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DEMAND MANAGEMENT IN INDUSTRIAL SECTOR BY IMPROVEMENT OF LOAD FACTOR: A STRATEGY DEVELOPMENT

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Abstract

Electric power system planning and management have become much more complex today in India than ever before. Resource crunch have made availability of power lesser and lesser to meet the expansion of power demand. Power shortage has become major problem in India and is of varying levels in different part of the country, in different seasons of the year at different periods of the day. With the interconnections of state networks to the national grid and huge central power stations, the attention of state electricity board is always turned towards supply-side to manage the power demand to prevent the collapse of the system. Most of the state electricity boards are having only supply side management by means of load -shedding in addition to power cuts, to meet the expansion, but there is no attention towards demand side-management. The objective of this paper is to enable the industry and the supplier to interact at this interface to understand the effect of power shortage and quantify the same to focus their attention on demand side management. A strategy is developed for the industrial consumer so that they can maintain their load factor and limit the maximum demand according to the budgeted parameters like production target and units required per kg of production. The developed strategy is verified by collecting the data of different industries situated in different part of state and it is observed that demand calculated and the demand noted by demand monitor is approximately equal. It is also proved that the strategy is effective in reduction of product cost.

Key words: Demand-side management, Production target, Load factor selection. Units (kwh)/kg, Maximum Demand

I. INTRODUCTION

Resource crunch (raw material like coal, water, transport, finance) has made availability of power lesser and lesser to meet the power demand. The open door policy of establishing industries anywhere and everywhere has complicated the work of the utilities, state electricity boards (SEB). The SEBs has to work for commercial viabilities for them, while catering to the social needs and agricultural sector as per directives of state government [1]. But the country, state and state electricity boards would stand to benefit if there is a regulated power supply management and growth of industries in clusters. Giving incentive for going in to cluster areas, attracting them for improving their efficiency in utilization making them partner in management of power within availability, are all actions requiring urgent action plan and implementation. There is thus an urgent need to stretch the use of available electricity to more and more industrial consumers by Demand-Side Management (DSM) [2]. Unfortunately most of the SEBs are having only supply side management by means of load shedding in addition to power cuts, to meet the expansion of power demand. The

possibility of carrying out demand side management therefore depends upon the existence of end use equipment machineries of Customer, whose demand and consumption can be modulated and diversified (spread out during the day) and whose efficiency can be improved [3]. This can be called load shaping. Electricity utilities have realized that consumer demands cannot be met satisfactorily by adding new generating capacity alone [4]. Due to increasing fuel prices and energy costs, utilities have started thinking of energy/demand management, in addition to the classical approach of encouraging off-peak energy utilization, penalization for excessive use at peak time has also been considered [5]. Differential changes for energy used at different times of the day have also been given due consideration. Load management is the concept of changing the consumer's electricity use pattern. Load management has the purpose of improving the effective utilization of the generating capacity and encouraging the best use of electricity by all consumer categories. Moreover the forced outages are reduced and service reliability is improved. By controlling the load at consumer's premises the load curve canbe flattened [6]. In this way the power generation by low efficiency generating units can be minimized and some forced outages are avoided. The peak load reduction can make it possible to postpone the building of new transmission and distribution

facilities, thus resulting in additional savings. The scope of load management includes Planning, development and Implementation of programs whose objective is to actively shape the daily and seasonal load profile of consumers so as to result in better overall capacity utilization and lower the energy costs. Load control can be achieved in different ways. Firstly the consumers may controltheir loads voluntarily by altering the use of their equipment's in response of tariff signals.Secondly the utilities may control the consumer's loads using a signal activated either remotely or at the point of use. Both these methods have more or less the same impact on the load shape[7]. In India the only method used by electric utilities is to de-energies a feeder (or a section) during peak demand hours so as to reduce the peak demand.

There is a definite pattern of power demand and the energy consumed every day and every month in any manufacturing industry. It is observed that the highest consumption of electrical energy has not necessarily required the highest power demand. Whilst the highest energy consumption may be considered to reflect the highest production there is an ample scope for reducing energy consumption by a close study on the working of the industrial equipment machines by optimizing their performance through appropriate improvements involving energy conservation/measurement techniques [7].

