World Journal of Engineering Research and Technology
WJERT
www.wjert.org
SJIF Impact Factor: 5.924

INNOVATIVE RESEARCH ON MINING MULTI-PROJECTS MANAGEMENT FOR IMPROVING PERFORMANCE

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Article Received on 25/09/2023 **Article Revised on 15/10/2023** **Article Accepted on 05/11/2023**

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ABSTRACT

Method studies and System studies are fundamental approaches in Industrial Engineering management. Improvement of Performance is a very important Key Result Area of any mining company. While working as General Manager, in ECL, the largest subsidiary of Coal India, part-time research for PhD was undertaken with ISM. The authors have also developed models for cost-benefit analysis of improved systems of mining operations on ground realities and database models. Current forecasts for India by the International Energy Agency and other analysts say India's coal consumption will climb by 4-5 percent a year through 2030. India has 320 billion tonnes of coal reserves and it is 7 percent of the reserve of the world. The energy consumption in India is about one-third of the world average and 60 percent of installed capacity of energy in the country is based on thermal plants. The paper also includes a summary of work done on the subject carried out over many years, on PhD Research at ISM & later in BESU. Further research is being continued for DSc in IIT(ISM) as an Enrolled DSc Researcher.

KEYWORDS: Key Result Area; Project Monitoring; Multi-Projects Format; Database Models; Operating Return; Cost Benefit Analysis.

1. INTRODUCTION

Operations Research is extremely necessary in managing mining multi-projects and here a coal company was thoroughly studied. Mine planning and project design is fundamentally

dependent on the geological attributes of the reserve. Mine reserves are widely varying and so the executive posted for each mine faces different activities. Billions of ₹(Rupees) are spent every year on mining and construction of projects spread all over India. Use of proper scheduling and monitoring techniques can ensure better ROI (Return On Investment) and quick completion of projects. Cost and time overruns of highly capital-intensive projects can be checked and even 5% saving could mean millions of Rupees. Proper viable planning can only make multi-project performance effective. Coal reserves are available in almost every country worldwide, with recoverable reserves in around 70 countries. The biggest reserves are in the USA, Russia, China and India. There are an estimated 1.1 trillion tonnes of proven coal reserves worldwide. India ranks fifth among the nations with the largest coal reserves in the world, and with a production of 761 million metric tonne in 2022, India is the second-largest coal producer in the world behind China.

Major producers of coal in India are CIL subsidiaries and coal blocks allotted to private companies. Coal India Ltd is making profits from opencast mines mainly, overcoming the losses suffered by underground mines. Projects of costing above ₹5000 million are approved by the Govt. through EFC/PIB and CCEA Environmental clearance is mandatory before the project proposal is posed to Cabinet Committee on Economic affairs for approval. Coal projects are monitored in the coal companies at colliery level, area level and HQ level. Remedial actions, wherever warranted are taken.

2. MODEL PROGRAMS AND RUNS

Computer Model Programs and Runs were all devised for the improvement of performance. For example, coded Java programs determined the best alternative for project design. Because of geological incongruities, no two mines are alike and to improve the performance of a project. The author has life-long part-time research experience while working in different management functions in the nationalized coal industry. Various systems of mining operations are studied on ground realities and database models. The authors have developed data-based computer methods in 14 original models; for result-oriented planning for multi-project scheduling and monitoring. Research was carried out development of computerized methods. Current forecasts for India by the International Energy Agency and other analysts say India's coal consumption will climb by 4-5 percent a year through 2030. India has 320 billion tonnes of coal reserves and it is 7 per cent of the reserve of the world. The energy consumption in India is about one-third of the world average and 60 per cent of installed

capacity of energy in the country is based on thermal plants. The paper presents a summary of work done on the subject carried out over many years while working as a General Manager with determined single and multi-project parameters.

3. RIGHT PLANNING

The objective is to develop the right planning for scheduling and monitoring and it has been found from the output data of ES that costs increased with the size of the mine projects. Investment decisions of projects should be made on: -

Payout time- i.e. when Break Even Point is reached, applied here.

Average yearly payout- in terms of capital, works, crew, materials, etc.

Accounting Return or net profit on original investment- used in this ES, as the main criterion.

Operating Return- indicated in the ES annually.

Present worth of Cash flow discounted @10-20%- used in the E.S for projection over 6 years.

