# Optimization of Electrical Load Distribution in Small Paper Mills Based on DG Sets

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## ABSTRACT

*The load of some electrical equipments vary with operational conditions and operating time cycle, while some other equipments operate at constant load. It was observed during the operation of a small waste paper based paper mill when only 2 sets of 380 KVA were in operation for production of 20 -25 TPD paper, many a times the mill suffered pulp shortage, even while at some of the times the sets were running at underioad condition. To smoothen the load round the clock rescheduling of load distribution alongwith the optimization of loading sequence was made. This paper describes how the optimization of electrical load distribution can be done to achieve zero down time due to power sortage.*


## INTRODUCTION

Due to poor power availlablity, and frequent power trippings, alongwith increased power terrifs, the industries have shown an incllnation towards diesel power generation. The small mills often face situation of power shortage with the limitation of size of D G sets. Normally, when the sets are designed to produce power just sutable for the plant needs, it becomes extremely important to optimize the loading behaviour in accordance to run the plant continuously with the limiting factor of running load below the capacity of D G sets.

## PROCESS LOAD BEHAVIOUR

A small paper mill consistes of many equipments, motored with different power, and their operation is done as per the process requirement. To model a small paper mill for the purpose of electrical load distribution, we can consider the motors in different groups based on operating cycle.

Here, the load of continuous operating equipments is to be considered in the normal way, but, simultaneously, the load of short cycle intgermnittant operation is to be taken as if the equipment is running continously. The reason behind this is that during stoppage of such equipments the spare power cannot be loaded with the other equipments. During load distribution designing, spare power should also be left for emergency operating equipments.

Table No. 1

| | Type of Operation | Example |
|---|---|---|
| A | Contnuous | Fan Pump |
| B | Short Cycle intermittant | Boiler ID Fan, Condensate Pump |
| C | Long Cycle Intermittant | H.P. Shower, Refiner, Pulper, Submercible Pump |
| D | Emergency | Couch Pit Pump |

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Table No. 2

| | Nature of Operation | Example |
|---|---|---|
| A | Individual | Submercible Pump |
| B | Interlocked to reduced load condition | Couch pit pump (as it is normally operated on a web break when the load on paper machine is reduced) |
| C | Interlocked to increased load | Pulper pit pump (as it is operated when the pulper is running), Decker |
| D | Emergency | Fire Fighting Pump |

The another grouping is to be made on the basis of process interlocks and requirements as in Table-2.

In the above table, the capacity to be computed as the sum of all equipments, excluding those which are interlocked to reduced load conditions. sometimes, these equipments may be needed to run at normal load condition, but, if the power connected to these equipments is not a significant fraction of total available power of the D G, the generator will accomodate the load thus increased.

The load behaviour of individual motors is then is to be groupped for different operating conditions. For a typical case, the simulated process flow sheet for a waste paper based plant is given in Fig. 1.

In the simulated flow sheet, the pulping & stock preparation section has been distributed into three groups-Pulping, Refining & Group of Small Motors. These groups have been considered on the basis of interlocked load conditions, i.e., to run the pulper, Turbo-500, Turbo -300, Johnson Screen, Back Water Pump etc. must run. Thus we may consider the set of these motors as a complete group.

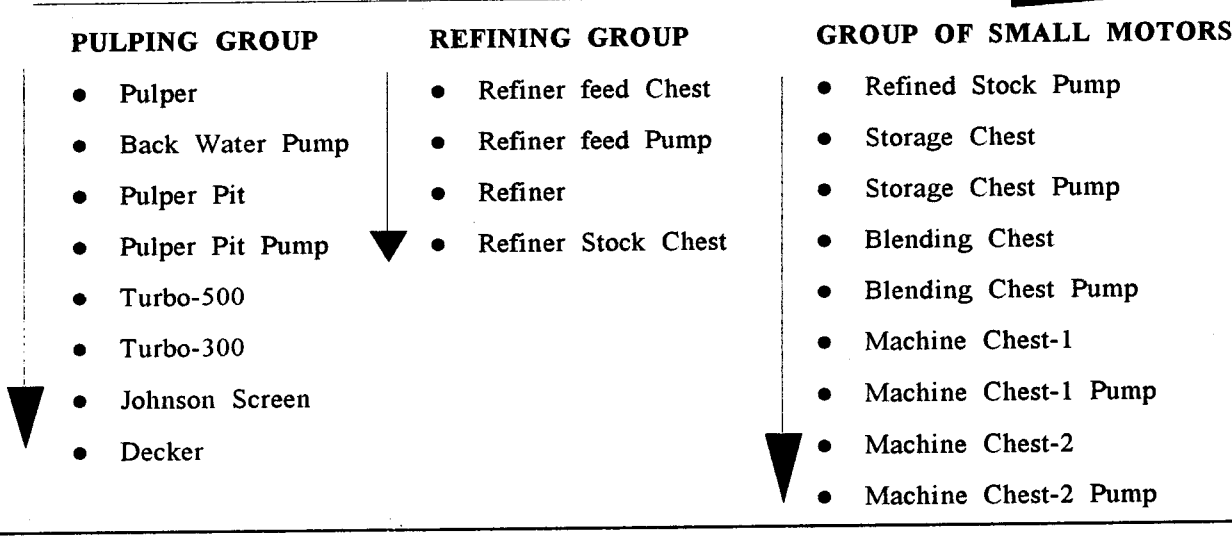
The load, for a particular group, in actual case increases slowly in a short span of time thus reaching to the normal operating load, and remains fairly constant untill the end of cycle.

