Multi-factor gains derived adopting Yield Analysis in a typical Indian SME.

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Abstract: All organisations constantly strive to improve their key business parameters quality, cost, accuracy and delivery to survive and excel in the extremely competitive environment. Strategies include integrated approach in performance improvements. This simple productivity measure of yield analysis reveals multi-function improvements and gains in manufacturing envisaged through implementation of ERP.

Key words: ERP, Integrated performance management, yield analysis

Literature survey:
We had extensive survey of research papers and we are presenting observations of top ten researchers- Achanga (2006) opined that Small and medium sized enterprises (SMEs) are of critical importance to any national economy and they face numerous challenges in implementing enterprise resource planning (ERP) systems, including lack of human and financial resources to support these initiatives Somers and Nelson (2001)felt like many other technological advances, ERP systems were initially implemented mostly in large organisations and most of the research focus was on large organisations. Bingi (1999) observes that in the last decade vendors have begun to provide SME-specific ERPs. Lee and Oakes (1995) felt that given that SMEs are significantly different from large organisations only basic ERP architecture has been implemented and ERP scope also grows with the growth of SME to the next level with increased scale of economy. It may be noted that ERP by nature is an integrating effort at the corporate level. ERPs in 1990s emerged by integrating programs that in previous decades existed separately across functional areas. Al-Mashari (2003) suggested that a basic ERP consisted of a database, an application, and an integrated interface. McCartan-Quinn and Carson (2003) reasoned that SME top management is usually involved in day-to-day activities and managers may have limited formal training. Mintzberg (2003) reasoned that, SMEs have relatively informal structures and culture which increase cross functional exchanges and small management teams, which results in efficient decision making. Ghabadian and Galler (1996) felt that one major disadvantage of SMEs is lack of human and financial resources and staff shortages at SMEs might even require production

halt during skill upgrading training and further more they may face challenges in paying to major consulting support. Kinni (1995) indicated that such resource shortages might hinder project success. It was also observed that regarding IT, SMEs seldom have dedicated IT staff, let alone a formal department. Internally SMEs may find it difficult to implement re-engineering projects due to limited resources ad may face greater challenges in adopting technology . Mabert (2000) felt cost of an ERP implementation may be proportionally higher for SMEs than for large organisations and SMEs may be severely impacted by unsuccessful implementation.

Organisation profile: This study was conducted in a SME group in Bangalore who are suppliers of mass production of precision engineering parts to a major MNC automotive ancillary giant. The company is a four decade old, seven units, multi-location group and aggressive growth has commenced from last one and a half decade. The structure is a flat organisation with respective units organised on group technology and similarity of part families and is in direct contact with the customer on a daily basis almost works as an extended arm of the customer's supply chain. Production system is made to order type and moving towards a lean manufacturing with super market concept of Kanban for quick replenishment. The total manpower is around 600 and works multi shifts matching with the load. Units are organised as Plant manager as the Head with all functions-production, quality, stores, administration reporting to him. Unit is certified for ISO and TS standards. ERP has a backend SQL server database with modern web technology connecting all the units and service provided by a small group. The ERP captures all the purchase, sales, material and machine and labour utilization data along with other standard data.

Problem definition: The units has already implemented few modules of ERP and now would like to introduce few more functionalities to improve planning and review on a roll-on basis with varying time buckets for production, capacity, raw material, gages, tools with sole focus on improving manufacturing effectiveness in the form of yield analysis. Total population of parts considered 63.

Objectives of the study: To improve the unit manufacturing performance through ERP implementation through yield analysis with active information system support from ERP.

- To improve the manufacturing yield
- To minimize yield loss
- To improve the data integrity of ERP
- To improve the stores discipline
- To improve the financial reporting of inventory
- To reduce the resistance for change for ERP new module implementation
- To reduce the quality rejections by taking corrective actions

Methodology: Unit level Cross-functional teams of Production, Quality, stores and ERP were formed. Training was given on relevant aspects of ERP, yield analysis, stores audit, "5S" and lean management concepts. The training covered all units of 600 employees. ERP screen was created to start with as a excel spread sheet covering all aspects of conversion factor, work-in-progress, finished goods , stock balance, sales data, quality rejection data, scrap data , physical data as per audits and calculated field of yield.

