirements of an application. We also determine the optimal radio low

power mode within RFID Impulse as the data rate varies. Proposal of adaptive radio low-power sleep modes within our previously proposed RFID Impulse protocol that can dynamically change based on network or node traffic.

Introduction of an energy model that considers radio energy consumption, including transmission, reception, listening, sleeping, and switching energy components, as an enabler for comparing protocols across node platforms that use different processor boards. Presentation of a simple algorithm based on the energy model for selecting the optimal protocol and sleep mode configuration for a given traffic load.

Energy efficiency evaluation of BMAC, and RFID Impulse. The evaluation considers the dependence of energy efficiency and optimal power mode on data rate. Provision of guidelines based on the evaluation results for MAC protocol, power mode, selection according to the expected traffic requirements of the target application.

II. MAC Protocols

This section presents the three protocols under consideration separately: BMAC,DMAC and RFID Impulse.

a) BMAC

BMAC [7] is an asynchronous and lightweight sensor network MAC protocol that aims at providing versatile medium access while keeping the MAC functionality as simple as possible. As an asynchronous protocol, BMAC eliminates the communication and processing overhead for scheduling and synchronization, which reduces energy consumption.

BMAC enables each node to wake up periodically to check for channel activity. The wake-up period is referred to as the check interval. BMAC defines eight check intervals, and each check interval corresponds to one of BMAC's eight listening modes. To ensure that all packets are heard by neighboring nodes, packets are sent with a preamble whose reception time is longer than the check interval. BMAC, therefore, defines eight different preamble lengths referred to as transmit modes. Although several optimizations have improved over BMAC.

b) DMAC

The Data–Gathering Medium Access Control (DMAC) is a schedule based MAC protocol which has been designed and optimized for tree based data gathering (converge cast communication) in wireless sensor network. The main objective of this MAC protocol is to achieve low latency and still maintaining the energy efficiency. In this protocol the time is divided in small slots and runs carrier sensing multiple access (CSMA) with acknowledgement within each slot to transmit/receive one packet. The sensor node periodically executes the basic sequence of '1' transmit, '1' receive and 'n' sleep slots.

c) Rfidimpulse

RFID Impulse is a very low-power radio wake-up scheme for sensor networks that relies on off-the-shelf RFID readers and tags. The Basis functionality of RFID Impulse is that all network nodes turn off their radios, including the voltage regulator and the oscillator, as long as they have no packets to send or receive and sends a short acknowledgment message through the standard radio to the sender, indicating that the RFID wake-up was successful. Upon receiving the short acknowledgment from the receiver, the sender commences the transmission. Once the sender completes all its packet transmissions, both sender and receiver again turn off their radios If a sender fails to receive an acknowledgment from the If a sender fails to receive an acknowledgment from the receiver in response to an RFID wake-up signal, the sender assumes that the receiver tag did not detect the signal or that the signal level is too low to activate the receiver tag. The sender then transmits the RFID wake-up signal again, with a maximum of three retries. If the receiver acknowledges receipt of one of the RFID wake-up signals, then the sender proceeds with the transmission. Otherwise, the sender ceases its attempts to use RFID wake-up signals to this receiver.

d) Trade-Offs

To address the energy trade-off, RFID Impulse supports traffic-based selection of low-power radio modes. As a general rule, when the traffic load is high in a particular region of the network, nodes use lighter sleep modes as they have to wake up frequently to send and receive packets. It is not worthwhile for nodes to go into deeper sleep modes due to the higher latency and switching energy involved in frequent wake-up transitions.

When the traffic load is low in a particular region of the network, switching between sleep and active states is less frequent, so nodes use deeper sleep modes that provide the highest energy savings. Determining quantitative thresholds for optimal sleep mode selection demands an energy model that captures all components contributing to energy consumption at sensor nodes.

III. Analytical Model

In order to model the energy consumption of the three MAC protocols, this section considers all the energy components that contribute to the overall energy consumption at a node including the radio.

Consider a convergecast application where all nodes sample their sensor periodically and send the data toward the base station. The discussion here

focuses on energy consumption during a single sampling period.

a) Listening Energy

We define the listening energy as the radio energy consumption when the radio is active but not receiving or sending any packets. Protocols that are based on low-power listening, such as BMAC [6], have the following listening energy:

$$E_l^{lpl} = \frac{S}{CK} * T_{CH} * I_{listen} * V$$

where S is the sampling period, CK is the check interval, T_{CH} is the time during which the node is awake every cycle, and I_{listen} is the current draw of the radio in listening mode.

b) Switching Energy

The switching energy component [15] is the energy consumed for switching the radio state between states, including normal, power down, and idle modes. The following equation determines the energy consumed for switching the radio from sleep mode α to active mode:

$$E_{switch}^{\alpha} = \frac{[(I]_{active} - I_{\alpha}) * T_{\alpha} * V}{2}$$

Where I_{active} is the current draw of the radio in active mode, I_{α} is the current draw of the radio in sleep mode α , and T_{α} is the time required for the radio to go from sleep mode α to active mode. Equation (7) assumes that the energy variation varies linearly while switching between sleep mode α and active mode. While the energy consumption due to switching can follow a nonlinear pattern, the linear approximation is reasonable for differentiating between the high cost of switching from a deep sleep mode and the low cost of switching from a light sleep mode.

c) Transmission Energy

The transmission energy component refers to the energy consumed for transmitting packets and their associated control overhead on the radio. During any time period, the transmission energy is expressed as

$$E_t = P_{sent} * P_{lenght} * T_B * I_t * V$$

where P_{lenght} is the length of a packet in bytes, It is the current draw of the radio while in transmit mode, and T_B is the time for sending 1 byte over the radio.

d) Receiving Energy

The reception energy component refers to the energy consumed while receiving packets and their associated control overhead on the radio. During any time period, the reception energy is expressed as

$$E_t = P_{recv} * P_{lenght} * T_B * I_r * V$$

where I_r is the current draw of the radio while receiving.

e) Sleeping Energy

The sleeping energy component is simply the energy consumption, while the radio is in low-power mode. The following equation computes the sleeping energy for a node that goes into sleep mode α when it is off:

$$E_{sleep} = T_{rf}^{off} * I_{\alpha} * V$$

f) Overall Energy

The overall energy consumption at each node using protocol P and sleep mode α is simply the sum of all of the above energy components of that node for the given protocol:

$$E_P^{\alpha} = E_l * E_{switch} * E_t * E_r * E_{sleep}$$

The selection of the optimal MAC protocol P and sleep mode α for a given network scenario can thus consider all available MAC protocols and sleep modes, and pick the combination of protocol and sleep mode that yields the lowest energy consumption.

The energy model described in this section provides the basis for evaluating energy performance, protocol trade-offs.

g) Delay Considerations

To understand the implications of using different low-power radio modes on the end-to-end delay, we consider a simple delay model that considers Tα for a given sleep mode α, the packet transmission time Tt, the backoff time Tbo, and the queuing delay Tq. Note that the transmission time Tt=$T_B * P_{lenght}$ and Tbo=T_B * 54 in a highly congested scenario for IEEE 802.15.4 radios.

IV. Performance Evaluation

This section explores the interdependencies among MAC protocols, node platforms, and traffic load in sensor networks. We built our energy model from the previous section into a custom Matlab simulator. The evaluation here considers three MAC protocols: 1) the widely used BMAC protocol, 2)DMAC 3)RFID Impulse.

The first part of this section exposes the energy trade-offs of the three MAC protocols for a low sampling rate multihop scenario and a high sampling rate multihop scenario. The goal of these simulations is to expose the dominant energy components for each protocol on the basis of traffic load

The second part of this section considers the effects of traffic forwarding on energy consumption under four fixed sampling periods. Building on these results, the third part of this section determines the energy consumption of each MAC protocol based on useful data rate and identifies the best performing protocol for each node platform and traffic load. The

final part of this section examines the delay implications of adaptive radio sleep modes.

a) Energy Trade-Offs

First explore the energy trade-offs of the three protocols mentioned above. In this evaluation, we consider a network with a 6-hop binary tree static topology. Although the topology of an actual sensor network can be both irregular and transient according to environmental conditions as well as location, this study serves as a representative case that exposes the energy trade-offs of the three MAC protocols under varying traffic loads. The network is convergecast in nature where all nodes periodically sample their sensors and send the data in a packet toward the base station that is colocated with the root of the tree topology. Packets are forwarded in a multihop fashion until they reach the base station. Each node's hop count from the root in the logical topology determines its forwarding load. Intermediate nodes must forward all packets of their children, while leaf nodes only send their own packets. The first scenario considers the energy trade-offs in a 6-hop binary tree network with a low data rate in which the sampling period S is set to 100 seconds. Because of the low traffic load in this scenario, RFID Impulse uses the deepest sleep mode.

V. Results

This section explores the result of the energy trade-offs between these three MAC protocols (RFID Impulse, BMAC, DMAC) and analyses the performance against the each MAC protocols.

Figure.1 plots the Power consumption trade-offs between the RFID Impulse, BMAC and DMAC when there is an communication between the nodes.