Further the pattern of working of individual equipment or machinery can be monitored when the maximum demand for power was the lowest and the deviation that takes place when there is no control resulting in the escalation of maximum demand.

In this paper from the load data of different Industries, need of load factor improvement is discuss in section II. In section III and IV simple relation is developed between the maximum demand and production target, keeping in mind the budgeted parameter of the industry which is useful for the industry to maintain the desired load factor. In section V from the collected historical data, the day of highest production, lowest power consumption and optimum value of power demand is find out which is helpful in deciding the desired value of load factor. Case study is discussed in section VI which shows effect of load factor improvement. In section VII For the verification of the developed relation, data of two different industries is collected and maximum demand is calculated by using developed relation. The calculated maximum demand is compared with the demand recorded by demand monitor and also illustrated in fig 9 and 10. The proposed strategy is implemented over various industries, the result of studies is present in table 1 and 2 and finally ends with the conclusion.

II. INDUSTRIAL LOAD SHAPING

Industrial Load shaping which emphasizes the reducing of the load of user industry to a specified limit at the time of the system peak and to shifting of the maximum demand of the existing industry to off-peak periods [8]. (rather than simply reduction in peak) Power and energy can often be saved cost-effectively by fine-tuning of already functioning industries in the cluster areas. This can be done by Demand-side management-Power management control system. (DSM-PMCS) The principle objective of the demand-side management

program is to develop the load shape models for each shapes of power availability, which would lead to avoidance of demand more than average during system peak time without restoring to load shedding[9]. The 72 days Load data of Soap, textile, and steel industries were collected and load curves of all three industries are plotted. The Graphical presentation of actual maximum demand (AMD) and actual average load (AAL) for 72 days is plotted as shown in fig. 1,2 and 3 which shows the need of load factor improvement.

