# Information compilation using expert system for performance improvement of a manufacturing plant

*Since 1990's the increased level of automation coupled with a highly competitive environment in all industries has led to heavy losses in case of equipment failure. Extremely automated plants like plastic molding units, fertilizer plants, petrochemical refineries etc suffer huge losses under such conditions. The trend initiated by the industries is to move towards total preventive maintenance, which means evolving a system, which never fails. This has lead to a shift from breakdown maintenance to preventive maintenance.*

*Failure free operation of a plant requires planned preventive maintenance, condition monitoring, failure analysis and detection of chronic problems, proactive corrective actions, and proper operating procedures and planned replacement of equipment.*

*The present paper aims at development of an expert system for complete information assimilation of all equipment, raw materials, and processes of any given plant with a view to help in total preventive maintenance. A detailed study of a large thermal power plant has been undertaken to identify the specifications of raw materials used, current manufacturing processes followed, existing maintenance practices, analysis of possible failures in future, evaluation of equipment against standards and condition monitoring methodology followed. The information system will include datasheets pollution constraints,for raw materials, checklist for process stages, recommendations for maintenance schedules, equipment repair and replacement, improvement of equipment efficiency, calibration schedule etc. The work aims at creating a knowledge base to be used by maintenance personnel in the absence of an expert in the field. The knowledge base is created by accumulation of the knowledge of several widely represented experts. Thus with this accumulated knowledge base the maintenance decisions become independent of the operating personnel and depend only on the plant condition.*

*Further the expert system also incorporates a knowledge base for diagnostics. An untrained operating personnel, detecting an abnormal operating condition (for example a leak, smoke, a blown of fuse, excessive heating of machinery etc) can seek the help of the expert system for diagnosing the fault and get recommendations for rectifying the fault.*

*In this paper, the expert system package "EXPIM" is developed using VP expert, which has a dominant backward chaining control mechanism. The package has an effective layout, incorporates plenty of graphics and supports methods for visualization. The package developed is extremely user friendly and wide applications in small and medium sized plants are envisaged.*

*The work can be further extended to any production unit, big or small with the only requisite of appropriate and handful data for the creation of the knowledge base which can be a helpful tool for information assimilation to increase productivity and aid for total preventive maintenance.*

## 1.INTRODUCTION

A major problem faced by manufacturing units today is of condition monitoring, maintenance and fault diagnosis of the equipment or process used. This problem predominantly exists owing to the fact that such manufacturing units hold a lot of information regarding the different aspects of the plant. Every personnel working in a particular wing of the plant is expert in that particular section only. Therefore any problem pertaining to the overall expertise of the plant becomes difficult to be solved, since all the personnel are not available at a every place and every time in the plant and the complete expertise is rarely available with a single expert. Such situations demand great amount of information assimilation from different standard sources and arranged in a proper format so that any personnel amateur to the field can also use for plant maintenance. It is found that expert system is the fit of the tool for such problems.

### 1.1.EXPERT SYSTEM

"An expert system is a computer program that represents and reasons with knowledge of a specified subject with a view to solving problem directly or giving advice".

### 1.2.ADVANTAGES OF EXPERT SYSTEMS

Expert system works by storing expertise of a domain expert. Then the user can interact with the system and let it solve a problem using the same logic generally used by the expert. Usually the expert system is faster and more accurate than a human, and does not get tired or bored. A very strong benefit of expert systems is being able to widely distribute the knowledge of a single expert, or being able to accumulate in one place the knowledge of several widely represented experts.

### 1.3. SOME SITUATIONS WHERE EXPERT SYSTEMS SHOULD BE USED

-- Only one expert is available, but is needed in multiple locations
-- Expertise is divided among several experts
-- Expertise is required in a harsh environment
-- An expert is retiring

Expert systems are especially helpful when a task is performed only occasionally and the expert has to learn the procedure each time it is performed. One can use expert systems to

standardize operations. Another use of expert system is as job aid for experts. This will allow them to perform more accurately, more consistently and faster, freeing up time for the expert to be more creative in performing the task. This is especially helpful when dealing with tedious, repetitious tasks. Thus an expert system is needed to completely fulfill a function that normally requires a human expertise or it may play the role of an assistant to a human decision maker. An expert system can be distinguished from a more conventional application program in that:

-- It simulates human reasoning about a problem domain, rather than simulate the domain itself.
-- It performs reasoning over representations of human knowledge, in addition to doing numerical calculations or data retrieval.
-- It solves problems by heuristic or approximate methods, which unlike algorithmic solutions are not guaranteed to succeed.

## 2.THERMAL POWER PLANT

A typical case considered in this paper is that of a thermal power plant. The various sections of a Thermal power plant are:

1. Fuels used
2. Power generation technologies
3. Heat rejection systems
4. Water supply or intakes
5. Solid waste disposal systems
6. Plant and sanitary waste discharge
7. Engineering and pollution control equipment & Their maintenance
8. Management systems

It can be seen that all these components of the Thermal power plant make use of a lot of standard data, which is to be referred very frequently for non-interruptive plant functioning.