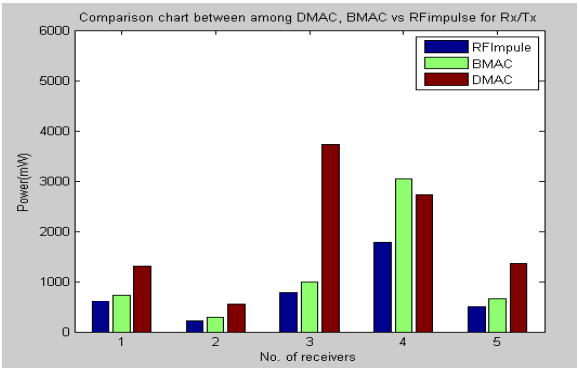

Fig.1. Power consumption trade-offs between the RFID Impulse, BMAC and DMAC for Rx/Tx.

Figure.2 plots the Power consumption trade-offs between the RFID Impulse, BMAC and DMAC which shows the energy level for each Mac Protocols when there is switching between the states from sleep mode to awaken mode or awaken mode to sleep mode.

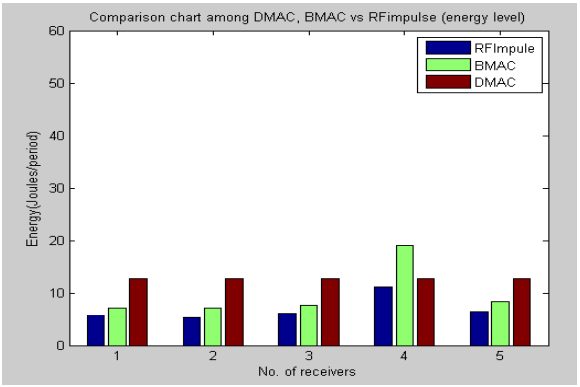

Fig.2. Power consumption trade-offs between the RFID Impulse, BMAC and DMAC which shows the energy level for each Mac Protocols.

VI. Conclusion and Future Work

This paper has proposed adaptive radio sleep modes as an energy optimization technique for wireless sensor networks. Because nearly all sensor network MAC protocol alternate frequently between sleep and awake states, the frequency of this state switching should dictate the appropriate sleep mode that minimizes energy consumption.

This paper has also provided an analytical model to conduct a comparative study of MAC protocol suitability of BMAC,DMAC, and the newly proposed RFID Impulse Building on the dependence of protocol performance on traffic loads, the paper has also quantitatively explored the application of adaptive low-power radio sleep modes based on the level of data traffic in the network

Our analysis of the delay implications of using adaptive sleep modes have considered uniform delay along the routing tree. In reality, queuing and collision backoff delay components are higher at critical nodes near the base station. This effect is purely dependent on the structure of convergecast topologies and not on the use of adaptive sleep modes. In fact, critical nodes may exhibit higher queuing and collision backoff delays because of the higher traffic rates in the vicinity of these nodes. If these nodes use adaptive sleep modes, they will select the light sleep mode for their operation as a direct consequence of their higher forwarding load which minimizes $T\alpha$, and consequently, reduces the end-to-end delay for the packets these nodes forward.

From comparative analysis confirms that RFID Impulse with adaptive low power modes provides lower energy consumption than the BMAC and DMAC in low traffic scenario. The evaluation also yields the optimal settings of low-power modes on the basis of data rates for node platform, and provides guidelines and a simple algorithm for the selection of appropriate MAC protocol, low-power mode, traffic requirements of a sensor network application.

An interesting direction for future work is to implement RFID Impulse by attaching RFID tags to the external interrupt pin of sensor node MCUs, and then, configuring the radio to trigger the remote tags.

Cross-layer dependencies in sensor networks [19] require consideration of not only energy performance based on the choice of hardware and MAC protocols, but also the delay performance and the choice of routing and scheduling protocols as well.

An interesting direction for future work is to explore the interdependencies and between the choice of node platforms, MAC protocols, and routing and scheduling protocols. Keeping in mind that these dependencies exist, the measurement-based comparative study in this paper will hopefully serve as a guide for designers and researchers in selecting node platforms and MAC protocols that are suitable for the expected traffic requirements in their applications.

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Global Journal of Research in Engineering
Volume 11 Issue 3 Version 1.0 April 2011
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
ISSN: 0975-5861

Determination of Exponential Smoothing Constant to Minimize Mean Square Error and Mean Absolute Deviation

By Sanjoy Kumar Paul
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Abstract- Exponential smoothing technique is one of the most important quantitative techniques in forecasting. The accuracy of forecasting of this technique depends on exponential smoothing constant. Choosing an appropriate value of exponential smoothing constant is very crucial to minimize the error in forecasting. This paper addresses the selection of optimal value of exponential smoothing constant to minimize the mean square error (MSE) and mean absolute deviation (MAD). Trial and error method is used to determine the optimal value of exponential smoothing constant. An example is presented to discuss the method.

Keywords: *Exponential smoothing constant, Forecasting, Trial and error method.*

Classification: *GJRE-J Classification: FOR Code: 099999*

Strictly as per the compliance and regulations of:

Determination of Exponential Smoothing Constant to Minimize Mean Square Error and Mean Absolute Deviation

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I. Introduction

Forecasting can be broadly considered as a method or a technique for estimating many future aspects of a business or other operations. All forecasting methods can be divided into two broad categories: qualitative and quantitative. Many forecasting techniques use past or historical data in the form of time series. A time series is simply a set of observations measured at successive points in time or over successive periods of time and forecasts essentially provide future values of the time series on a specific variable such as sales volume. Exponential smoothing is one the time series techniques which is widely used in forecasting. Exponential smoothing gives greater weight to more recent observations and takes into account all previous observations. In ordinary terms, an exponential weighting scheme assigns the maximum weight to the most recent observation and the weights decline in a systematic manner as older and older observations are included. Weight in the exponential smoothing technique is given by exponential smoothing constant (α). Forecast values are varied with the values of this constant. So, forecast errors are also depended on α. Many authors used exponential smoothing method in forecasting. Snyder et al. (2002) has shown that exponential smoothing remains appropriate under more general conditions, where the variance is allowed to grow or contract with corresponding movements in the underlying level. Taylor (2003) investigated a new damped multiplicative trend approach. Gardner (2006) reviewed the research in exponential smoothing since the original work by Brown and Holt and brought the state of the art up to date and invented a complete statistical rationale for exponential smoothing based on a new class of state-space models with a single source of error. McKenzie and Gardner (2010) provided a theoretical rationale for the damped trend method based on Brown's original thinking about the form of underlying models for exponential smoothing. Hyndman (2002) provided a new approach to automatic forecasting based on an extended range of exponential smoothing methods. Corberan-Vallet et al. (2011) presented the Bayesian analysis of a general multivariate exponential smoothing model that allows us to forecast time series jointly, subject to correlated random disturbances.

No research paper has found which determine the optimal value of exponential smoothing constant. In this paper, mean square error (MSE) and mean absolute deviation (MAD) are considered to determine the forecast error and to minimize MSE and MAD, optimal values of exponential smoothing constant are determined.

II. Mathematical Formulation for MSE and MAD

Different forecasting techniques and time series analysis are described by Montgomery and Johnson (1976). From Montgomery and Johnson (1976), forecast at period t is given for exponential smoothing technique is given by,

$F_1 = A_0$; When $t = 1$

And

$$F_t = \alpha A_{t-1} + \alpha(1-\alpha)A_{t-2} + \alpha(1-\alpha)^2 A_{t-3} + \ldots\ldots\ldots\ldots + \alpha(1-\alpha)^{t-1}A_0 \quad (1)$$

When $t > 1$

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Where, F_t = Forecast at period t
A_{t-1} = Actual value of period $t-1$
α = Exponential smoothing constant
From (1), for different period, it can be written as,

$$F_1 = A_0 \quad (2)$$

$$F_2 = \alpha A_1 + \alpha(1-\alpha)A_0 \quad (3)$$

$$F_3 = \alpha A_2 + \alpha(1-\alpha)A_1 + \alpha(1-\alpha)^2 A_0 \quad (4)$$

$$F_4 = \alpha A_3 + \alpha(1-\alpha)A_2 + \alpha(1-\alpha)^2 A_1 + \alpha(1-\alpha)^3 A_0 \quad (5)$$

$$F_5 = \alpha A_4 + \alpha(1-\alpha)A_3 + \alpha(1-\alpha)^2 A_2 + \alpha(1-\alpha)^3 A_1 + \alpha(1-\alpha)^4 A_0 \quad (6)$$

And so on…..
The most commonly used measures of forecast accuracy are discussed by Mentzer and Kahn (1995). In this paper, mean square error and mean absolute deviation are considered to measure forecast accuracy.
Now Mean Square Error (MSE) can be determined as,

$$MSE = \sum_{i=1}^{t}(F_i - A_i)^2 / t$$

This can be written as,

$$MSE = [(F_1 - A_1)^2 + (F_2 - A_2)^2 + (F_3 - A_3)^2 + \ldots\ldots\ldots\ldots + (F_t - A_t)^2]/t$$

Putting the value of $F_1, F_2, F_3, \ldots\ldots\ldots, F_t$ equation of MSE is found,

$$MSE = [\{A_0 - A_1\}^2 + \{\alpha A_1 + \alpha(1-\alpha)A_0 - A_2\}^2 + \{\alpha A_2 + \alpha(1-\alpha)A_1 + \alpha(1-\alpha)^2 A_0 - A_3\}^2 + \ldots\ldots\ldots + \{\alpha A_{t-1} + \alpha(1-\alpha)A_{t-2} + \alpha(1-\alpha)^2 A_{t-3} + \ldots\ldots\ldots\ldots + \alpha(1-\alpha)^{t-1} A_0 - A_t\}^2]/t \quad (7)$$

Again, Mean Absolute Deviation (MAD) is given by,

$$MAD = \sum_{i=1}^{t}|(F_i - A_i)| / t$$

This can be written as,

$$MAD = [|(F_1 - A_1)| + |(F_2 - A_2)| + |(F_3 - A_3)| + \ldots\ldots\ldots\ldots + |(F_t - A_t)|]/t$$

Putting the value of $F_1, F_2, F_3, \ldots\ldots\ldots, F_t$ equation of MAD is found

$$MAD = [|\{A_0 - A_1\}| + |\{\alpha A_1 + \alpha(1-\alpha)A_0 - A_2\}| + |\{\alpha A_2 + \alpha(1-\alpha)A_1 + \alpha(1-\alpha)^2 A_0 - A_3\}| + \ldots\ldots\ldots + |\{\alpha A_{t-1} + \alpha(1-\alpha)A_{t-2} + \alpha(1-\alpha)^2 A_{t-3} + \ldots\ldots\ldots\ldots + \alpha(1-\alpha)^{t-1} A_0 - A_t\}|]/t \quad (8)$$

Now Trial and Error method is used to find minimum value of exponential smoothing constant. Putting the different values within 0 to 1 for exponential smoothing constant, MSE and MAD are calculated.