Fig. 1 Comparison of AMD and AAL of Industry 1

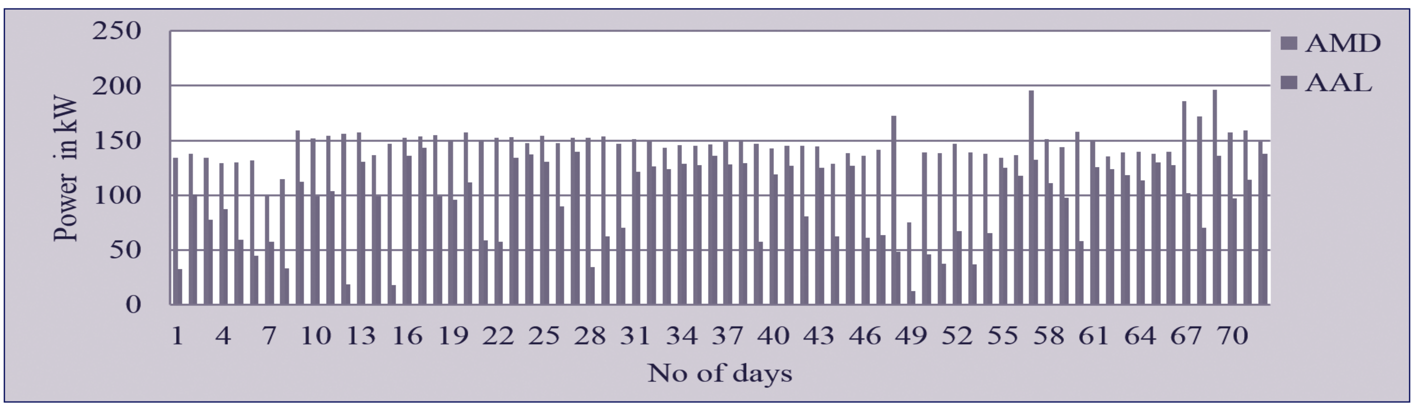


Fig. 2 Comparison of AMD and AAL of Industry 2

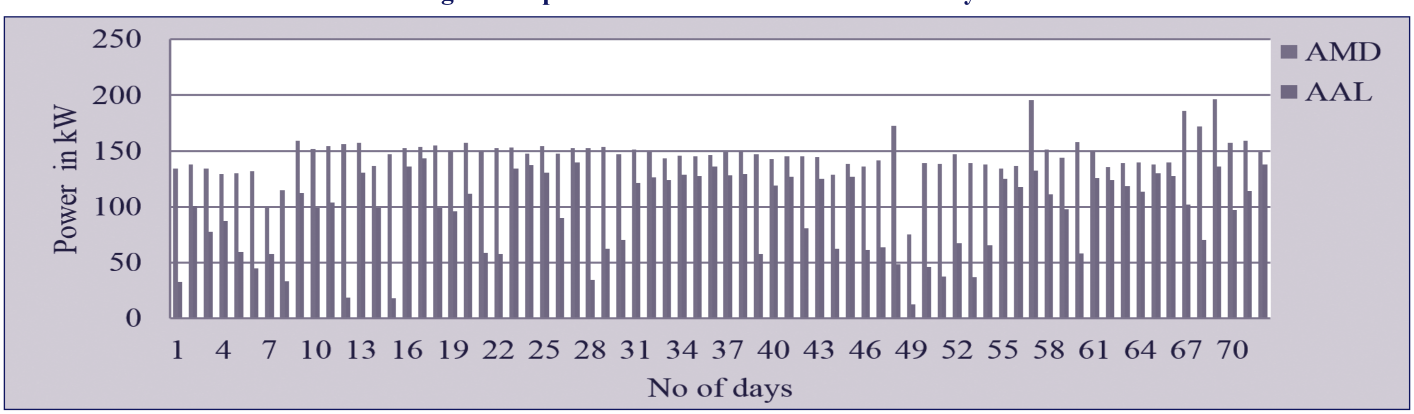
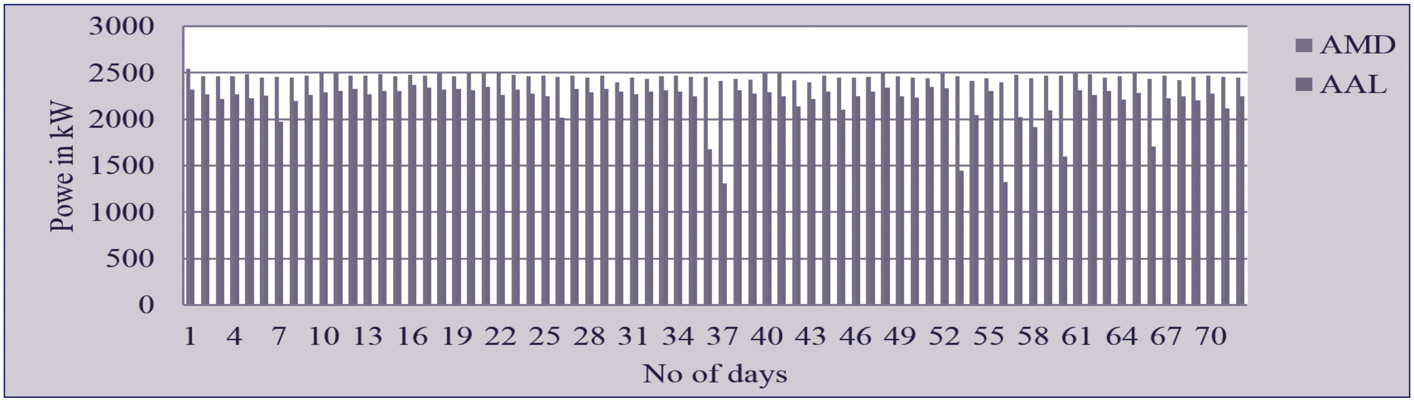


Fig. 3 Comparison of AMD and AAL of Industry 3



III. LOAD FACTOR (LF)

The efficiency of utilization of electrical energy in any industry is a key indicator of how plants are running. The energy consumption has a direct relation with the production. With total production computed normally at the end of the month, it is possible to assess the electrical energy (kwh or units) consumed per kg of production. It is electricity consumption that can be watched every day when all other input factors are taken care of. If this consumption is kept within limits as achieved on a best production schedule (lowest consumption per ton/per unit of products) then one can expect the same efficiency in energy utilization. If for the lowest consumption per day the maximum demand is also monitored and kept under check, there will be better power utilization[10]. The load factor (LF) for a system of a plant is the ratio of the average load to the peak load for a certain period of time.