Net Profit- is computed excluding taxes and royalties.

DCF Return- could be computed from the ES.

Sensitivity Analysis- Change in output by change in input- indicated by higher BEP.

Actuarial analysis for estimating service life for depreciation- in CIL for 9 years.

Incremental cost analysis for marginal cost etc. - could be computed from the data generated.

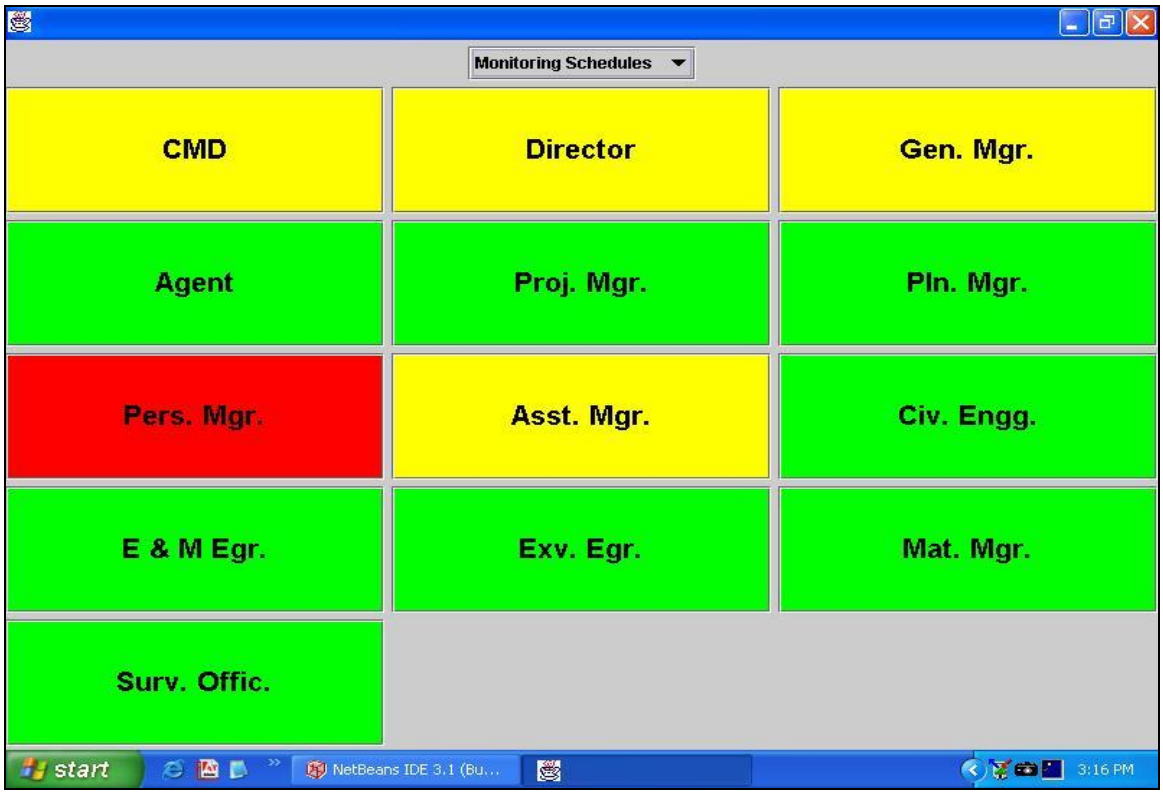
Profitability Index (PI) Return On Investment (ROI) or Discounted Cash Flow (DCF) rate of return are some of the indicators of profits. ROI could be computed from: -

ROI = a+ (b-a) {(ar-1.0)/(ar-br)} = 18% to 28%;

Where, a = initial rate of interest, b = higher interest rate, ar or br = discounted receipts / discounted investment = 1.1 to 1.2. ROE or Return on Equity is given by profit after Tax/ Net worth. Run of the program 'QEP' with actual data from mines shows: - IRR should be 12% at 85% production. To achieve very high OMS and profitability, Continuous Miner technology with roof bolting could be adopted even in geologically disturbed areas.

Program 6.4/'mbo'- shows Key tasks against Management Positions dynamically. Table No-1 shows the model program run, monitoring schedules against different executive positions.

Table 1: Model Program run of mbo.