III. Result and Discussion

The method is described by considering a problem. A company's historical sales data are given for some previous periods. Actual values of sales are given in Table 1.

Table 1: Actual values sales data

Period (t)	Actual Value (A_t) (In thousands)
0	10
1	8
2	14
3	13
4	12
5	12.5

For different values of exponential smoothing constant, MSE and MAD are calculates. Mean square error for different values of exponential smoothing constant are determined using equation (7). Table 2 shows the MSE values for different α.

Table 2: MSE for different values of α

Exponential smoothing constant (α)	Mean Square Error (MSE)
0	133.85
0.1	76.374
0.2	45.241
0.3	28.3
0.4	18.95
0.5	13.685
0.6	10.687
0.7	9.02
0.8	8.211
0.82	8.13
0.84	8.074
0.85	8.054
0.86	8.04
0.87	8.033
0.88	8.031
0.89	8.034
0.9	8.044
0.95	8.175
0.97	8.267
1	8.45

Mean absolute deviation for different values of exponential smoothing constant are determined using equation (8). Table 3 presents the MAD values for different α.

Table 3: MAD for different values of α

Exponential smoothing constant (α)	Mean Absolute Deviation (MAD)
0	10.7
0.1	8.038
0.2	6.028
0.3	4.535
0.4	3.443
0.5	2.663
0.6	2.241
0.7	2.041
0.75	1.961
0.78	1.919
0.8	1.894
0.82	1.869
0.83	1.858
0.84	1.867
0.88	1.921
0.9	1.949
0.95	2.022
0.98	2.068
1	2.1

Values of MSE and MAD are differed with the values of α. MSE is decreased with increasing α up to 0.88 and after that MSE increases. Variation of MSE with α is shown in Figure 1. MAD is decreased with increasing α up to 0.83 and after that MAD is increased. Variation of MAD with α is shown in Figure 2. The value of exponential smoothing constant is 0.88 and 0.83 for minimum MSE and MAD respectively.

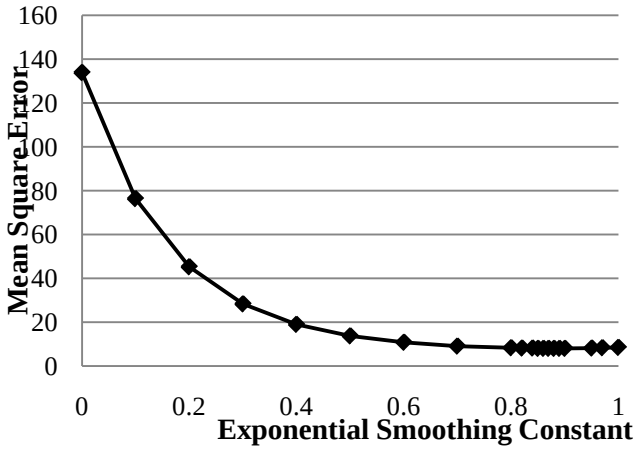

Figure 1: Variation of Mean Square Error for different values of α

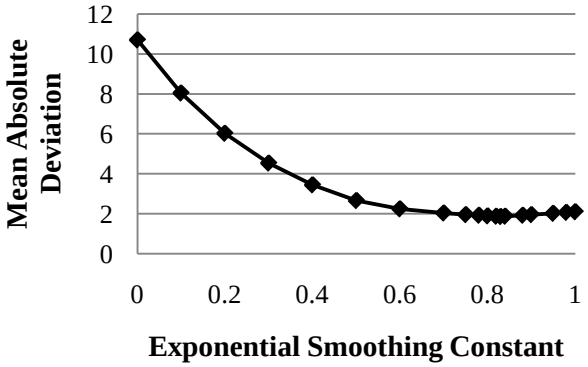

Figure 2: Variation of Mean Absolute Deviation for different values of α

To find the optimal value of exponential smoothing constant, minimum values of MSE and MAD are selected and corresponding value of exponential smoothing constant is the optimal value for this problem.

Minimum values of MSE and MAD and corresponding value of exponential smoothing constant is given in Table 4.

Table 4: Optimal Values of α for minimum MSE and MAD

Criteria	Minimum Value	Optimal value of α
Mean Square Error	8.031	0.88
Mean Absolute Deviation	1.858	0.83

From the optimal value of α, forecast values for different period are determined using equation (1) and it is shown is Table 5. From the five period actual values, a sale at sixth period is also forecasted. Forecasts at sixth period are 12.455 thousand and 12.068 thousands for minimum MSE and MAD respectively.

Table 5: Forecast values for minimum MSE and MAD

Period	Actual values (in thousands)	Forecast values (in thousands) for minimum MSE	Forecast values (in thousands) for minimum MAD
0	10	---	---
1	8	10	10
2	14	8.096	8.051
3	13	13.291	12.750
4	12	13.034	12.765
5	12.5	12.124	11.794
6	---	12.455	12.068

Figure 3 represents the actual values and corresponding forecast values for minimum mean square error. At period 2, forecast value differs significantly from actual value because forecast at period 1 is equal to actual value at period 0 and after that, forecast values are very close to actual values. The minimum mean absolute deviation is shown in Figure 4. actual values and corresponding forecast values for

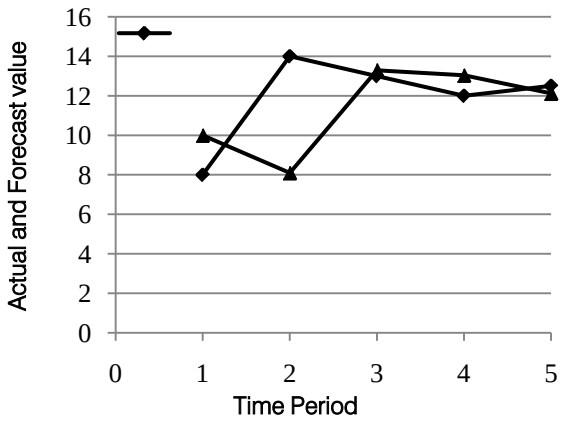

Figure 3: Comparison of actual values and forecast

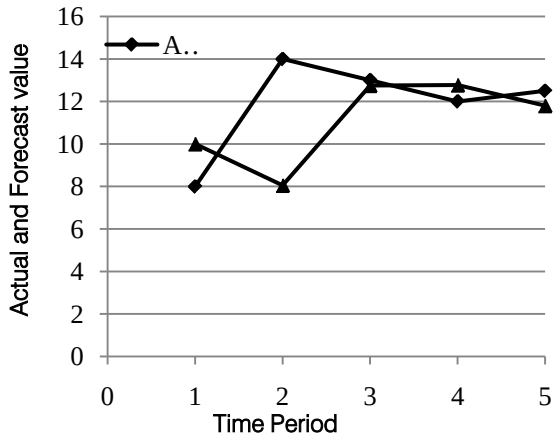

Figure 4: Comparison of actual values and forecast values to minimize MAD

VII. Conclusions

An exponential smoothing technique is widely used by many organizations to predict the future events. But problems are raised to assign the value of exponential smoothing constant. In this paper, this problem is solved by determining the optimal value of exponential smoothing constant. Mean square error and mean absolute deviation are minimized to get optimal value of the constant and optimal values are 0.88 and 0.83 for minimum mean square error and mean absolute deviation respectively. In this method, any organization can compute the optimal value of exponential smoothing constant to enhance the accuracy of forecasting. This work can be extended to minimize some other forecast errors such as mean absolute percent error (MAPE), cumulative forecast error (CFE) etc.

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Global Journal of Research in Engineering
Volume 11 Issue 3 Version 1.0 April 2011
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
ISSN: 0975-5861

Analysis of Technological advancements in Pakistani Automobile Car Industry

By M. Shahrukh Mirza, Irfan Anjum Manarvi

Abstract- The auto market is one of the largest segments in world trade. The annual size of automotive export trade in the world has grown to a massive level of over US$ 600 billion, which accounts for about 10 percent of the world export. Changing models, improving fuel efficiency, cutting costs and enhancing user comfort without compromising quality are the most important challenges of the auto industry in a fastly globalizing world. Hence there is a need for exploring the industrial collaborations in this sector globally for better quality, favorable costs, fuel efficiency and attractive designs. Therefore, the requirement of information exchange is much more pronounced now then ever before for keeping the auto industry afloat and competitive.