Load Factor (LF) = (Average load) / (Peak load) (1)

The load factor can also be defined as, It is the ratio of energy consumed in a certain time (Ect) (for a day or 24 hour) to the energy which would have been consumed if the load is maintained at Peak value throughout that time.

Load Factor (LF) = (Ect) / (Peak load * time) (2)

The peak load is generally taken(as per the norms of state electricity board) for a half hour period and the average load may be that pertaining to a day, a month or a year; thus giving daily, monthly or a yearly load factor. Each device at the consumer terminals has its rated capacity [11]. The connected load of a consumer means the sum of the continuous ratings of all the connected load on his distribution circuit. The maximum demand of consumer means the maximum power that consumer circuit will draw at any time, if all the device and outlets were used simultaneously to the full extent, the maximum demand is equal to his connected load. From the definition of the load factor it can be written as.

LF = (Average load) / (Maximum Demand)

If the average load is kept constant then the max. demand is inversely proportional to the load factor.

Max.Demand = (Average load) / (LF) (3)

IV. ENERGY MANAGEMENT BY LOAD FACTOR CONTROL

The main objective of the study is to determine the practical ways of maximizing production and increase productivity within the constraints of power availability bychoosing lower power and energy consumption path and to evaluate them for appreciation from both user and supplier. As the load factor is improved the maximum demand will reduces, also the nature of the load curve becomes flat. The industrial consumer can control their maximum demand on daily basis so that the load factor will be maintained as desired and the nature of the load curve becomes flat. In every industry the production target (PT), Units required per Kg of production (U/Kg) and the hours (Hrs) in which the target production is to be achieved is decided in advance in their yearly budget. Keeping in mind the above budgeted parameter and keeping their maximum demand within limit [12]. The following relation is developed which is useful for the industries to maintain the desired load factor

Load Factor (LF) = (Average load / MD)

Load Factor (LF) = (Units / Hr * MD")

LF = (U/Kg * Kg) / (Hour * MD) (4)

As Production Target is in Kg we can re-write the equation as

Load Factor = (U/kg*P T) / (Hrs*MD)

The maximum demand required for specific production target to be achieved in particular time can be obtain as

M D = (P T * U / Kg) / (Hrs * LF)" (5)

As the production target, U/kg,Production hour is known the optimum value of Maximum demand can be calculate and set in the demand monitor for controlling purpose. Since power cost can be calculated by knowing the specific energy consumption and unit cost[7]. Conversion cost of product is given by.

C = (U * UC) + (CMD+ Cfixed) / P (6)

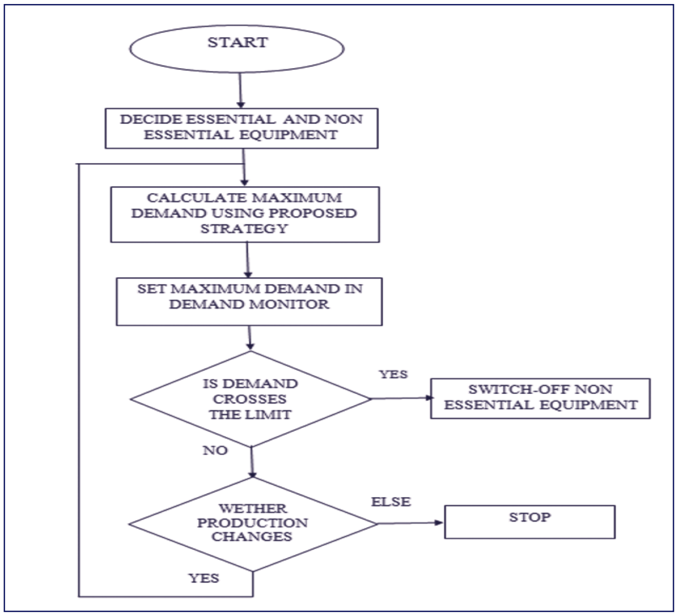
Where C is the conversion cost of product per kg.

Uc is unit cost.
U is units consumed.
CMD is maximum demand charges.
Cfixed is fixed charges.

P is production achieved in specific time.