4. Reorganized Projects

In planning reorganized projects from old mines, crossing the Break Even Point (BEP) level of production is essential. The researcher has developed 2 Database model programs, 'bep' for Recalculating BEP, reducing Variable Cost, and 'bep2' for Revised BEP, on Additional. Investment for making an old mine viable.

As mentioned earlier, data are compiled from the cost sheets submitted by the collieries of a company in 3 different months. Since fixed costs and variable costs are not indicated they are computed and entered in the records. Profit/loss and fixed cost were computed by:-

PROF_LOS = SAL_PRIC-NET_COS

FIX_COS = NET_COS-VAR_COS

BRK_EVN_PT = FIX_COS*PR_TPD/(SAL_PRIC-VAR_COS)

If BEP could not be achieved without additional production from mechanization, needing additional investment for the additional production, total BEP changes: -.

TOT_BEP = BRK_EVN_PT+ADL_PROD

It is assumed that 22% of the annual depreciation + interest and 300 is the number of working days in a year. Random checks can be made of any mine in the database like a model program run of 'bep' for showing TOT_BEP after ADL_INV is made in a mine, without changing databases. A random run of model program 'bep2' for displaying revised BRK_EVN_PT lessened by 50t, with reducing VAR_COS of the mine is shown without changing databases.

5. COAL MULTIPROJECTS

All the packages are further divided into sub-packages and totalling is made head-wise, applicable for all types of mining, in conformity with budget heads. The model program 'mps' for computing the entries of a single project and model program 'mpt' for different projects of a company in a particular month, with budget vs. actual and %schedule vs. %progress for monthly monitoring. Combining different activities into common packages and running 'mps' for individual projects and then feeding them into 'mpt' and yielding company-wise output for any month. Such a single-page summary for a month of project monitoring budget, expenditure, and % schedule and % progress is very useful for top management and ministry for a quick review for deciding remedial actions for slippage.

6. COST BENEFIT FOR METHODS

Improvement of methods and systems could plan better projects to schedule and monitor. Cost Benefit Analysis before planning, especially new and emerging methods can make successful projects.

6.1 Shaft lining - Underground mining is reducing in the world for high cost of sinking and lining, while major opencast mines are approaching economic cut-off-ratio. Recently, Shotcrete type of lining is finding favour in the world. The model program run of ‘scl’ makes some projections and coded in this program are ’netsave’- expected net saving, ’conlicst’- saving in concrete lining cost, ’exvcst’- saving in excavation cost, ’wincst’ - saving in winch and shuttering cost, ’slcst’- shotcrete lining cost, ’diam’- diameter of the finished shaft, ’depth’- of the shaft in m etc. By realistic input of data, a sample program run with different diameters and depths showing the cost benefit by applying shotcrete lining compared to monolithic concrete lining is determined.

It could be observed from the program run that approximate cost saving by adopting shotcrete lining, as compared to monolithic concrete lining, is quite considerable and the savings are

high for larger size shafts. In the program run, net savings have been computed, from 29.38 million for 5m□, 100m depths; to 59.69 million, for 7m □, 450 m depth, compared to conventional monolithic concrete lining in shafts.

6.2 Strata Control Cost Benefit- Among the various methods of stowing for filling voids after extraction of coal, sand stowing is the most prevalent, as compared to costlier crushed stone, pneumatic or highspeed belt stowing, etc. On approximate capital cost for pumps and pipelines, used in the computer program run, the coded 'dre' shows great benefit. Annual net savings ranged from 1.3 million for the Maithon- BCCL pipeline to 137 million for the Maithon- Maithon rivulet pipeline. These pipelines show pronounced savings, compared to conventional systems of transport. Discounting all savings in flood control, power generation, and truck transport, the cost per cum of sand was worked out by computer simulation to 10-17/ cum at the peak capacity of pipelines.

6.3 Quarry Planning Cost Benefit & Scheduling- When the model program 'troq' was compiled and run, with the layout of crusher, bucket elevator, and bunker with screen for steam and slack coal. The program run output shows accrued savings ranged from Rs.40.10/t, in RJ-RJM mine to Rs.1175.62/t in MU-SHP mine. Many other small variables have been discounted and realistic savings could be less. But, irrevocably the fact stands out that there is a considerable justification for reorganization to electricity-driven vertical trans port in opencast mines, especially small mines. There will be greater utilization of shovels, especially in small quarries. Surplus dumpers and trucks could be shifted to new or other mines resulting in more production. There should be more OB removal, as haul roads would be solely used for the purpose.