In third world countries, due to non availability of indigenous development, lack of necessary skill level and industrial infrastructure, no institutionalized set up appears to be available to back up the acquired technology and facilitate its absorption.

The Pakistani Automobile Industry is amongst the fastest growing sector in national economy. Heavy investments have been made in establishing Automobiles assembling plants by various global automobile manufacturers during past few years. Under 'The Auto Industry Development Programs', through incentives offered by 'The Government of Pakistan, deletion of automobiles spare parts up to a certain level is being carried out by automobile manufacturers depending upon the potential capabilities and infrastructure availability with the local vendors. The objective of this research is to understand the advantages attained by Pakistani automobile car assemblers and vendors, during last thirty years through mutual collaboration and technology acquisition from global automobile manufacturers.

This paper also focuses on the deletion of spare parts of various locally assembled automobile cars by analyzing those vendors who are generating maximum revenues through production of these spare parts under foreign technical assistance, cost effectiveness of these parts compared to imported parts and the manufacture of complex parts locally. Based on the analysis of above mentioned variables through graphs, various inferences are drawn and recommendations given for further improvement of the automobile industry of Pakistan.

Classification: *GJRE-A Classification: FOR Code: 091302,091303*

Strictly as per the compliance and regulations of:

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I. Introduction

"Give a man a fish and you will feed him for a day. Teach him how to catch fish and you will feed him for the whole life"
(Chinese Proverb)

The Asia-Pacific region is considered by many scholars, practitioners, and investors to be one of dynamic and rapidly growing economic regions in the world. Countries included in this region are Japan, China, Taiwan, South Korea, North Korea, Hong Kong, Thailand, Malaysia, Indonesia, Singapore, Philippines, Vietnam, India and Pakistan. The region is a voracious importer of new technologies and an innovative user of existing technologies. Many of these countries have undergone major economic reforms to be able to facilitate the domestic firms to compete in the global market. Many strategic alliances, joint ventures (JVs), and collaborations came into existence. Lately, many of these firms expanded their operations in other countries to evolve into multinational companies.

In Pakistan, the process of economic reforms started in 1960s, which was followed by partial accessibility in 1980s. The market was fully opened up for foreign firms in late 1980s. In the wake of globalization of trade, commerce industry and liberalization of economies of the various countries of the world, it has become mandatory for all the players to have a sound technology base, without which accomplishing operational and strategic goals would become not only uneconomical but almost impossible. The increasingly demanding global business environment calls for a separate management function which looks after corporate interests of the technology.

At the global level, there are perceived advantages of technological collaborations that are taking place all over the world. Developed and developing countries stand to gain from legislative and economic reforms. Technology transfer is now taking place in Pakistan with organizations from many developed countries like US, Japan, UK, Germany, etc.

Competitiveness of an organization can be accessed from various parameters, the most important of them being technological innovations and breakthroughs which the organizations realize over a period of time. It may be difficult to measure the impact of adopting an innovation or rejecting the same, but over a period of time overall financial and marketing

results can definitely help in drawing conclusions regarding technology-based decisions. Technological changes and decisions to adapt to changes in the environment can make or break an organization. Examples of the significant impact of commercializing a technology on the overall performance of the organization are numerous, from the invention of the steam engine to intelligent cars. In the changing global scenario, those organizations that integrate technology related decisions into business strategies have considerably improved their chances of reaping benefits from technological innovations. There is always an element of risk associated with adoption of a new technology. This indicates that technological innovations cannot be adopted without prior analysis in context to a particular organization. Technology involves moderate to high investments, and it also has an effective lifetime, after which the same technology may not remain commercially viable and hence, needs either upgrading or total replacement. Under the circumstances, where total replacement is called for, the previous technology which was in use must generate enough revenues so that the investment for the new one may be either totally or partly funded from operations.

New organizations must consider all these factors quite carefully, and the choice of technology becomes an extremely crucial decision for them. For existing organizations, a watchful approach will help not only in survival and growth but also in taking and maintaining technological leadership in their respective industries. For those organizations that are already technology leaders of their respective industries, technology management strategy becomes a more crucial weapon by which they can sustain their positions in their existing businesses and also explore new markets, thereby restricting the entry of competitors and exit of customers in different parts of the world. By evolving suitable technology strategy leading firms can identify and cultivate core competencies in the businesses they are in.

II. Research Methodology

The study carried out in this paper covers the major Pakistani automobile car companies carrying out collaborations for technological advancement in 1980s and 1990s. It also addresses the advancements made in acquisition of technology by Pakistani Automobile car Vendors with special emphasis on clarity in technology acquisition, rather than mere manufacturing and operational know how, by developing the capabilities to adopt, adapt and implement new technologies, indigenization, competitiveness and effectiveness of technological alliances. The study also examines the nature and impact of Auto Industry Development Programs, planned by the government of Pakistan, for effective technology management and gradual parts deletion . During the course of study, following variables have been worked out:

A. *Major vendors in Pakistani Automobile Industry*
B. *Key products of these vendors as per their complexity.*
C. *Date since manufacturing these parts.*
D. *Automobiles using these parts.*
E. *Product quality certification of these vendors.*
F. *Cost of locally manufactured parts.*
G. *Cost of imported parts.*
H. *Savings because of Vendors.*
I. *Business volume of Vendors.*
J. *Number of parts produced annually.*

III. The Auto Industry Development Program

Pakistani auto industry observed a "Preparation Phase – 1985-2005" which was based on the formulation and implementation of compulsory local content conditions, commonly referred as deletion programs. Deletion programs worked on the basis of Industry Specific Deletion Programs (ISDPs) and Product Specific Deletion Programs (PSDP). Under these programs annual deletion targets for each model of vehicle would be set by giving choice to assembler to choose components from a basket carrying fixed indices based on their individual values. The Engineering Development Board (EDB) would conduct the technical audits annually to determine the achievement or shortfall of deletion targets. In case of shortfall, assemblers would be penalized by charging the Component Based Unit (CBU) rate of duty on the value of components which were not indigenized in that period.

The auto industry expressed resilience during the next 1 ½ year before it switched over from compulsory local content conditions for Trade Related Investment Measures (TRIMs), to compliant tariff based system (TBS), which came into effect on 1st July, 2006. The changeover was relatively hassle free for the assemblers but has posed many challenges to the vendors who remained comfortable in the previous system and are now pushed to improve the quality, supply systems, shop floor efficiencies and better marketing. The industry nevertheless faces a challenge of relatively poor human resource skills and productivity despite it being cheap and abundantly available. The issues of re-location, mergers and lean / mean production technologies are now more frequently discussed in the stakeholders meetings. Investment in modern production infrastructure, testing equipment and automation remains high priority.

The vendors are mostly SMEs (Small Medium Enterprises), which are developing their approach and are looking for professional support to reintegrate and

re-design their work flow processes and improve quality through better technologies, testing equipment and adoption of best manufacturing practices.

Government has approved a 5 year tariff plan in 2008, 'The Auto Industry Development Program', for the auto sector to ensure a stable and predictable environment and to facilitate investment. Government is now focused on facilitating the industry through development of infrastructure, human resource development, technology acquisitions, investment in productive assets, cluster development and development of standards on safety, quality and environment through a well structured and deliberate approach. The cornerstone of approach remains close consultation and ensuring stake holders participation in implementation and assessment of policy.

AIDP envisage to achieve a critical mass of production, double the contribution of auto industry to GDP from the existing 2.8%, by the year 2011-12 with high focus on investment, technology up gradation, increasing its exports to US$ 650 million, enhancement in jobs alongside the development of critical components to further increase the competitiveness of domestically produced vehicles.

IV. Major Automobile Car Assemblers in Pakistan

There are three major automobile assemblers of passenger cars dominating the Pakistani market with maximum business volume and annual production. In this study, the area of research is focused on the "Car Manufacturing Companies and Vendors associated with them". Details are described as following.

a) Indus Motor Company

Indus Motors have established a Joint Venture with Toyota Motors Corporation Japan, in 1993, to acquire essential training and knowhow for assembling Toyota and Daihatsu vehicles. Currently they are producing following vehicles.

Daihatsu Cuore – 1000 cc (production: 200-300 vehicles per month).
Toyota Corolla- 1300 cc and 1800 cc (production: 3000-3500 vehicles per month).
Toyota Corolla Diesel – 2000 cc (production: 2000-2500 vehicles per month).
Toyota Hilux – 3000 cc (production: 500-700 vehicles per month).

Toyota is involved in technology transfer directly to local vendors through parts, drawings and process sheets. Infrastructure and manufacturing facility is monitored first to judge the potential of a local vendor before permitting him to provide sample of the product for testing/ approval. Japanese are ready to provide technological assistance up to a certain level, but still no adequate infrastructure and skilled manpower has been evolved to meet the desired standards.

An average of only 45% parts of various models have been permitted to be developed locally by Toyota after their extensive test trials in Japan. Due to non availability of expensive quality control equipment, all precision safety components are imported. Extensive training at all levels is being imparted locally at factory area in Karachi as well at dealerships throughout Pakistan. Highly trained engineers and technicians are also sent to Toyota Behren Training Centre for further skills enhancement. Manufacturing knowhow is transferred directly to local vendors as per their qualification and skills, whereas assembly and operational knowhow is provided to Indus Motor Company.