Power cost consists of unit cost and maximum demand charges since unit cost fixed, the maximum demand charges can be reduced if the maximum demand willreduces, as the reduction in the maximum demand charges will result in the reduction in power cost which will effectively reduces conversion cost [13-15].The flow chart of proposed strategy for controlling the load factor using the budgeted parameter is given in fig. 4

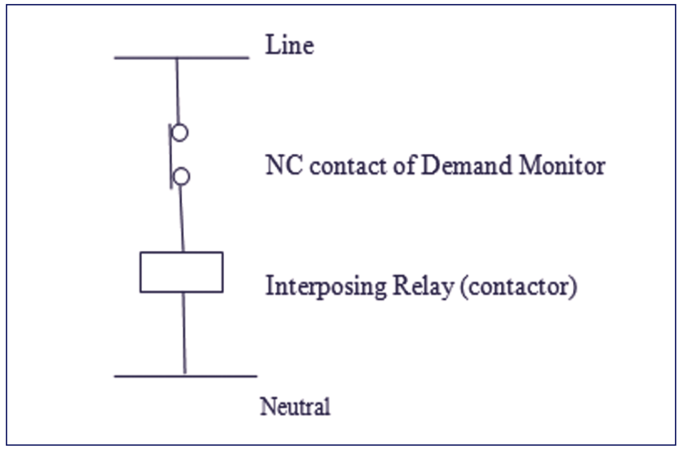
Fig.4 Flow Chart of proposed Strategy



V. SELECTION OF LOAD FACTOR

For selection of desired load factor, the historical data should be collected [14]. Using this it is possible to find out the day of highest production, lowest consumption and minimum value of power demand, which will be helpful in deciding the load factor. By using the strategy developed the optimum value of maximum demand can be calculate but the question arises how the maximum demand can be meet without sacrificing the production. It is observed that in every industry there are two types of equipment i.e. essential equipment and Non-essential equipment's. Essential equipment is that equipment which directly affects the production target and the Non-essential are those which does not affect the production target [15]. The value of maximum demand calculated by using the developed strategy is fed in the demand monitor. Demand monitor is a device that provides a every minute information about the extent to which power can be drawn without exceeding the sealing demand limits. If the demand crosses the limit the demand monitor will give the signal to the circuit breaker of non-essential equipments that will cut-off

Fig.5 Control circuit for Load Factor control



the supply of non-essential equipments and the demand will remain within limit [16]. In this way maximum demand can be controlled without loss of production. The circuit for monitoring demand is given in figure no. 5VI. A CASE STUDY

To prove the usefulness of proposed strategy, the load data of 72 days of soap, textile and steel industries were collected the load curve are plotted and analyzed. The further studies on proposed strategy conducted on the pvc pipe and injection molding plant. Analysis of load data of industry 1,2 and 3 is done using software .The value of Actual maximum demand (AMD) and value of maximum Demand(SMD) after maintaining the LF=0.95. for industry-1 AMD = 282 kW , SMD = 185 kW, for industry-2 AMD=195 kW, SMD = 150 kW for industry-3 AMD=2539 kW, SMD = 2480 kW are calculated. The Graphical presentation of result of

case studies are given in fig 6 ,7 and fig 8 for industry 1,2,3 respectively, if the respective industry maintain the load factor of 0.95.