6.4 Underground Machinery Cost Benefit & Scheduling- The model program 'eqp' has considered 4 types of equipment packages, most commonly used in Indian coalmines, namely Side Discharge Loader (ESDL), Load Haul Dumper (ELHD), Continuous Miner (ECHMN) and Longwall Shearer with Power Support (ELWPS). Here, the prefix E stands for equipment set, for the type of face. The variable names have been declared with codes and data types-namely SLNO, COLLIERY, COE (Cost of Equipment), POC (Production of Coal/y), DIT (Depreciation and Interest), PMT (Power & Maintenance), SC (Store Cost), WC (Wage Cost), OC (Other Cost), PC (Production Cost), CP (Cost of Production), and CB (Cost Benefit in Rs/t). The cost of equipment has been shown with switchgear and declared in the DATA statement, in Rs. Millions – ACNV (Armored Conveyor), BCNV (Belt Conveyor),

CCNV (Chain Conveyor), SDL, LHD, CNMN (Continuous Miner) and LWPS. The Run file is named eqp.txt and the header is formatted as per program.

The program is designed with a subroutine for selecting Equipment Type, with the input of Shear Strength of roof stone (SSR), coal (SSC), floor stone (SSF), seam thickness (CST), largest faultless panel (LFP), etc. EQTYP selection has been based on the parameters in the program. EQTYP=ELWPS if LFP>100 Hectares and SSR<100 bar; =ECNMN if SSC<20 and LFP>50; =ELHD if CST>5 and SSF>80; =ESDL if CST<4 and SSF>100. Pre-Feasibility Report can be made using the model 'eqp' to select the appropriate equipment set.

7. Performance Improving Models

When cost-benefit analysis is improved by the designed program run with realistic data for a new or reorganized method, then planning for scheduling is the logical next step. Coal mine project construction is highly capital-intensive; funding requirements are very often changing for geological and techno-economic reasons.

7.1 Opencast Coal Mine Project Monitoring- Computerized AON PERT diagram, created on VAX Mainframe Computer of CMPDI by the set of input data of SNB project of ECL. Since the project has been rescheduled, there was very little float, found in the chart. The critical activities are shown by bold lines, on the bar chart, as computed by the compiler. New techniques were applied by the researcher for numerous advantages of reviewing computerized networks, after the first input of data. Review could be done on any date, provided all data of revision or reschedule of activities are right. Activities could be split, deleted, inserted, or even relocated with the change of dependencies, with the change of start dates and resources, the compiler automatically computes, all remaining parameters of the network.

7.2 Underground Coal Project Monitoring- According to the above system of packages, a project network of an underground mine of ECL, codenamed SAT, was computerized. The project was designed to produce 1.2 Mt of coal per year. 2 new shafts, 7.2 m Φ had been sunk up to the Dissergarh seam in the first phase and were being equipped. A pair of inclines was driven to the Dissergarh seam also to work the seam in the rise area.

Sample activity bar chart of SAT project, with McProject program of Apple McIntosh PC. The program run in McProject software, displays the Activity Table of SAT Project, with

resources and responsibility. An activity bar chart of skip installation with the MS-Project Windows program was made. Computerized PERT network with MS_PROJECT and difference in design is noticeable.

7.3 Capital Budget Reallocation- Because of geo-mining problems, rescheduling has to be resorted to very often and adjusting fund scheduling. Resource allocation as per schedule is essential, like men, money, machinery, and materials of which money is the most important, as it can arrange other resources. The spreadsheet columns and rows are required to be updated every month, a model 'macro' program has been designed by the researcher for automatic cursor movement, input of data, saving, and printing.

Moreover, in the spreadsheet, cell formulae have been incorporated for automatic computing of the assigned variable, totals, etc. Computing monthly financial scheduling, showing the columns that need not be changed every month of all projects of a company. In multi-project financial allocation, as per priority of projects and criticality of activities some re-allocation of budget between different heads and projects has to be made with joint meetings and exigencies of the situation.