## 3.EXPIM

The complete information of the specifications and standards of each of these components is thoroughly studied and gathered in the knowledge base of the package EXPIM-expert system for performance improvement of manufacturing plants. This package has several modules, each of which is available to any user at the click of a mouse. The modules are:

1. Pollution constraints
2. Raw materials
3. Process followed
4. Equipment used

Each module specifies the required standards for maximum productivity with minimum deviation from environmental constraints and also provides the necessary recommendations for total preventive maintenance and fault diagnosis of the complete unit. Each module is explained in detail.

## 3.1.MODULE FOR POLLUTION CONSTRAINTS

Any thermal power plant has to maintain less than certain maximum emissions levels normally acceptable to the World Bank Group in making decisions regarding the provision of World Bank Group financial assistance. All these levels for ambient air quality, liquid effluents, ambient noise and solid effluents are taken as standards to design the knowledge base for this module.

Ambient air quality in thermal power plants:
(Micrograms per cubic meter)

| Pollutant | 24-hour average | Annual average |
|---|---|---|
| PM10 | 150 | 50 |
| TSPa | 230 | 80 |
| Nitrogen dioxide | 150 | 100 |
| Sulfur dioxide | 150 | 80 |

a. Measurement of PM10 is preferable to measurement of TSP.

Effluents from thermal power plant:
(Milligrams per liter, except for pH and temperature)

| Parameter | Maximum value |
|---|---|
| PH | 6-9 |
| TSS | 50 |
| Oil and grease | 10 |
| Total residual chlorine | 0.2 |
| Chromium (total) | 0.5 |
| Copper | 0.5 |
| Iron | 1.0 |
| Zinc | 1.0 |

| | |
|---|---|
| Temperature increase | ≤ 3°Cb |

Ambient noise from thermal power plants:

| Receptor | Maximum allowable log Equivalent (hourly Measurements), in dB (A) Day (07:00-22:00) | Night (22:00-07:00) |
|---|---|---|
| Residential, Institutional, Educational | 55 | 45 |
| Industrial, Commercial | 70 | 70 |

These all standard values form the knowledge base of the pollution constraints module of the EXPIM.A small part of it is explained below:

```
rule 9
        if  ph= yes and
        value = >9
        display" the ph content is more than the standard value. take necessary actions to
          Maintain it in the range of 6-9";
```

These rules form a part of the knowledge base and are hidden from the user.
When the system is used the user will be posed the following questions:

WHAT IS THE EFFLUENT TO BE CHECKED?

PH COPPER IRON ZINC:

When clicked on for PH user interface again asks:

WHAT IS THE VALUE OBTAINED?

<6,6-9, >9

When clicked on for >9 the user interface displays:

THE PH CONTENT IS MORE THAN THE STANDARD VALUE.TAKE NECESSARY ACTIONS TO MAINTAIN IT IN THE RANGE OF 6-9.

Since the standard information is now ready with the software, the day to day on hand information obtained by direct measurement of the concentrations of emissions in samples of the effluents can be checked against the standard information

Monitoring data can be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary action can be recommended by the "EXPIM".

## 3.2.RAW MATERIAL MODULE

The raw material generally used in Thermal power plant is coal, though now solar energy, natural gas and oil are also used for the purpose.

Coal used for the power sector is the non-Coking and middling of coking coal washeries as well as washed coal of Non-coking coal washeries.

The properties of Non-Coking coal are as follows:

Such coals, which do not have coking properties, are Non-coking coal.

Mainly used as thermal grade coal for power generation.

also used for Cement, Fertilizer, Glass, Ceramic, Paper, Chemical, Bricks manufacturing and for other heating purpose.

The properties of washed and beneficiated coal are as follows:

Washed and beneficiated coal are such coal which have undergone process of coal washing or coal beneficiation causing value addition of coal by way of reduction in ash %age.

Beneficiated coking coals find use in manufacturing of hard coke for steel making.

Beneficiated washed Non-coking coal finds use mainly for power generation.

Cement plants, Sponge Iron plants and other industrial plants, can use Beneficiated Non-coking coal.

The properties of middling are as follows:

Middling are by-product of three stage / coal washing / beneficiation process, as a fraction of feed raw coal.

Middling can be used for power generation.

it can also be used by domestic fuel plants, brick manufacturing units, Cement plants, Industrial plants etc

| NON-COKING COAL | |
|---|---|
| GRADE | UHV RANGE (KCALS/KG) |
| A | EXCEEDING 6200 |
| B | EXCEEDING 5600 BUT NOT EXCEEDING 6200 |
| C | EXCEEDING 4940 BUT NOT EXCEEDING 5600 |
| D | EXCEEDING 4200 BUT NOT EXCEEDING 4940 |
| E | EXCEEDING 3360 BUT NOT EXCEEDING 4200 |
| F | EXCEEDING 2400 BUT NOT EXCEEDING 3360 |
| G | EXCEEDING 1300 BUT NOT EXCEEDING 2400 |

rule 3

if non-coking coal= yes and
uhv range = 3360-4199
display"the grade of the non-coking coal used is E.