Monthly physical audit was conducted for Raw material, work-in-progress and finished goods. Yield – effective conversion of raw materials to finished parts was calculated as per the formula as per Table 01given below:

Table 01-Formula for Yield

Yield = Sales+ Physical Qty of audit (WIP+RM+FG)-(Rejections +Scrap) / Total RM purchase

Process scrap was weighted and removed regularly as per "5S" practice. This was done to ensure avoidance of any mix-up and also to start fresh for the next audit. After each audit, audit findings were checked with the Unit heads for any reconciliation based on factual observations. Period of study covered 12 months and yield analysis was done part-wise for each month. Monthly , shop level meetings were held sharing the yield information with all cross functional teams and brain storming sessions were held to generate ideas for system improvements covering all aspects of the production system with focus on process planning and execution.

A five point scale (95-100%-Excellent; 91-95%-Very Good; 85-90%-Good; 80-85%-Average and below 80%-Needs Improvement) was used to evaluate the yield efficiency. The output of the yield analysis was used for best practices sharing (Above 95),Team problem solving like QCC, Kaizen(85-95%) and Managerial intervention like lean manufacturing, advance SPC techniques for yield lower than 85%. Suitable reward systems were put in place for team rewards. Success of this initiative is at two levels- one is information integration for planning, reviewing and control and second level is to enhance the technical competence of the organisation at manager, supervisor and worker levels.

Each analysis for improvement underwent rigorous technical data collection and team evaluation. One sample check list at Table 02 and sample process flow diagram at Fig 01given below. The feedback goes back to ERP for database tables, fields and screen improvements. Currently data updating is on a monthly basis synchronizing with monthly audits. Plans are on the way to reduce this time buckets to one week so that ERP screens will provide analysis and graphs part-wise on all screens in the production systems so as to take corrective actions faster and move towards excellent yields. In some cases yields have gone beyond 100% indicating better improvements in process of improving on the established standards. In those cases, the conversion factors have been suitably revised to reflect productivity gains.

Table 02-Sample Check List for Critical Characteristics

Sl. No.	Particulars	Machine & Machine Parameters	Tools and Cutting Media	Special Characteristics
1	Raw Material	----------	----------	EN-31 Alloy steel bars
2	Material Inspection	----------	----------	Bar diameter - 18mm,Hardness -250BHN
3	Turning	Multi spindle automat, Low RPM and High depth of cut.	Tool inserts Corner radius, special tools, and rake angle –High Viscosity cutting oil used to avoid heat generation.	Collar Height, Shaft Length, Collar and shaft diameters. Radius of the tool.

4	Main bore drilling	Deep Hole Drilling, High RPM and Low feed rate.	Special gun drill, Drill approach angle, Back taper - Low viscosity cutting oil to facilitate chip evacuation.	Bore size ,bore finish, straightness and Roundness of the bore,
5	Slot Milling and Drilling	SPM with simultaneous milling & drilling	Form tools–water soluble cutting oil	Slot depth and symmetry, whole diameter and depth.
6	Cross hole Reaming	Drilling Machine with low RPM	Reamer –water soluble cutting oil	Whole diameter and Symmetry.
7	Oil hole drilling	Drilling Machine with high RPM and special fixture	1.2 mm high speed drill	Whole angle and distance.
8	Main Bore countersinking & counter bore	SPM - simultaneous operation on both sides	Special form tool – Water soluble oil	Counter bore diameter and depth
9	Main Bore Reaming	Drilling Machine with low RPM	Special reamer with 30° approach angle	Removal of cross whole burr.
10	Pinning/ Main Bore Reaming.	Drilling Machine with low RPM	Special reamer with 30° approach angle	Removal of burr in cross hole.
11	De burring	Bench grinder	Special abrasive wheel	Removal of burr all over the part.
12	Cleaning	High pressure washing machine with heating facility	Special cleaning agent with water	Washing of all dirt and swarf.
13	Part number and MFD inscription.	Number rolling machine	Special rolling punches with manufacturing date	Number legibility and current manufacturing date.
14	Final inspection	----------	----------	All dimensional parameters.
15	Packing	----------	----------	Packed in special trays.