7.4 Coal Projects Responsibility Scheduling- The main Purpose is to ensure the achievement of targeted schedules, within budgeted cost and manpower, by solving day-to-day problems of responsibility scheduling. Thus, a model program 'mbo' is created, for a specific purpose, here for charting the key tasks for different management positions according to conditions in the coalmine project. Decision Chart and the query-based computer program can produce a revised Decision Chart, of any month for any project. In detailed studies, the outcome of this process to standardize coal project 24 key tasks against 13 different management positions in the coal industry.

Job Effectiveness Description JED of a mine Project Manager, developed by the researcher, shows the Program Run of mbo.java for a Particular Project for the Review Month. The executives in green-coloured boxes should actively cooperate for the key task area shown, those in yellow colour to help whenever required and those in red colour need not bother with this key task and concentrate on their routine duties.

If the coalmine project officials are not responsive to the changing situations and stick to routine duties, the project would suffer and so there is a need for responsibility scheduling.

Objective Setting by Action Plan, Responsibility scheduling with Decision Chart by Confidence Factor CF, and sample run mbo.bat displays for a particular project for a certain month.

7.5 Crisis Management Scheduling - Quick scheduling of activities is very important in any disaster or crisis on strategies with the allocation of responsibilities by phone, wireless, etc. Coal mining is very disaster-prone and numerous catastrophes have taken place owing to fire, explosion, inundation, roof-fall etc. in which many employees lost their lives. Most of the equipment, skilled technicians, and executives for Mahabir rescue were by multi-project help.

Disaster struck at Mahabir Colliery, west of Raniganj town of ECL, a subsidiary of CIL on 13th Nov'89 at 4 AM, when there was a sudden inrush of water from old workings of upper Nega (R-VIII) seam to working Narainkuri (R-VII) seam. Water swirled down inundating the pit-bottom of the working pits A & B and the lower workings of the mine. A program was coded and run to find the dewatering time of the flooded mine.

In the model program 'dew' inputs of STAT_VOL (Static volume of water underground), SEPG_WAT (Make of water), DEW_RAT (Dewatering rate), FLB_RAT (into the mine through surface fissures), are made for computing DEW_TIME in days (for dewatering). A sample run of the model program, with incremental dewatering and flow-back rates of water, was done.

Disaster management scheduling, as accomplished, between 13/11/89 and 16/11/89, had been made on Openproj software. This is a unique world-record-making disaster management scheduling work, in which the researcher had played a key role. The researcher's contribution was acclaimed by international journals like Reader's Digest, the June '91 issue in English, Oct '91 issue in Hindi, the January'92 issue in Dutch, and many other language editions. Mahabir capsule rescue is still a world record of its type, with 65 employees in 4 days, in contrast to the rescue of the 33 miners trapped deep underground for 69 days, in a mine in Chile, who got trapped on 5 August and brought up on 14 October 2010.

8. MEETING FUTURE CHALLENGES

Prioritization should be implemented on what is important and what is urgent, before deciding what to do next. Consider the Pareto principle, also known as the 80/20 rule; we get 80% of our results from 20% of our work. Prioritization should generate more time for the

right things, for the valuable 20% that contributes to your long-term personal and professional goals. McKinsey survey: satisfied executives spent less time on administrative activities and more time making decisions, collaborating with their team, and engaging with stakeholders. There are several methods- Personal Prioritization Methods; Stephen Covey's Time-Management Matrix; Alan Lakein's ABC Method- A: High value, B: Medium value, C: Low value; Team Prioritization Methods; Stakeholder Prioritization Methods.

Coal is a fossil fuel, and is the single largest source of global temperature rise. Renewable energy sources – which are available in abundance all around us, provided by the sun, wind, water, waste, and heat from the Earth – are replenished by nature and emit little to no greenhouse gases or pollutants into the air. Renewable energy sources like solar and wind are intermittent and depend on weather conditions, which makes them less reliable than fossil fuels. Renewable energy sources like solar and wind have grown rapidly in recent years, but they still only account for around 11% of global energy consumption. Therefore, coal is estimated to continue as a major energy source of fuel.