For ease of control, being the st artup time very low comparable to the total time cycle of the group, the load can be considered as constant throughout the group operating time. In this way, we can have $2^n$ combinations, where n is the number of such groups made.

## PROCESS MODEL FOR PRODUCTION RATE & LOAD

For the optimization purpose, the next step to be taken is to evaluate the system capacity as a whole as well as groupwise in order to design the loading

Fig. 1: Simulated Process Flow Sheet For a Typical Waste Paper Based Plant



| | Newsprint | Abri Printing | Kraft | M G Poster |
|---|---|---|---|---|
| Pulper | 1350 | 1350 | 1050 | 1300 |
| Refiner (I) | 800 | 850 | 670 | 750 |
| Refiner (II) | 700 | 700 | 530 | 650 |
| Group of small motors | 2200 | 2200 | 2200 | 2200 |
| Min. Desired Production Rate | 900 | 800 | 900 | 900 |

**Table 3: Different Groups Production Capacity (Kg/Hr) for Different Qualities of Paper Produced.**

cycle of the different groups. Obviously, this needs a detailed analysis of the past experience of the equipment behaviour. Some such data collected are being given in Table-3.

After the system capacities are known, the next step is to compute the operating load in normal operating conditions as well as in case of high load conditions. In the plant under study, the following load figure were obtained and Shown in Table-4.

## FORMULATION OF OPTIMIZATION PROBLEM

The operating load data gives a clear description of the problem. Now, we can, for a given furnish, formulate our optimization problem as under-

Set -

Overall Prod. Rate to MAXIMUM

Where,

Overall Prod. Rate = Min ($P_{02}P_1+P_2$)

$P_0$ = % Run $Hours_{Pulper}$ * Prod. $Rate_{Pulper}$

$P_1$ = % Run $Hours_{Refiner1}$ * Prod. $Rate_{Refiner1}$

$P_2$ = % Run $Hours_{Refiner2}$ * Prod. $Rate_{Refiner2}$

Subject to the constraint that-

Running Load at a particular time ≤ D G Rated Current

## RESULTS

for the typical case under study, the rated current was 529 A for 380 KVA set for this typcial case. In this way, for an eight hour shift, following results were obtained after optimising the problem with the solver program of Microsoft Excel worksheets. After carrying the optimization process, it was possible to set our target to a higher value i.e. 996 kg/Hr. production rate for newsprint. The results after optimization are being given in Table-5

It also indicated that it is very easily possible to maintain the operating load on the system within the normal working range for the D G sets.

| | Connected HP | Normal Operating Load | High Operating Load |
|---|---|---|---|
| Pulper | 160 | 163A | 185A |
| Refiner (I) | 185 | 190A | 220A |
| Refiner (II) | 155 | 163A | 170A |
| Group of small motors | 120 | 85A | 130A |
| Other Equipment on the Same DG | 110 | 60A | 108A |

**Table 4: Connected HP and operating load data for different groups**

| Run Hours-for- | 5.9 Hrs | 2.1 Hrs | Nil | Nil |
|---|---|---|---|---|
| Pulper | Running | Stop | Running | Stop |
| Refiner (I) | Running | Running | Sto | Running |
| Refiner (II) | Stop | Running | Stop | Stop |
| Group of Small Motors | Running | Running | Running | Running |
| Normal Running Load | 498A | 498A | 308A | 335A |

**Table 5: Optimized conditions for maximum capacity utilization during preparation of pulp for Newsprint.**

## OVERLOADED OPERATION OF EQUIPMENTS

Many a times, some of the equipments work at elevated load. These conditions may arise due to some mechanical or process abnormalities, and are purely temporary in nature. For example, the couch pit pump may trip leading to increased level of couch pit. Stoppage of dilution water supply may thicken the stock making the slurry harder to pump. A web break may even makeis problem much harder. Thus, it becomes necsary to operate itelevated load. Though, this optimization has given a flexibility by giving a llowance of 31 Amtp. for the same, it is also possible to reduce the load of other equipments for a short while. Switching OFF of pulper pit pump will not only reduce load from DG, equal to its operating load, but also reduce operating load on Turbo-500 and Turbo-300. Such practices often generate from the shop floor, and can be used effectively by training the shop floor personnel by simulating the abnormal increased load conditions within the plant itself.

## CONCLUSION

The earlier objects were targetted to achieve the safe, underloaded and smooth operation of the D G sets. After the optimization was done, it made the plant operation very smooth, in addition to improving the capacity of pulp preparation for paper making, thus enabling the paper machine to run at even higher speeds. After the load was kept smooth, it also ensured that the power is not being wasted for idle operation of pump/agitators etc. Though a closer vigilance over the load has to be kept, it is being planned to get it done by adding interlocking circuits in the MCC s (Motor Control Centres) to allow the operation of motors switching ON/OFF as per the emergency conditions.