Note: Parts were checked at each stage by line inspectors before implementation of lean manufacturing system. Operators have been trained during lean implementation to do self inspection of parts enabling to initiate corrective action in case of any deviations in the process.

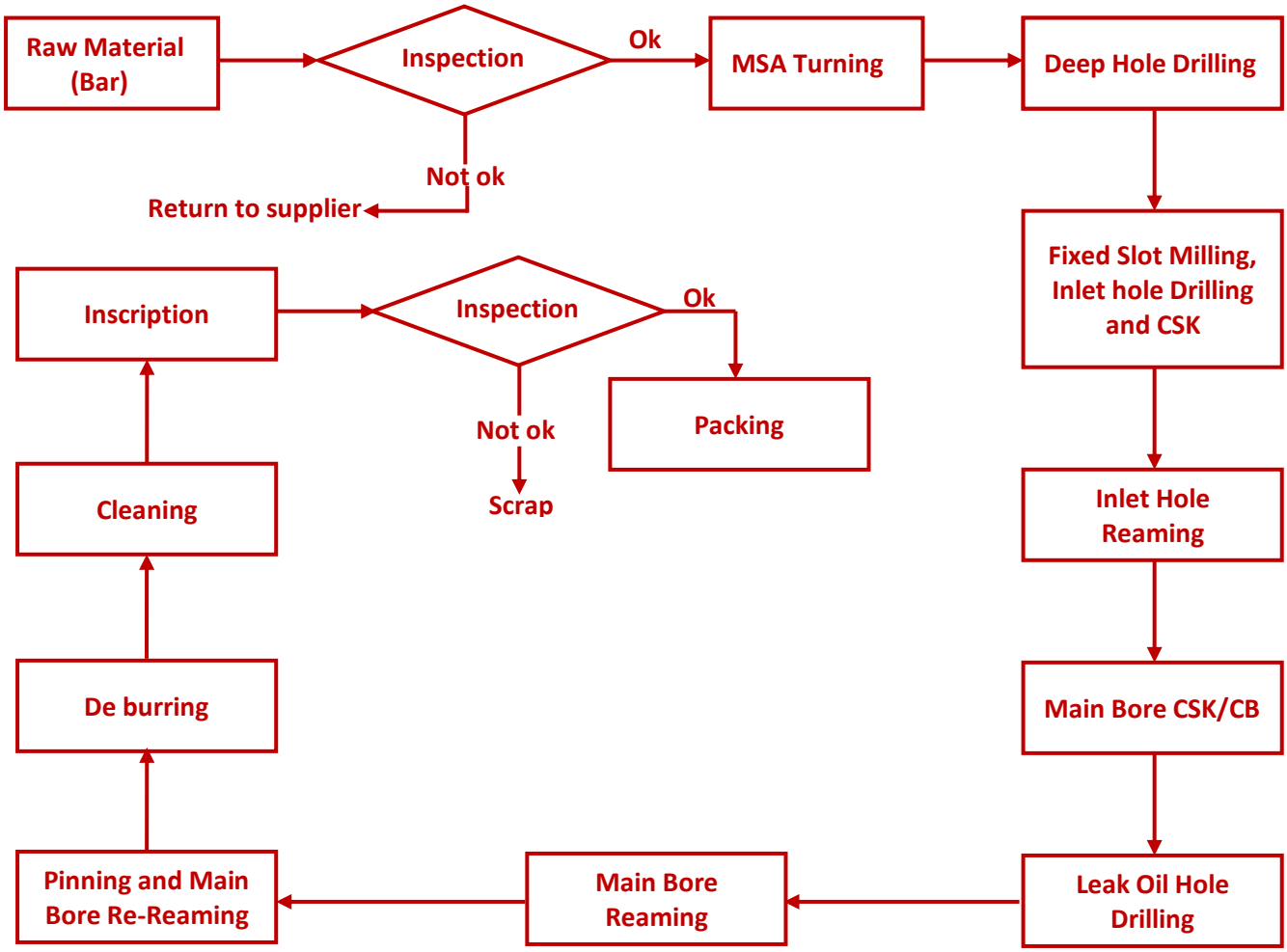

Figure 01-Process flow diagram of sample part (Barrel)

Data Analysis and observations: Study period covered the whole of calendar year 2012 from January to December. Currency used is Indian Rupees (INR). Due to space constraints we have given detailed sample data for one part as per Table 03 giving full details opening and closing stock, ERP stock data, physical stock, sales, rejection, unit price and yield. Table 04 indicates the summarized monthly yield data for 12 months for all 63 parts. Fig 02 indicates the monthly yield of parts.

TABLE 03 – Sample data for product P1 (Period Jan-Dec 12)

PART	MONTH	UNIT	UOM	OPENING STOCK	PURCHASE QTY	SALES	STOCK ERP RECORDS	PHYSICAL STOCK	VARIANCE
p1	JAN	U 1	NOS	48796	240200	234594	54402	53701	-701
p1	FEB	U 1	NOS	53054	230000	220457	62597	62314	-283
p1	MAR	U 1	NOS	61884	210034	262350	9568	9492	-76
p1	APR	U 1	NOS	9253	250005	220015	39243	39200	-43