Initially, manufactured product sample by a vendor is tested locally by Toyota experts. Later it is sent to Toyota Japan for further trials. The benefits achieved by Toyota include saving of foreign exchange through development of 45% local parts. Also, local industry is promoted and developed resulting in employment benefits and economic boost as per Pakistani government policy. There is no long term government policy for auto industry development. Yet short term policies are made time to time, following tariff based systems with no fixed quantity of parts to be developed locally (AIDP). Many auto assemblers in Pakistan are not getting any parts manufactured locally, due to non implementation of any policy forcefully and to avoid giving design and manufacturing knowhow to local vendor industry.

Due to non availability of research and development facilities in automobile industry, lack of highly skilled manpower and well developed infrastructure, it is extremely difficult for any foreign automobile manufacturer to provide any manufacturing technology to Pakistan.

b) Pak Suzuki Motor Company

Pak Suzuki was established as a Joint Venture with Suzuki Motors Japan, in 1982, to acquire essential training and knowhow for assembling Suzuki vehicles. Currently they are producing following vehicles .

Suzuki Mehran – 800 cc (production : 3000-3500 vehicles per month).
Suzuki Bolan – 800 cc (production : 3000-3500 vehicles per month).
Suzuki Alto – 1000 cc (production : 2500-3000 vehicles per month).
Suzuki Cultus – 1000 cc (production : 1500-2000 vehicles per month).
Suzuki Swift – 1000 cc (production : 50-100 vehicles per month).
Suzuki Liana - 1300 cc (production : 300-500 vehicles per month).

Suzuki Motors Japan supports the technology transfer directly to local vendors through parts, drawings and process sheets. Based on the

infrastructure, manufacturing facility and the potential, a local vendor is permitted to provide sample of the product for approval. Due to the increasing demand of automobiles day by day and non availability of strong competitors in local market, the company remains unable to meet the technological assistance requirements of local vendors to the desired level. Still no adequate Quality Control Standards are emphasized to meet the required standards of the automobiles. This has resulted in consistently deteriorated quality of the finished products especially in Mehran, Bolan and Alto vehicles.

Averages of 65% parts amongst all products have been developed locally after their test trials. Due to non availability of expensive quality control equipment, many of the precision safety components are imported. Regular training at all levels is being imparted locally at factory area in Karachi as well at dealerships throughout Pakistan. Manufacturing knowhow is transferred directly to local vendors as per their qualification and skills, whereas assembly and operational knowhow is transferred to Pak Suzuki Motor Company.

The benefits achieved by Suzuki include saving of foreign exchange through development of 65% local parts. Also, local industry is promoted and developed resulting in employment benefits and economic boost as per Pakistani government policy.

c) Honda Atlas Car

Atlas Group has established a Joint Venture with Honda Motor Company Japan, in 1994, to acquire essential training and knowhow for assembling Honda Cars. Currently they are producing following vehicles .

Honda Civic – 1600 cc (production : 2000-2500 Cars per month).

Honda City - 1300 cc (production : 1000-1500 Cars per month).

Honda Motor Company Japan is getting only 5% parts manufactured locally, due to non implementation of Government policy (AIDP) forcefully and to avoid giving any design and manufacturing knowhow to local vendor industry. They are of the opinion that due to non availability of research and development facilities in automobile industry, lack of highly skilled manpower and well developed infrastructure, it is extremely difficult for Honda to provide any manufacturing technology to Pakistan. Instead of relying on local vendors, Honda has continued to import their vehicle parts. It can be a short term advantage for them. But in long term, they are loosing credibility in local market through increased production cost by depreciation in currency value and non availability of local vendors for manufacturing their vehicle parts.

V. Role of Vendors in Auto Parts Manufacturing and Their Technological Capabilities

Various vendors started establishing their setups in 1960s initially with foundries to manufacture small parts of Tractors and Bedford trucks. Later on, they specialized gradually in cast and machined ductile Precision Engineering Components for various automobiles. Currently, some of them, like Rastgar Engineering, have started parts export also. Most of the Vendors have acquired Certification of ISO / TS 16949: Development and Manufacturing of Automobile Parts, from various foreign organizations. These Technological Standards are accepted globally and audited technically by leading US, German and Japanese car manufacturers. As per certifications and technological collaborations with various Foundry and Machining Associations of USA and Europe, most of the vendors are trying to meet all desired specifications in auto parts manufacturing as per customer requirements. Some are also spending fairly large amount annually on their R&D programs to design parts locally and carryout their development and testing under foreign support. A large number of test equipments and gadgetry are acquired by vendor industry to conform their products quality, strength, performance and reliability with global requirements. Details about some of the test equipments are as following.

1. *Optical Emission Spectrometer; Q6 Columbus.*
2. *Coordinate Measuring Machine; Mitutoyo.*
3. *Cryogenic Impact Testing Machine.*
4. *Ultrasonic Flaw Detector.*
5. *Universal Cross Sectional Testing Machine.*
6. *Metal Image Analyzer.*
7. *Profile Projector.*
8. *Burst Test Machine.*

Inspection- Rastgar Engineering.

(Figure:1)

Continuous ongoing training is now considered mandatory at all levels from managerial to technician /

operator by most of the leading vendors. Up gradation training and refresher courses are also carried out at regular intervals. Special emphasis on training is given before

adoption of new technologies.

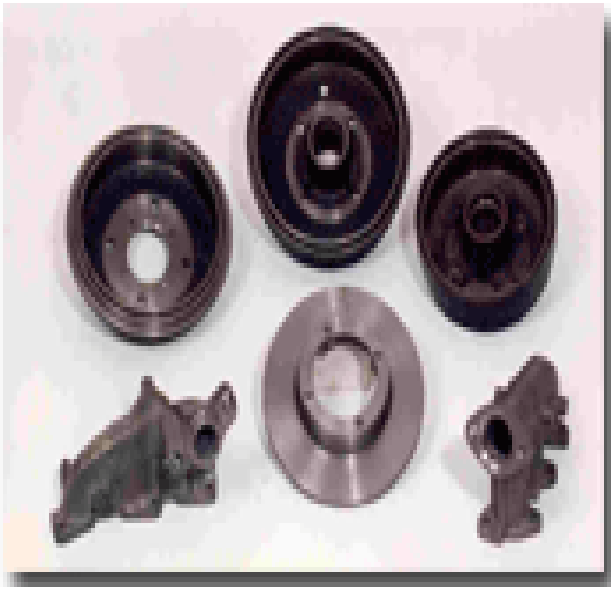
Today, many of the Pakistani vendors have attained Competitive Advantages locally as well in South East Asia, by acquiring the status of sole manufacturers of complex mechanical parts. These products are also exported globally as OEM (Original Equipment Manufacturer). For example, Rastgar Engineering is the only non Toyota company in the region after Japan and Thailand, manufacturing Steering Knuckle Assembly of new Corolla (2009-10 model).

Regular R&D feature as per customer requirements and latest state of the art technology makes them prominent in local as well in global market. Most of the local Vendors have achieved the Cost effectiveness in reliability and quality as compared to imported parts. That is why many global car manufacturers are getting their parts manufactured locally.

Technology up gradation is also being established as a regular feature by Pakistani Automobile Vendor Industry. Establishment of new Core Shops under collaboration with foreign Foundries to make Binder Risin (chemical) for auto parts and installation of automated Fatling and Grinding Machines are a few examples of utilizing latest techniques in auto parts manufacturing.

Various Globally accepted parts manufactured by local Vendors.

(Figure:2)



Self Reliance in automobile Vendor Industry cannot be achieved without adequate government support through Investment friendly policies, basic infrastructure and facilities provision. In addition, a close interaction between Academia and Industry is essential in human resource as well as in R&D support. Due to availability of all these above mentioned requirements, India is advancing speedily towards self reliance.

VI. Major Vendors Associated With Automobile Parts Manufacturing

Sr.No	Name of Vendor	Products of Vendor	Date since making parts	Vehicles using these parts
1	Allied Engineering Works	Shock Absorbers-150 (Gabriel)	1990	Toyota Corolla, Suzuki Mehran
		Shock Absorbers-160 (Gabriel)	1996	Suzuki Alto, Suzuki Bolan
2	Agri Auto Industry	Shock Absorbers	1988	Toyota Corolla, Suzuki Alto
		Struts Assembly	1995	Daihatsu Cuore, Suzuki Liana
		Steering gear box	2005	Suzuki Alto, Suzuki Bolan
3	Alsons auto parts (pvt) Ltd	Cooling Fans	1992	Toyota Corolla, Daihatsu Cuore
		Brake Assembly	1992	Suzuki Vehicles (All type)
4	Atlas Engineering	Radiators, Fly wheel assembly	1967	Toyota Corolla, Daihatsu Cuore
		Disc Brake, Brake Drum	1982	Suzuki Van/ Pickup
		Piston, Sleeves	1996	
5	Atlas Battery Company	Dry Cell Batteries.	1969	Vehicles (All type)
		Range (12V 6 AH to 12V 200 AH)		
6	Baluchistan wheels limited	Wheel rims.	1980	Vehicles (All type)
		Range (12 inch to 30 inch)		
7	General Tires.	Tire size	1964	Vehicles (All type)
		Diameter (12 inch to 30 inch)		
8	Infinity Engineering	Spur gear for transmission .	1994	Toyota Corolla, Daihatsu Cuore
		Transmission shafts, Connecting Rod.	1994	Suzuki Vehicles.
9	Mecas Engineering (pvt) limited	Brake Disc, Drum.	1987	Toyota Corolla, Daihatsu Cuore
		Axle Hub Mounting Bracket.	2000	Suzuki Vehicles.
10	Rastgar Engineering	Steering Knuckle.	1994	Toyota Corolla, Daihatsu Cuore

a) Various Automobile parts manufactured by Vendors.