Major solutions to be overcome to meet future challenges of coal mining are making underground mining more viable, as large quarries making a profit now are coming close to economic cut-off ratios. So, a Geotechnical Analysis of Mine Shaft Lining Cost Benefits should be undertaken. Innovations of Deep Opencast Mining with Sustainability by steep transport methods are needed. In the event of stoppage of mining in deep quarries, Economic Pisciculture on Mine Closure of Quarries; has to be planned economically for the creation of jobs. Mining properties have to be realistically assessed by an innovative scientific valuation of Mineral Reserves. With international competition growing innovative management to solve critical mining disputes is needed for viable mining. Geological prospecting is finding out more and more multiple seams at greater depths. Present underground mining methods allow upper coal seams susceptible to damage for partial extraction and chances of fire. At the present level of mining cost structure, a very high level of underground production is needed to be viable. Long Wall Power Support LWPS needs regular caving of goaf thus caving the working seams and above. Room and Pillar system with Continuous Miner although highly productive, has to go for partial extraction leaving barrier pillars. Recent progress of research on Earthquake Proof Support Systems for full extraction underground has been encouraging, But, a detailed S&T project has to be undertaken to go for the final design with a Data Analytics application with a Universal Testing Machine. If proven

successful, Room & Pillar and in Bord & Pillar methods stooks and barriers could be replaced with earthquake proof support, preventing any future damage to upper seams. The prospect of mine curtain grouting technology being used to cut off the regional groundwater flow in deep underground mines.

9. CONCLUSIONS

The Ministry of Coal, New Delhi office has been equipped with NIC COAL CELL and IP-based Video Conferencing System (EVCS). Master Control Network originally prepared by CMPDI, has to be revised for various reasons, delays, failures, etc. It has also been experienced due to escalation of prices of essential inputs as also change of activities, the sanctioned cost could not be adhered to, and the Revised Cost Estimates have to be made and sent for approval of Government monitoring packages, sub-packages, and activity is not done properly at the project level normally, like start date, completion date, duration, resourced need, slippage, reasons for slippage, responsibility, physical and financial provision of critical activities required to overcome time and cost overrun. Undertaking networking projects in four key areas, advanced Internet applications, advanced middleware and meta-systems, advanced infrastructure, and policy. COALNET developed by MOC with the help of IIT, Kharagpur should be made more effective.

Computerized development of a database can help in financial resource planning for projects. Private companies allotted 289 coal blocks can take advantage. Coalmine projects require high investment and the world trend for high-production mines for viability is noticeable.

Contractual agreements have assumed significant complexity, like the client-contractor agreement. Mixed integer linear programming, based on practical methods can be applied. Features of optimal schedules, model properties, observation from sample projects, and contractor's NPV with the client's PP schedules should be examined.

1. Every Feasibility Report is recommended to have a Master Control Network and Project Management Service of the Subsidiary Company to update the network. L-3 network recommended to fortnightly construction plan for the project level, reviewed on predetermined dates.
2. The recent trend in computer networks is the replacement of Activity on Arrow (AOA) networks by Activity on Node (AON) networks or Precedence type.

3. Project quality assurance is required in contract services, discipline, change control, etc. Motivation is ensured by authority, influence, leadership, power, conflict resolution, team development, incentives, etc.
4. A system of equipment deployment with the equipment manufacturers/mine operators on a risk-gain-sharing basis are in operation at a few mines in CIL. By this mode of operation, a manufacturer of equipment/mine operator is expected to provide and maintain the equipment. This method can be very useful for companies with large negative Net Worth, as no capital investment is required.
5. Power with approval of State Government and SEBs, depositing fees, HT agreement, and Power Factor increase by capacitor banks, at substations, etc.
6. Satellite transponder or microwave link-up, as proposed is recommended to be implemented so that LAN and WAN techniques are being used by COALNET to link up projects in subsidiaries of Coal India.
7. Accurate EAC, or Estimate at Completion, is one of the most critical pieces of a project. The EAC is made up of "actuals" (labor, materials, other direct costs, and indirect costs) plus your Estimate to Complete (ETC) - the cost of the work left to complete. So, EAC = Actuals + ETC.

10. ACKNOWLEDGEMENT

The authors are indebted to late Dr. D. K. Sinha, former Director, ISM, my PhD Guide, Dr. S.P. Banerjee, former President MGMI and former Director, ISM. The authors express gratitude to Dr. D.C. Panigrahi, former Director, of IIT(ISM), Dr. Rajiv Shekhar, former Director of IIT(ISM), and also to Dr, J.K. Pattanayak, present Director, of IIT(ISM) for encouragement.

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