Fig. 6 Comparison of AMD and SMD for Industry-1

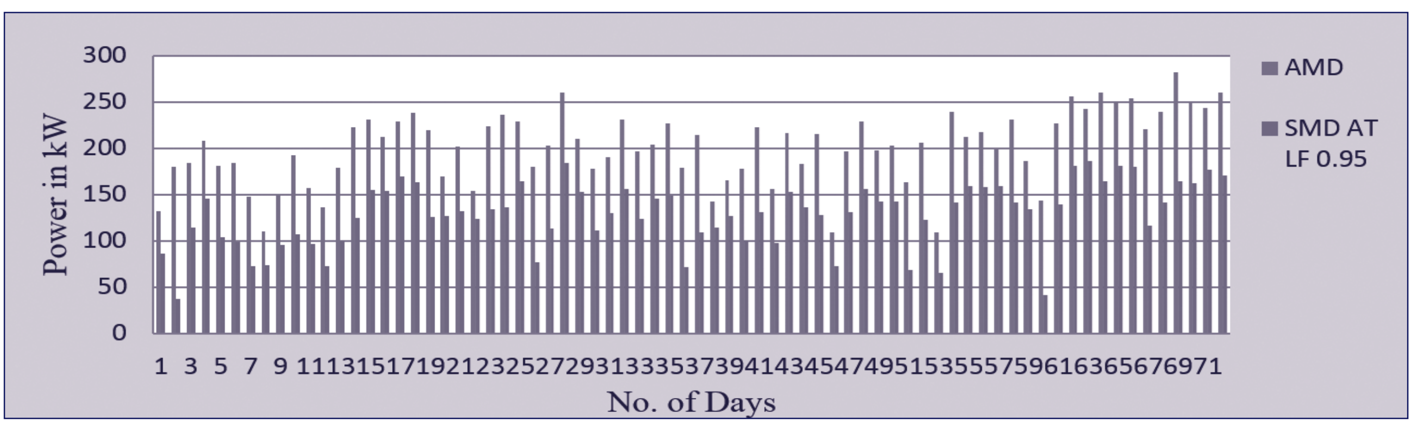


Fig.7 Comparison of AMD and SMD for (Industry-2)

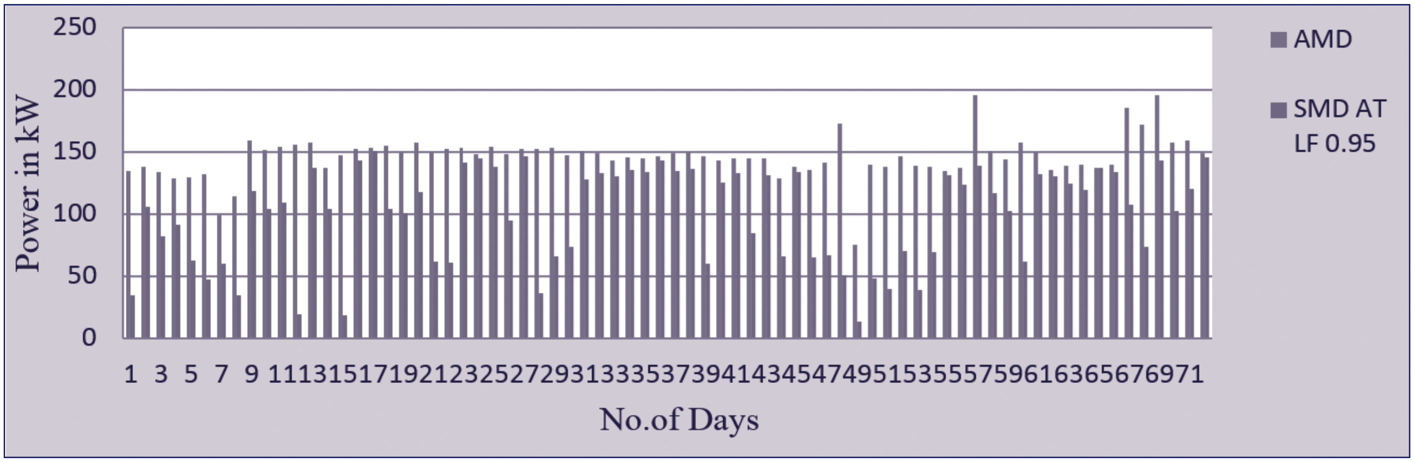
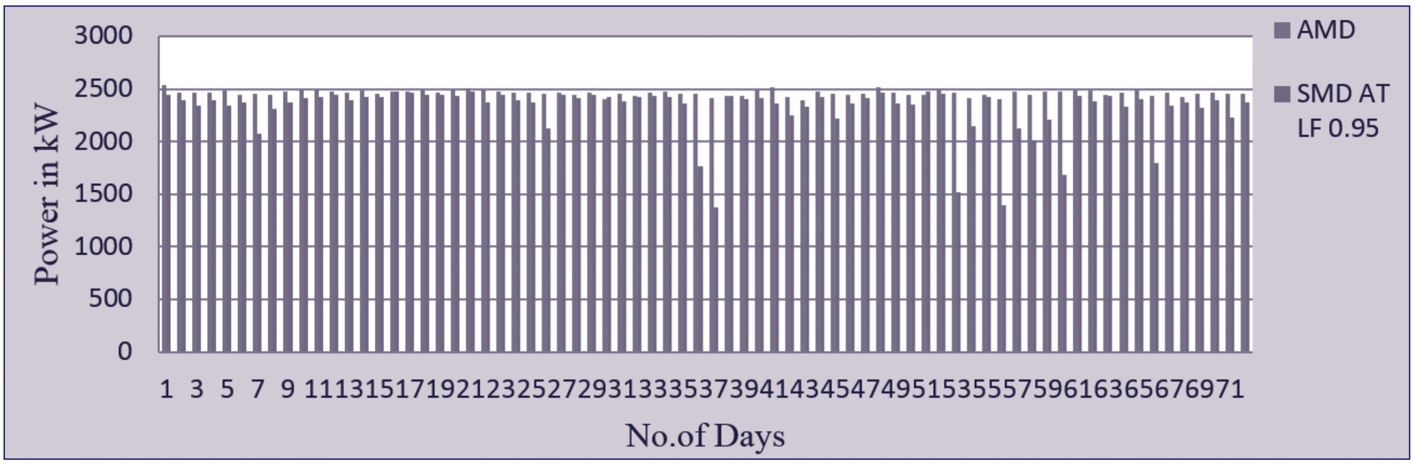