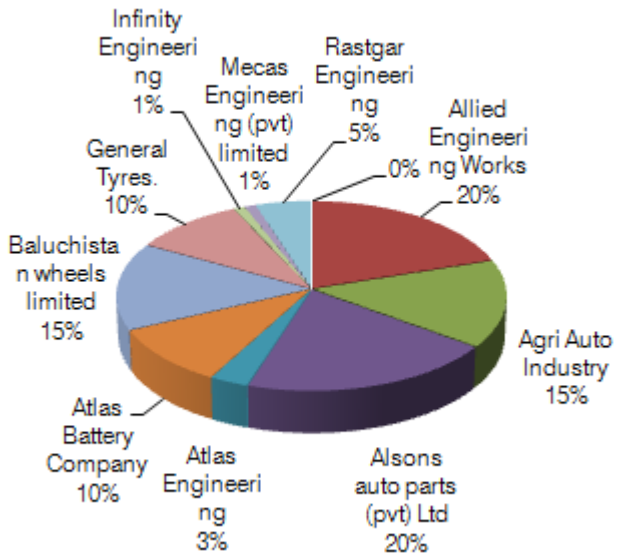
AGRI AUTO INDUSTRY.

(Figure:3)

ATLAS ENGINEERING.

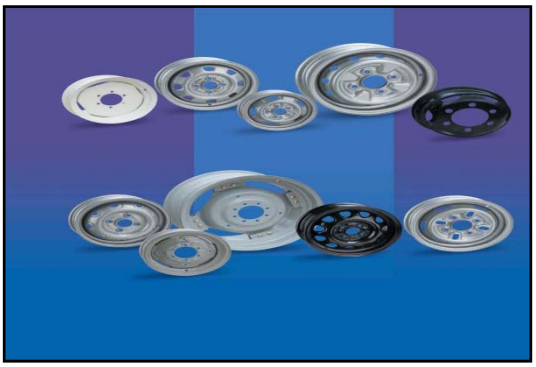
(Figure:4)

Share of each Vendor in manufacturing of Automobile parts: (%)



BALUCHISTAN WHEELS

(Figure:5)



GENERAL TIRES

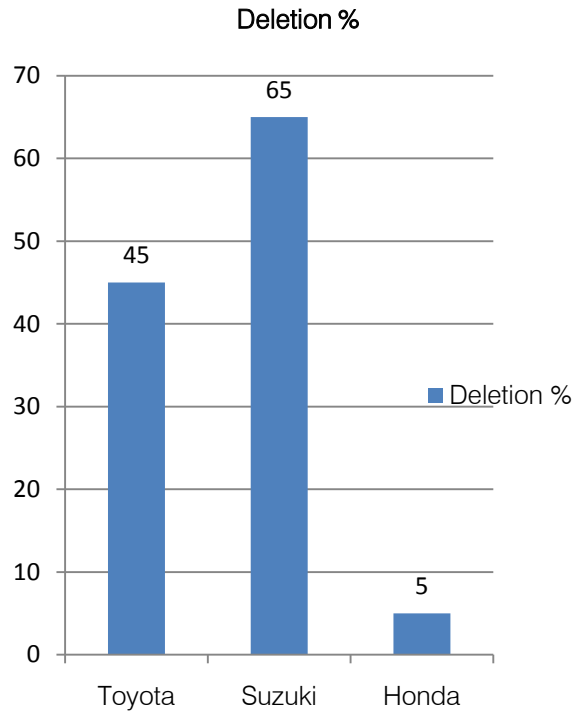
(Figure:6)

MECAS ENGINEERING.

(Figure:7)

VII. The Effectiveness of Automobile Parts Deletion Program

a) Toyota, Suzuki, Honda - Deletion %.

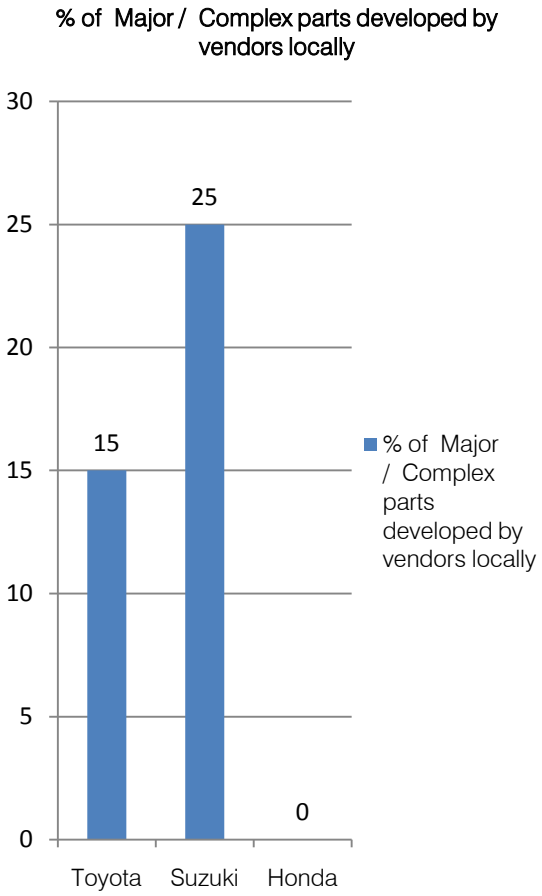


Results indicate that Suzuki has followed maximum deletion program by supporting local vendors. However , despite generating high business volume and large scale products, the company has given secondary importance to Quality of parts. No strict Quality Control measures have been adopted to avoid compromise on product reliability and performance. This gives Low Quality Products with Dissatisfied Customers.

Toyota has although slightly less % of parts deletion, yet it has never compromised on parts quality until proven successful. This has resulted in satisfactory performance of its products, considered trust worthy by customers and truly claimed as Reliability in Motion.

Honda, on the other hand has entirely different picture. Instead of relying on local vendors, Honda has continued to import their vehicle parts. It can be a short term advantage for them but in the long term, they are losing credibility in local market through increased production cost by depreciation in currency value and non availability of local vendors for manufacturing their vehicle parts.

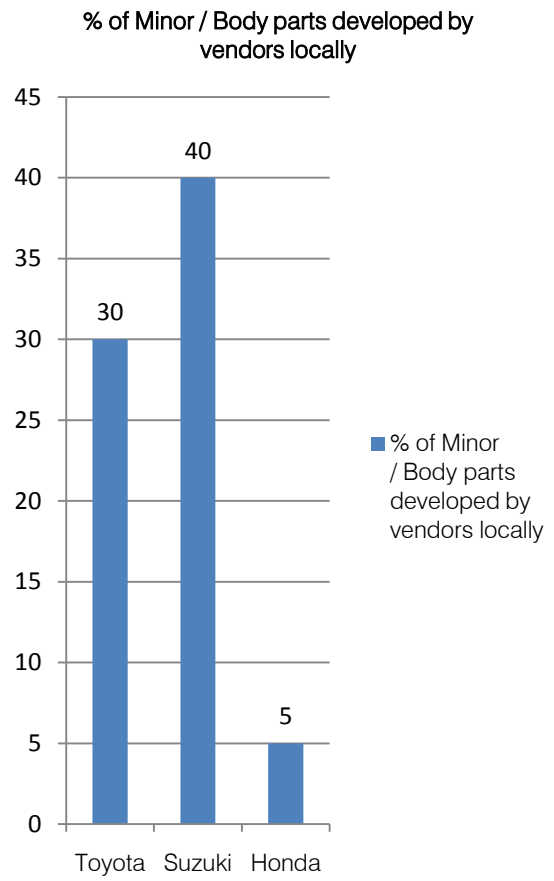
b) Toyota, Suzuki, Honda- % of Major/ Complex parts developed by vendors.



Although Suzuki is getting more complex parts developed through vendors locally, however no rigid quality control is applied. Unless it takes strong measures and adequate quality checks on local parts production, its products quality will never improve. This may result in reduction of its share in local automobile market, no matter how much bulk production it carries.

Toyota, is having relatively lesser share in developing complex parts through local vendors. Yet it has never compromised on product quality and reliability. Through adequate technological support and quality checks, it will certainly come up having largest automobile products share in local market in near future.

c) Toyota, Suzuki, Honda- % of Minor/ Body parts developed by vendors.