p1	MAY	U 1	NOS	38666	329000	210750	156916	156900	-16
p1	JUN	U 1	NOS	156665	190000	240650	106015	106005	-10
p1	JUL	U 1	NOS	105813	213450	250340	68923	68923	0
p1	AUG	U 1	NOS	68823	250000	230000	88823	88823	0

p1	SEP	U 1	NOS	88748	270250	220130	138868	138868	0
p1	OCT	U 1	NOS	138768	250270	260240	128798	128798	0
p1	NOV	U 1	NOS	128616	220345	250430	98531	98531	0
p1	DEC	U 1	NOS	98364	210345	230470	78239	78239	0

Table 03 Sample data ...Continued.

PART	MONTH	UNIT	UOM	CLOSING STOCK	REJECTION QTY	VARIATION %	Yield %	Unit Value-INR	Sales value-INR
p1	JAN	U 1	NOS	53054	647	-0.24%	99.76%	177	41523138
p1	FEB	U 1	NOS	61884	430	-0.10%	99.90%	177	39020889
p1	MAR	U 1	NOS	9253	239	-0.03%	99.97%	177	46435950
p1	APR	U 1	NOS	38666	534	-0.02%	99.98%	177	38942655
p1	MAY	U 1	NOS	156665	235	0.00%	100.00%	177	37302750
p1	JUN	U 1	NOS	105813	192	0.00%	100.00%	177	42595050
p1	JUL	U 1	NOS	68823	100	0.00%	100.00%	177	44310180
p1	AUG	U 1	NOS	88748	75	0.00%	100.00%	177	40710000
p1	SEP	U 1	NOS	138768	100	0.00%	100.00%	177	38963010
p1	OCT	U 1	NOS	128616	182	0.00%	100.00%	177	46062480
p1	NOV	U 1	NOS	98364	167	0.00%	100.00%	177	44326110
p1	DEC	U 1	NOS	78050	189	0.00%	100.00%	177	40793190

Table 04 Month-wise yield for all parts for whole year.