Fig.8 Comparison of AMD and SMD for Industry-3



VI. RESULT AND DISCUSSION

For the verification of relation (5), data of two different industries is collected, industry- 1 is the pvc

pipe fitting accessories (injection molding) manufacturing division and having their sanction maximum demand is 800 kVA and industry-2 is the pipe manufacturing division having their sanction maximum demand 1500 kVA, Units/kg of industry-1 is 1.10 U/kg and industry -2 having 0.30 U/kg which is decided in-advance in their annual budget. Variation in parameter is observed when there is any breakdown or Tool / Die-change program planned on the machine. By using the developed strategy maximum demand is calculated and compared with the maximum demand noted by the demand monitor it is observed that both values, calculated from the formula and noted by the demand monitor is approximately equal.

Production planning and other parameter of

Industry-1 are as below

Production target = 90MT, U/kg = 0.319 Production Hours = 24, LF = 0.8

MD (Recorded by Energy meter) = 1500 kW

Keeping all the above parameter in the relation (4)

MD = (Production Target * U/Kg) / (Hour * LF)

MD = (90000 * 0.319) / (24 * 0.8)

MD (calculated) = 1495 kW

Production planning and other parameters of Industry-2 are as below

Production target = 6.88 MT, U/kg = 1.4

Production Hours = 24, LF = 0.9

MD (Recorded by Energy meter) = 442 kW

Keeping all the above parameter in the relation (4)

MD = (Production Target * U/Kg) / (Hour * LF)

MD = (6880 * 1.4) / (24 * 0.9)

MD (calculated) = 446 kW

The proposed strategy is implemented over various industries to find its usefulness the results obtained were tabulated in Table-1 and Table -2 from the result it is observe that the maximum demand calculated using equation (5) and maximum demand recorded by demand monitor is approximately equal. Therefore the maximum demand can be obtained for specific production target by using equation (5) and demand controller can be set accordingly to control the maximum demand. It is also noted that error 5 to 6 % is reported in the recorded and calculated values of maximum demand.

Table1: Results of studies on industry-1

Sr. No	Production in Kg	Units /Kg	LF	MD Calculated	MD Recorded
1	10526	1.10	0.85	567	596
2	9105	1.17	0.85	554	596
3	9012	1.16	0.80	554	596
4	9455	1.19	0.80	586	596
5	9943	1.21	0.85	556	596
6	10153	1.18	0.80	574	596
7	10030	1.16	0.80	570	596
8	10011	1.18	0.80	579	596
9	10000	1.18	0.85	614	596
10	9400	1.23	0.80	602	619
11	9556	1.20	0.80	597	619
12	10734	1.14	0.85	599	619
13	10844	1.11	0.85	605	619
14	9881	1.12	0.80	627	619
15	9902	1.14	0.75	628	619