These rules form a part of the knowledge base and are hidden from the user.
When the system is used the user will be posed the following questions:

WHAT IS THE RAW MATERIAL USED?

NON-COKING COAL MIDDLING WASHED AND BENEFICATED COAL:

When clicked on for NON-COKING COAL the user interface again asks:

WHAT IS THE UHV RANGE OBTAINED AFTER TESTING(IN KCALS/KG)?

>6200,5600-6200,4940-5599,4200-4939,3360-4199,2400-3359,1300-2399:

When clicked on for 3360-4199 the user interface displays:

THE GRADE OF THE NON-COKING COAL USED IS E.

All these standards form the knowledge base for the raw materials module of the EXPIM. The properties of the coal used in the plant should be appropriately checked with the standards from time to time, since inventory build up and shelf period is to be maintained accordingly.

3.3.EQUIPMENT MODULE

The TPP has mainly electrical, electronic, mechanical, computer and measuring equipment and instruments. This module comprises the knowledge base of the total equipment specifications, faults and recommendations for fault diagnosis. A small part of the ES is explained below for the alternator:

```
rule 3
        if  alter= yes and
        sym2 = fail_start and
        fault6 = burnt_fuse
        display"the remedy is ";
        display"examine the fuses . replace if necessary";


rule 4
        if alter = yes and
        sym2 = fail_start and
        fault6 = worn_bearings
        display"the remedy is";
        display"check the bearings.replace if necessary.supply should be checked";
```

These rules form a part of the knowledge base and are hidden from the user.
When the system is used the user will be posed the following questions:

WHAT IS THE ENVIRONMENT OF THE FAULT?

TRANSFORMER ALTERNATOR ELECTROSTATIC PRECIPITATOR

When clicked on for ALTERNATOR user interface again asks:

WHAT ARE THE SYMPTOMS OBSERVED?

FAIL_START, NOT RUN PROPERLY, RUN SLOWLY, EXCESS_HOT, ABNORMAL NOISE, RUNS REVERSE:

When clicked on for FAIL_START the user interface again asks:

ALTERNATOR FAILS TO START DUE TO?

BURNT FUSE, WORN BEARINGS, OVER LOADING, OPEN PHASE, SHT COIL, LOOS BARS, WRONG CONN:

When clicked on for BURNT FUSE the user interface gives the remedy as follows:

EXAMINE THE FUSES AND REPLACE IF NECESSARY.

When clicked on for WORN BEARINGS the user interface gives the remedy as follows:

CHECK THE BEARINGS. REPLACE THE BEARINGS. SUPPLY SHOULD BE CHECKED.

The detailed knowledge base has been created for some of the equipment of the thermal power plant and the package is found to work satisfactorily.

.

## 4.RECOMMENDATIONS

All these modules along with diagnosis of problem or fault act as checklist and also gives recommendations either to clear the fault or to discard the equipment. The EXPIM - Expert system for performance improvement of a manufacturing unit is developed using the VP-Expert system.

### 4.1.VP EXPERT SYSTEM

Paperback software vp expert system is primarily a rule based expert system building tool but it offers several additional features and costs less than $100. Its dominant control mechanism is backward chaining, however the program can do limited forward chaining through the use of a special command. vp expert offers a standard if--then rule structure and can handle situation involving uncertainty very effectively. More over, vp expert also supports limited induction feature that can generate rule for data. but unlike true induction tools, even when this feature is used in vp expert the end result is that the program still performs its reasoning from a standard if--then set.

Vp expert has an effective layout, incorporates plenty of graphics and is well written. It takes a straightforward "editor" approach to knowledge entry. The rules can be typed in directly and even when induction is used the editor is still the primary means for finishing or refining

the expert system. vp expert also supports other methods for visualization of reasoning process. Trace feature when invoked will save the search pattern that led to a particular result during a consultation. It handles uncertainty or "confidence factors" in a variety ways. It also offers a high level graphic feature for tracing system logic.

This type of module is best suited for a captive thermal power plant since all the data required for the creation of knowledge base is ready available and the module can be a handy tool for performance improvement of the plant.

## 5.CONCLUSIONS

The paper covers every aspect for improved performance of a thermal power plant, i.e. with respect to the environmental condition, generation of power per unit of coal, quality of power generated etc. Such a module can be created, in fact for any manufacturing unit with proper information assimilation of the plant .the package will be within the reach of all employees in the plant and just with the visual inspection data trouble shooting can be done using the “EXPIM” by any person anywhere in the plant. Such a package helps in increasing then plant productivity with the same inputs as a result of condition monitoring and preventive maintenance.