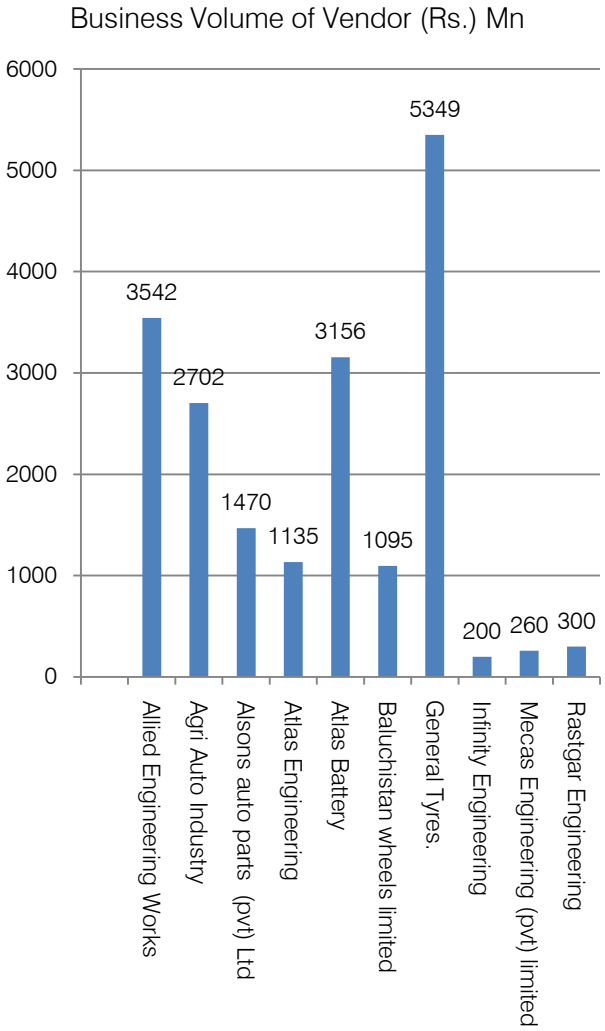


Suzuki is getting more minor/body parts developed through vendors locally, still no rigid quality control is applied. Unless strong measures and adequate quality checks on local parts production is not taken, its products quality will never improve. This may lead to the reduction of its share in local automobile market, no matter how much bulk production it carries.

Toyota, having slightly lesser share in developing minor/body parts through local vendors. Yet it has never compromised on product quality and reliability. Through adequate technological support and quality checks, it is gradually coming up having largest automobile products share in local market.

Honda is continuing to import their vehicle parts and have only utilized the Tires and Batteries, produced locally, in Honda Cars. Misinterpretation of Government Policy will continue to occur unless implemented forcefully. Honda is also losing its credibility amongst the local customers.

d) Vendors Vs Business Volume in local market.

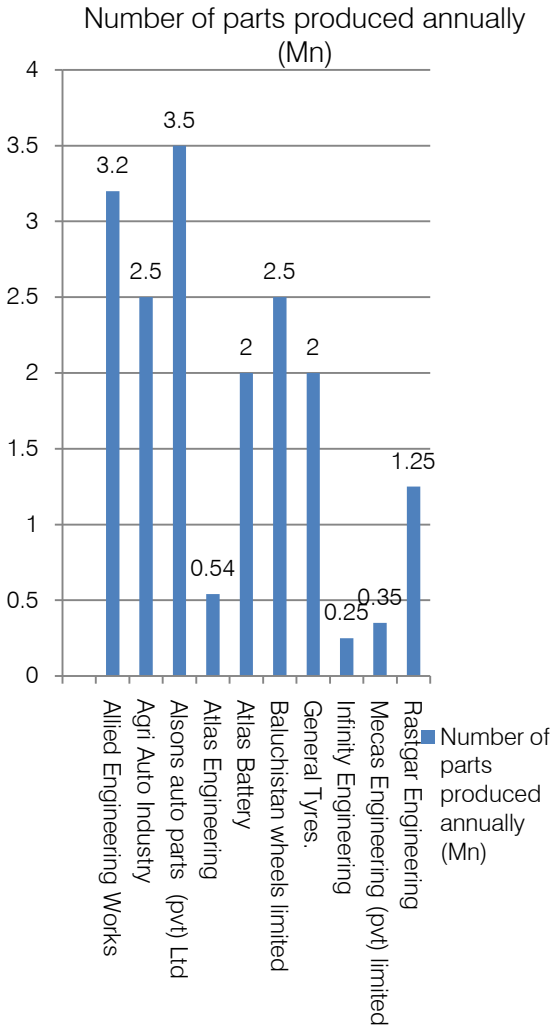


The graph shows that General Tires is having the highest business volume, being the sole manufacturer of tires in Pakistan. This is followed by Atlas Battery, being utilized in bulk for all kinds of automobiles especially the cars.

Small and bulk utilized parts manufacturing firms are also having major share in local business. Reason being producing frequently replaced parts like shock absorbers, brake parts, gears and shafts.

Complex and larger parts manufacturing vendors are having lesser share in local business, having the production of less replaced parts. Moreover, most of them are also exporting parts. For example, Rastgar Engineering is having 70 % of its parts exported and only 30% supplied to local market.

e) Vendors Vs Number of parts produced annually.

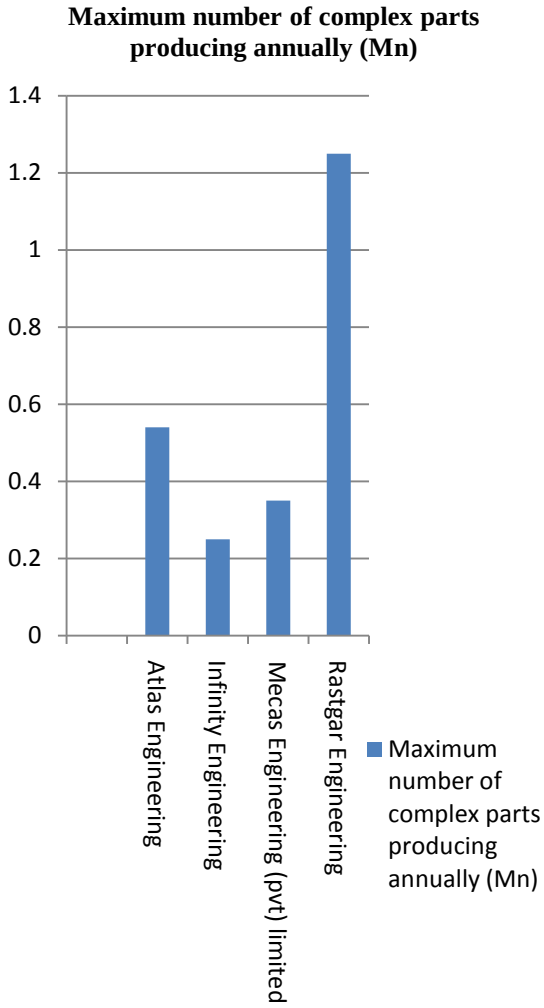


The graph clearly indicates General Tires, Atlas Battery and Baluchistan wheels are having relatively higher production volume, being the sole manufacturers of products in Pakistan.

Small and bulk utilized parts manufacturing firms getting major share in production volume having frequently replaced parts in production like shock absorbers, brake parts, gears and shafts.

Complex and larger parts manufacturing vendors like Atlas, Infinity, Mecas and Rastgar Engineering are having lesser share in local production, manufacturing less replaced parts. Some of them are also exporting parts.

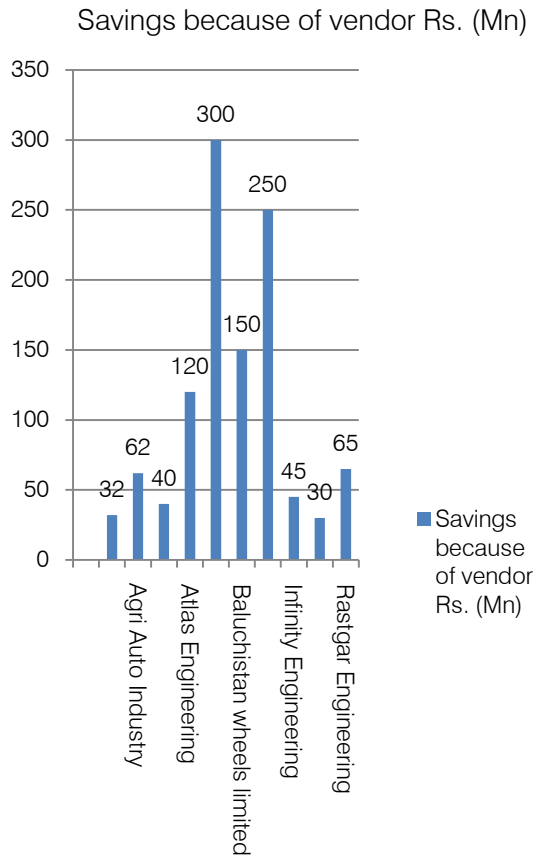
f) *Vendors Vs Maximum number of Complex parts producing.*



The graph shows Rastgar, Mecas, Infinity and Atlas engineering produce maximum number of complex parts like steering knuckle, axle hubs, disc plates, gears, shafts, piston.

Rastgar is the leading vendor in innovation and technological advancement. Having acquired state of the art manufacturing techniques from US and Germany, it is producing a vide range of precision products for the global vendors as per their requirements.

g) Vendors Vs Savings because of vendors.



The graph clearly indicates General Tires, Atlas Battery and Baluchistan wheels are getting maximum savings through larger differences in prices of imported products as compared to their locally manufactured products.

Small and bulk utilized parts manufacturing companies give comparatively lesser savings in terms of cost difference, because of having lesser price variations in smaller parts as compared to larger parts. For example, difference in price of imported and local shock absorber will be much lesser as compared to the Tire prices.

Complex parts manufacturers may have larger differences in their product prices as compared to imported, but many of them are getting their products exported as per global car manufacturers requirements. Hence their profit margins cannot be termed as the Savings.

VIII. Findings From Role of Car Manufacturers and Vendors

a) Performance of car manufacturers

1. PAK SUZUKI MOTOR COMPANY

The company has followed maximum deletion program by supporting local vendors. However, despite generating high business volume and large scale products, the company has given secondary importance to Quality of parts. No strict Quality Control measures have been adopted to avoid compromise on product reliability and performance resulting in **low quality products** and **dissatisfied customer.**

Suzuki is getting many complex as well as minor / body parts developed through vendors locally, but no rigid quality control is applied. Unless it takes strong measures and adequate quality checks on local parts production, its products quality will never improve. This may **result in reduction of its share in local automobile market**, no matter how much bulk production it carries.