PART	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
P1	0.763	0.772	0.799	0.836	0.828	0.889	0.893	0.885	0.856	0.955	0.935	0.987
P2	0.752	0.783	0.801	0.830	0.833	0.872	0.886	0.842	0.827	0.902	0.941	0.959
P3	0.786	0.795	0.763	0.829	0.817	0.801	0.847	0.848	0.907	0.972	0.956	0.948
P4	0.794	0.775	0.756	0.801	0.807	0.850	0.831	0.835	0.871	0.925	0.928	0.974
P5	0.799	0.795	0.763	0.823	0.857	0.864	0.851	0.901	0.871	0.964	0.954	0.922
P6	0.750	0.750	0.789	0.822	0.819	0.869	0.833	0.824	0.894	0.969	0.986	0.955
P7	0.765	0.791	0.819	0.822	0.829	0.876	0.843	0.851	0.873	0.973	0.982	1.002
P8	0.769	0.759	0.753	0.806	0.848	0.865	0.890	0.830	0.832	0.924	0.945	0.957
P9	0.787	0.755	0.773	0.808	0.862	0.832	0.887	0.885	0.920	0.905	0.979	0.922
P10	0.792	0.771	0.783	0.821	0.807	0.884	0.878	0.880	0.836	0.963	0.987	0.944
P11	0.785	0.775	0.759	0.819	0.804	0.838	0.831	0.919	0.854	0.910	0.920	0.965
P12	0.758	0.800	0.768	0.814	0.869	0.830	0.837	0.911	0.872	0.902	0.911	0.990
P13	0.758	0.773	0.813	0.814	0.816	0.865	0.854	0.836	0.853	0.949	0.971	0.944
P14	0.760	0.760	0.752	0.818	0.826	0.825	0.828	0.885	0.850	0.959	0.962	0.982
P15	0.752	0.772	0.760	0.813	0.807	0.853	0.865	0.917	0.891	0.990	0.924	0.931
P16	0.788	0.759	0.775	0.820	0.817	0.888	0.825	0.824	0.856	0.976	0.979	0.924
P17	0.759	0.808	0.803	0.831	0.837	0.851	0.849	0.915	0.896	0.944	0.990	0.929
P18	0.793	0.809	0.752	0.827	0.857	0.803	0.841	0.907	0.859	0.908	0.927	0.959
P19	0.787	0.770	0.796	0.825	0.811	0.842	0.877	0.879	0.843	0.932	0.956	0.950
P20	0.787	0.779	0.782	0.803	0.854	0.836	0.852	0.870	0.905	0.927	0.980	0.986
P21	0.756	0.793	0.756	0.823	0.820	0.852	0.873	0.880	0.929	0.992	0.937	0.994
P22	0.768	0.774	0.784	0.822	0.845	0.817	0.821	0.898	0.851	0.955	0.995	1.003
P23	0.759	0.768	0.798	0.838	0.815	0.847	0.829	0.844	0.920	0.951	0.937	0.940