Table 2: Results of studies on industry-2

Sr. No	Production in Kg	Units /Kg	LF	MD Calculated	MD Recorded
1	97280	0.303	0.85	1444	1450
2	86749	0.325	0.84	1303	1380
3	86053	0.320	0.82	1399	1385
4	91532	0.316	0.85	1417	1416
5	84194	0.319	0.83	1348	1351
6	95332	0.285	0.78	1451	1460
7	94741	0.284	0.88	1273	1275
8	97647	0.286	0.84	1385	1386
9	98405	0.290	0.88	1351	1350
10	94587	0.291	0.86	1333	1321
11	95352	0.280	0.83	1340	1340
12	95303	0.283	0.80	1404	1400
13	90240	0.300	0.80	1410	1400
14	89150	0.297	0.79	1385	1400
15	87469	0.293	0.79	1348	1350

Graphical Presentation of MD Calculated by using the proposed strategy and Recorded in demand monitor of Industry-1 and 2 for various values of Load Factor is shown in fig. 9 and fig. 10

Fig.9 Comparison of Calculated and Recorded Maximum Demand for various values of Load Factor for Industry-1

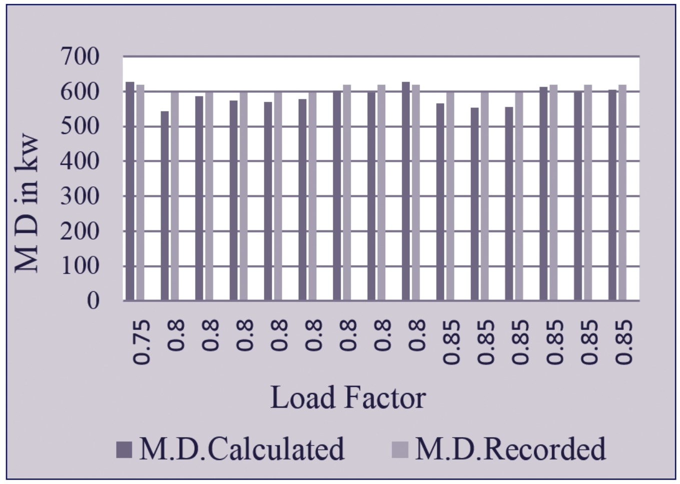
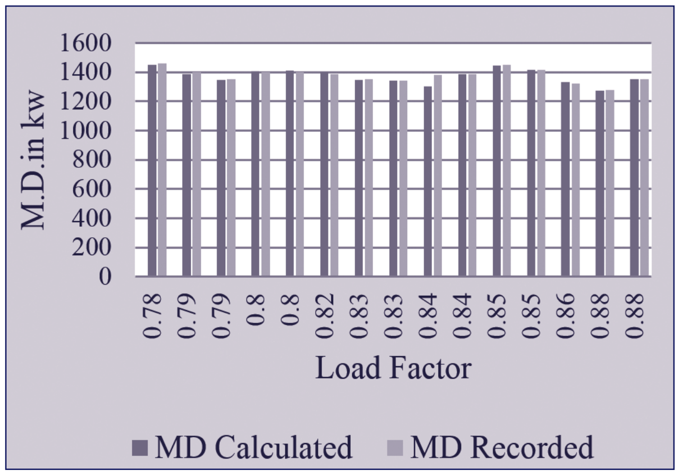


Fig.10 Comparison of Calculated and Recorded Maximum Demand for various values of Load factor for Industry-2



VII. CONCLUSION

Improvement in the load factor will result in the reduction of maximum demand of the particular industry, which will result in the reduction of power cost and conversion cost of the industry, which will effectively reduce manufacturing cost of the product. But the industry does not have any method to calculate the maximum demand according to the production target so that they can control the maximum demand without loss of production.

In this paper, the simple formulations and guidelines are provided in terms of budgeted parameters, which are helpful to the industry to calculate and control the maximum demand of the industry. With increase of fuel cost of captive generation, now it is necessary to identify diversity in the essential equipment, which can further reduce the maximum demand. Further study of adding the diversity in the formulation is under progress.

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