2. INDUS MOTOR COMPANY

Although having slightly less % of parts deletion, yet Indus Motors have never compromised on parts quality until proven successful. This has resulted in satisfactory performance of its products, considered trust worthy by customers and truly claimed as Reliability in Motion.

Indus Motors have relatively lesser share in developing complex as well as minor / body parts through local vendors. But they have never compromised on parts quality and reliability. Through adequate technological support and quality checks, they are gradually coming up with largest automobile products share in local market in near future.

3. HONDA ATLAS CARS

They have entirely different picture. Instead of relying on local vendors, Honda has continued to import their vehicle parts. It can be a short term advantage for them but in the long term, they are losing credibility in local market through increased production cost by depreciation in currency value and non availability of local vendors for manufacturing their vehicle parts.

b) Performance of Vendors

1. TRAINING AND DEVELOPMENT OF SKILLED MANPOWER

Continuous ongoing training is being emphasized at all levels from managerial to technician / operator by most of the leading vendors. Up gradation training and refresher courses are also carried out at regular intervals. Special emphasis on training is given before adoption of new technologies, locally as well as abroad, keeping in view the requirements.

2. UTILIZING LATEST EQUIPMENT AND TECHNIQUES

By acquiring Certification of ISO / TS 16949: Development and Manufacturing of Automobile Parts, majority of the vendors have become able to carry out technological collaborations with various Foundry and Machining Associations of USA and Europe. This has

resulted in precise auto parts manufacturing as per customer requirements. A large number of test equipment and gadgetry has also been acquired by vendor industry to conform their products quality, strength, performance and reliability to global standards.

3. DEVELOPMENT OF COMPLEX AND PRECISION PRODUCTS.

Many of the Pakistani vendors have attained Competitive Advantages locally as well in South East Asia, by acquiring the status of sole manufacturers of complex mechanical parts. These products are also exported globally as OEM (Original Equipment Manufacturer). For example, Rastgar Engineering is the only non Toyota company in the region after Japan and Thailand, manufacturing Steering Knuckle Assembly of new Corolla (2009-10 model).

Regular R&D feature as per customer requirements and latest state of the art technology makes them prominent in local as well in global market.

4. UP GRADATION OF TECHNOLOGY.

Technology up gradation is also being established as a regular feature by Pakistani Automobile Vendor Industry. Establishment of new Core Shops under collaboration with foreign Foundries to make Binder Risin (chemical) for auto parts and installation of automated Fatling and Grinding Machines are a few examples of utilizing latest technology in auto parts manufacturing.

5. BUSINESS AND PRODUCTION VOLUME.

Large scale manufacturers like General Tires, Atlas Battery and Baluchistan wheels have managed the highest business and production volume, being the sole manufacturers of specialized products in Pakistan. Small and bulk utilized parts manufacturing firms including Alsons, Allied and Agri Auto Engineering have also acquired major share in local business and production volume, manufacturing frequently replaced parts like shock absorbers, brake parts, gears and shafts.

Mecas, Infinity, Atlas and Rastgar Engineering are the major complex parts manufacturing vendors having lesser share in local business because of production of less replaced parts like steering knuckle, axle hubs, disc plates, gears, shafts. Many of them are also exporting parts. For example, Rastgar Engineering is having 70 % of its parts exported and only 30% supplied to local market.

6. SAVINGS DUE TO LOCALLY MANUFACTURED PRODUCTS.

Due to larger differences in prices of imported products as compared to locally manufactured products, large scale manufacturers like General Tires, Atlas Battery and Baluchistan Wheels are getting maximum savings.

Small and bulk utilized parts manufacturing companies are giving comparatively lesser savings in terms of cost difference, because of having lesser price variations in imported and local parts.

Complex parts manufacturers have larger differences in their product prices as compared to imported, but many of them are exporting major share of their products. Hence their profit margins cannot be termed as the Savings.

IX. Recommendations

a) Technology strategy

In absence of a clear statement of strategy the firm keeps hitting in the dark. Short term success in the market does not guarantee the strength of technology strategy. Strong technology strategy ensures long term success in the market. The top management commitment to build strategic attitude is of utmost importance and needs to be visible in its decision making process in general and regarding technology in particular. Quick and effective adoption of the product technology to local conditions, developing capabilities to adopt manufacturing technology, promoting innovation culture and formation of core technology group are few determinants of technology strategy.

Technology strategy needs to be derived from the long term corporate goals and should take into account each and every component of technology management function in an organization. Short term strategy may emphasize on product and technologies absorption and making incremental innovations as continuous basis, but long term strategy must clearly indicate the firm's intention of cultivating the core competencies.

Two of the companies, Pak Suzuki and Indus Motors, discussed above, had rightly identified the need of the hour as indigenization. Sense of competition will keep them adopting opportunities to develop Innovation Capabilities.

b) Competitiveness

Vision to develop core competencies can only keep a firm front runner in the race of competitiveness, which can only be based on competitive advantage. A firm essentially relies on technological strength to achieve sustainable competitive advantage while it seldom depends on market forces, which are highly dynamic in nature, and beyond one's control. Honda Atlas Cars should envisage the need for developing technology base locally as an effective way of sustaining competitiveness. Pak Suzuki and Indus Motors flourishing under protected market. However, Pak Suzuki Motors got exposed with the entry of new passenger car manufacturers in Pakistani market, the Indus Motors. Pak Suzuki may loose market up to

some extent. They are still considered as cheaper and user friendly car manufacturers of the country. They need to concentrate on their technology, durability and quality to stay in the competition. Indus Motors seems to be more competitive in terms of price, reliability and performance of its products to become dominant in smaller cars category also, in addition to bigger cars.

c) Technological Leadership.

Capability to develop technology on its own, being able to provide technologically superior products, being able to compete at the global level, to be able to afford state-of-art technology in the core and allied industries, competence to make breakthroughs and radical innovations and ability to retain competitive advantage in terms of technology are the characteristics of technology leaders. Indus Motors seem to be marching ahead on this aspect in entire Pakistani automobile industry. When the collaboration part will be over, these companies should be able to work out their future survival and growth plans. Concern for technology leadership and technological independence appears to be figured in the strategy of Pak Suzuki and Indus Motors only.

Atlas Honda Cars should also emphasize on developing their technological strengths locally. Active transfer of technology through long term collaborations is strongly recommended to take place to give better chances to local car manufacturers for developing themselves as technology leaders at least in the domestic market.

d) Vendor Development

Effective vendor development brings down the total investment in the automobile manufacturing project and obviously reduces the risk. It also provides flexibility to introduce new models in minimum time. The foreign exchange rate fluctuation effects can also be minimized to a great extent with local vendor development. Volume plays an important role in vendor development activity. Pak Suzuki and Indus Motors started with availability of fewer strong bases of parts manufacturing locally. Later on, both of these companies supported infrastructure and skill development along with technical assistance and supervision to create strong vendor bases locally.

Atlas Honda Cars must also concentrate on the development of local vendors to stay in the local market in the near future and avoid banking heavily on foreign vendors.

e) Indigenization

Government regulations should not be the guiding force behind indigenization agenda of the firm. Indigenization process may be looked upon as a measure of technology absorption capability. Low volumes, poor capacity utilization and higher investment will always disapprove the economics of indigenization only initially, but efforts on the global marketing and quality fronts will restore the balance. In collaborations, the firms know that they need to be self sufficient or at least reduce the dependence on technology providers considerably after the arrangement is over. There is fair amount of clarity in indigenization schedule. The domestic firms can always expedite implementation of indigenization programs. The capability to indigenize is the important step in the process of realizing technological innovations and subsequent developments.

f) Effectiveness of technological collaboration

Successes of collaborations lie in the faith which the partners have in technological capabilities of one another. Clarity of technology transfer and subsequent absorption also plays an important role in smooth functioning of local firm. Efforts should be directed towards reducing the dependence on technology providers. Generally, the problem arises when the firm grows strong in the local market and starts planning for market expansion. A healthy collaboration is one which develops its own strengths and exploits the opportunities it is exposed to. Management control by technology providers should be used to strengthen the firm technologically and financially.

X. Conclusion

Collaborations are very effective when the local firm has the competence to absorb the acquired technology within the period already decided by both the parties. Joint Ventures (JVs) have the advantage of attracting the foreign investments and the commitment of the technology providers towards market success. In view of the fact that no technology provider transfers state-of-the art technology to a JV located in the same or different country, the technology acquired in JV is either in the late maturity stage of technology life cycle or an obsolete one. In JVs, the process of transfer of out of use technology continues and JV becomes the dumping ground for old technologies. As long as the products succeed in the market, technology borrowers do not mind such an arrangement.

In case of collaboration, the short term or one time arrangement succeed only when the firm has enough experience of technology acquisition and subsequent absorption. When the hand holding part is over, the firm is free to acquire-state-of-the art technology and stand in front of its earlier collaborators in the international market. Self Reliance in automobile Vendor Industry cannot be achieved without adequate government support through Investment friendly policies, basic infrastructure and facilities provision. In addition, a close interaction between Academia and Industry is essential in human resource as well as in R&D support. Having availability of all these above

mentioned requirements, India is advancing speedily towards self reliance.

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