P24	0.784	0.769	0.816	0.828	0.850	0.808	0.858	0.873	0.910	0.981	0.923	0.987
P25	0.756	0.804	0.784	0.826	0.816	0.865	0.836	0.885	0.886	0.949	0.965	0.980
P26	0.755	0.756	0.767	0.837	0.801	0.843	0.895	0.895	0.904	0.903	0.932	0.962
P27	0.766	0.751	0.796	0.816	0.831	0.889	0.846	0.893	0.900	0.943	0.912	1.000
P28	0.765	0.804	0.777	0.804	0.809	0.803	0.893	0.821	0.908	0.962	0.931	0.962
P29	0.773	0.799	0.753	0.805	0.845	0.876	0.882	0.857	0.839	0.944	0.942	0.993
P30	0.757	0.773	0.804	0.801	0.813	0.805	0.851	0.837	0.861	0.930	0.973	0.921
P31	0.783	0.793	0.795	0.806	0.862	0.834	0.871	0.902	0.898	0.939	0.927	0.971
P32	0.751	0.806	0.783	0.808	0.828	0.878	0.833	0.834	0.895	0.979	0.987	0.954
P33	0.752	0.778	0.793	0.834	0.857	0.834	0.855	0.888	0.831	0.957	0.937	0.977
P34	0.773	0.769	0.757	0.810	0.812	0.843	0.854	0.899	0.918	0.934	0.929	0.998
P35	0.766	0.753	0.767	0.814	0.808	0.855	0.893	0.871	0.910	0.987	0.923	0.958
P36	0.775	0.774	0.788	0.839	0.851	0.839	0.842	0.867	0.926	0.939	0.946	0.977
P37	0.771	0.806	0.798	0.801	0.867	0.858	0.898	0.904	0.925	0.948	0.918	0.963
P38	0.787	0.775	0.813	0.803	0.860	0.835	0.895	0.842	0.850	0.987	0.927	0.991
P39	0.753	0.800	0.781	0.832	0.855	0.822	0.894	0.902	0.900	0.931	0.937	0.962
P40	0.772	0.770	0.788	0.801	0.826	0.844	0.845	0.920	0.911	0.951	0.947	0.941
P41	0.778	0.776	0.767	0.839	0.811	0.845	0.866	0.859	0.913	0.943	0.917	0.946
P42	0.786	0.767	0.797	0.823	0.824	0.886	0.848	0.831	0.919	0.974	0.931	1.003
P43	0.752	0.767	0.800	0.803	0.868	0.870	0.881	0.896	0.911	0.906	0.928	0.989
P44	0.776	0.763	0.781	0.809	0.836	0.851	0.854	0.906	0.864	0.986	0.983	0.992
P45	0.772	0.766	0.800	0.811	0.839	0.878	0.852	0.914	0.828	0.917	0.923	0.944
P46	0.755	0.752	0.782	0.831	0.813	0.823	0.875	0.822	0.925	0.923	0.946	0.973
P47	0.781	0.809	0.810	0.829	0.815	0.809	0.836	0.830	0.911	0.969	0.923	0.948
P48	0.765	0.798	0.812	0.826	0.852	0.810	0.868	0.851	0.826	0.987	0.969	0.932
P49	0.789	0.781	0.787	0.815	0.867	0.824	0.889	0.892	0.880	0.945	0.974	0.924
P50	0.776	0.795	0.773	0.820	0.810	0.814	0.840	0.871	0.833	0.938	0.952	0.972
P51	0.785	0.762	0.801	0.824	0.818	0.861	0.843	0.917	0.866	0.907	0.942	0.950
P52	0.767	0.759	0.776	0.838	0.844	0.842	0.889	0.917	0.899	0.915	0.968	0.971
P53	0.767	0.756	0.782	0.839	0.848	0.828	0.841	0.885	0.842	0.917	0.953	0.973
P54	0.787	0.784	0.771	0.802	0.805	0.885	0.861	0.833	0.863	0.984	0.964	0.935
P55	0.759	0.764	0.770	0.806	0.801	0.876	0.862	0.829	0.826	0.994	0.980	0.925
P56	0.751	0.756	0.766	0.811	0.813	0.839	0.870	0.883	0.846	0.929	0.971	0.989
P57	0.795	0.754	0.796	0.804	0.863	0.845	0.864	0.832	0.912	0.951	0.940	0.938
P58	0.760	0.760	0.793	0.803	0.808	0.844	0.850	0.845	0.822	0.906	0.918	0.999
P59	0.751	0.793	0.785	0.825	0.838	0.807	0.875	0.834	0.909	0.979	0.982	0.920
P60	0.771	0.794	0.769	0.831	0.835	0.857	0.838	0.849	0.862	0.907	0.949	0.980
P61	0.793	0.791	0.771	0.810	0.809	0.858	0.896	0.822	0.865	0.914	0.921	0.949
P62	0.790	0.787	0.811	0.826	0.834	0.884	0.845	0.828	0.918	0.945	0.989	0.925
P63	0.774	0.760	0.805	0.833	0.848	0.861	0.882	0.863	0.881	0.994	0.912	0.928
Average	0.771	0.777	0.784	0.819	0.831	0.847	0.860	0.869	0.879	0.947	0.949	0.960

Note: For economy of space, yield of 100 is shown as 1.000 (Typical example 0.879 is 87.9%)

Following are the general observations:

- Constituent elements of yield analysis like rejection levels are varying for different parts and so also the variance.
- In the same production system, some part yields are at excellent levels indicating positive variance better process controls and need for tightening production norms for productivity gains.
- After five months of audit, opening and closing stock balance differences came down significantly indicating higher acceptance and better stores functional discipline.
- Since the rejection data was shared across the cross functional teams and regular monthly review by managers , rejection rates showed a downward trend beyond three months.
- Due to better material management (checking, issues, weighing and counting), physical count matched with ERP data ensuring data integrity for management decisions.
- Financial reporting was also improved due to better data integrity of ERP and reduced variance of opening and closing stock balances of the inventory.
- Improved yields also reduced additional inventory that was required to make up the earlier yield losses.
- Cross functional teams helped in better problem analysis due to their diverse views and expertise thereby leading to better idea generation, trials and implementation of improvements.
- ERP team was enthused to build new tables, fields, simple logic accepted by shop, displays with user involvement thereby making implementation seamless without traditional resistance from the production system.
- Teams were willing to look at data from a monthly basis to fortnight to weekly basis so that ERP system display becomes near dynamic and also accelerate the improvement initiatives.
- Management control improved through ERP.

Yield improvement and financial gains:

- Average yield of all parts improved from baseline of 77.1% to 96% at the end of 12 months –an improvement of 19% (refer Table 04 on month-wise average and Fig 02).

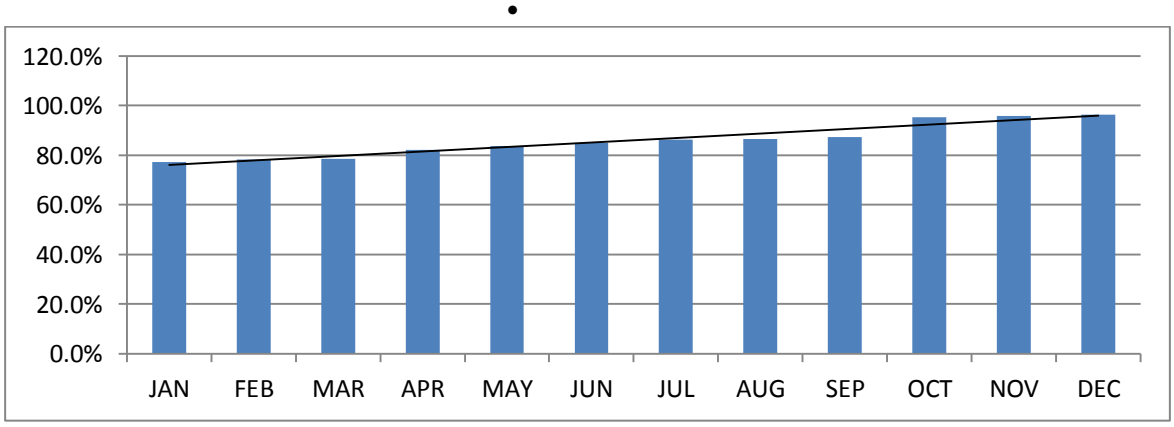

Figure 02 -Average Yield % month-wise

Yield loss function showed a downward trend from INR 3,63,352 to INR 50,771 indicating drop of 87% (refer Table 05 and Fig 03)

Table 05 -Yield loss data month-wise in INR

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
363562	299828	198967	300906	159756	142246	128407	115610	82074	88228	72654	50771

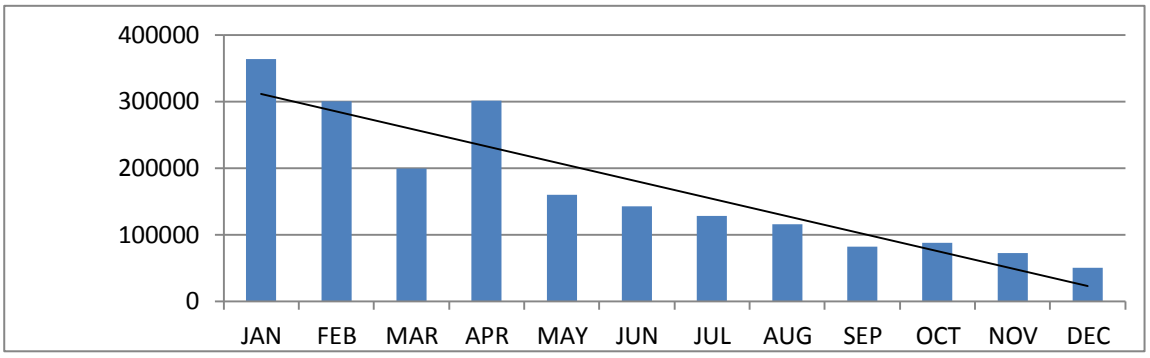

Fig 03- Yield Loss functions for 12 Months in INR.

Proposed results: It is expected that improvement in manufacturing systems through ERP implementation will minimise organisational slack or in-efficiencies there by making the units more efficient and effective. These improvements when applied to cluster of SMEs will make them more effective and thereby strengthen the manufacturing base on the national level.

Conclusion; this study has demonstrated that a simple productivity ratio like yield analysis has improved the yield of parts over the observed time frame by integrating all functions into a team. This also had the user involvement in development of logic and screens there by reducing the traditional resistance to change. Also cross functional teams trained in problem solving skills and effective production systems were able to solve problems and implement the improvement changes indicating improvement in their motivation levels and ownerships. ERP data integrity, stores stock discipline and financial reporting have improved.

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Bibliography:

Achanga P., Shebab, E., Roy, R and Nedler, G. 2006. Critical success factors for lean implementation within SMEs. *Journal of Manufacturing Technology Management* **17(**4): 460-71.

Adam, F and O'Dohoerty, P. 2000. Lessons from enterprise resource planning implementation in Ireland-towards smaller and shorter ERP projects. *Journal of Information Technology*. **15(**4): 305-16.

Al-Mashari, M., Al-Mudimigh, A and Zairi, M. 2003. Enterprise resource planning; Taxonomy of critical factors. *European Journal of Operations Research*. **146(**2): 352-64.

Bell, S and Orzen, M. 2007. Small, yet mighty. *APICS Magazine.* **17(**6):40-3.

Bingi, P, .Sharma, M K and Godla, J. 1999. Critical issues affecting ERP implementation. *Journal of Information Systems Management*. **16(**3): 7-14.

Ghobadian, A. and Gallear, D N.1996. Total Quality management in SMEs. *Omega* **24(**1):83-106.

Gunasekaran, A, Okko, P., Martkainen, T, and Yli-Oli, p. 1996. Improving productivity and quality in SME-Cases and analysis. *International Small Business Journal* **15(**1): 59-72.

Jacobs, F R and Weston, F C .Jr. 2007. Enterprise resource planning (ERP) - a brief history. *Journal of operations Management* **25(**2):357-63.

Mabert, VA., Soni, A and Venkatramanan, M A. 2003. Enterprise resource planning ; managing the implementation process. *European Journal of Operations Research.* **146(**2): 302-14

Mandal, P, and Gunasekaran, A. 2003. Issues in implementing ERP-a case study. *European Journal of Operations Research* **146(**2): 274-83.

Nah, FFH, and Delgado, S. 2006. Critical success factors for enterprise resource planning implementation. *Journal of Computer Information Systems* **46(**5): 99-113.

Somers, T M. and Nelson, K. 2001. Impact of critical success factors across the stages of enterprise resource planning implementations. *Proceedings 34th Huwai International conference on systems sciences*, Maui, Hawaii. 10.

Umble, E J, Haft, R R and Umble, M. 2003. Enterprise resource planning; implementation procedures and critical success factors. *European Journal of Operations Research* **146** (2): 241-57.