Programming for sustainable mining projects

Many new and reorganized projects from existing mines have to be made profitable by methods and system study with techno-economic analysis. The author has developed about 14 computerized data-based models on field investigations in a coal company with methods which can be fruitful for planning, scheduling and monitoring for the benefit of the mining industry. Based on field investigations, prevalent cost data, projected cost-benefits have been determined with computer programming models. Advanced management methods have been applied as formidable problems are there for standardization, because of differing mining methods, depending on the type of reserve. Based on field investigations, prevalent cost data, projected cost-benefits have been determined with computer programming models. The researcher has developed about 14 computerized data-based models on field investigations in a coal company. Methods are found fruitful for planning, scheduling and monitoring for sustainable mining industry. This paper has attempted to find innovative techno-economic solutions for continued viability in mining industry with model programmes. Researchers have studied more than 300 scheduling, project, portfolio related software and developed his own programme.

1. Introduction

Pressures for improving performance are mounting due to increasing cost of wages and inputs. Better results are necessary not only for the company, but also for career growth of employees. Development of computerized methods found to hasten preparation of pre-feasibility reports, advance action proposals, project reports, revised cost estimates for new and reconstruction projects, apart from scheduling and monitoring. The researcher has attempted to develop programmes and models from his life-long experience of working in Indian coal industry, with R&D for designing appropriate projects, scheduling and monitoring to minimize time and cost overruns. Basic approach in this study has been to analyze the present particular mining operation, find a better method and determine cost benefit by programming for implementation. Coding of model programmes, has been done in JAVA HLL so that different operating systems like WINDOWS, MAC, LINUX etc. can be used, as shown in Table 1.

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2. New projects

Once, the geological report is available and preliminary study indicates underground method has to be adopted. The researcher has designed a small model programme 'QEP' based on present concept and runs it with practical field and cost data. Project method A1 is for semi-mechanized bord and pillar system with tub loading and haulage. Project method A2 is for mechanized bord and pillar system with side discharge loader (SDL) and chain conveyors. Project method A3 is for mechanized longwall with shearer, armoured face conveyor (AFC), self-advancing hydraulic support etc. Investment decision of projects should be done on:

1. Pay out time i.e. when break even point is reached, applied here.
2. Average yearly payout in terms of capital, works, crew, materials etc.
3. Accounting return or net profit on original investment-used in this ES, as main criterion.
4. Operating return indicated in the ES annually.
5. Present worth of cash flow discounted @10-20%- used for projection over 6 years.
6. Net profit is computed excluding taxes and royalties.
7. DCF return could be computed from the ES.
8. Sensitivity analysis – change in output by change in input indicated by higher BEP.
9. Actuarial analysis for estimating service life for depreciation in CIL for 9 years.
10. Incremental cost analysis for marginal cost etc. computed from the data generated.

Profitability index (PI) or return on investment (ROI) or discounted cash flow (DCF) rate of return are some of the indicators of profits. ROI could be computed from:

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

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/networth.

(a) In the model programme run, with available mine cost data, longwall method has shown lower A/C return 10.75 and so ES has indicated as less suitable.

Table 1: List of computer programs applied for runs

	Chapter/ programme	Purpose of programme
1	3.1/qep.java	Programme for quick formulation of projects
2	3.2/bep.java	Database programme for recalculating BEP, reducing var. cost
3	3.2/bep2.java	Database programme for revised BEP, on additional. investment
4	4/mps.java	Programme for single project scheduling package-wise
5	4/mpt.java	Programme for multi-project scheduling for company
6	5.1/scl.java	Programme for cost-benefit of shotcrete lining in shafts
7	5.2/stl.java	Programme for cost-benefit of track steel/RCC sleepers
8	5.3/dre.java	Programme for cost-benefit in dam dredging for stowing
9	5.4/troq.java	Programme for opencast mine transport reorganization
10	5.5/eqp.java	Program for selection of U/G equipment and scheduling
11	6.2/snet.java	Simulation of PERT for mine project scheduling
12	6.3/fecl.xls	Macros programmed for updating financial scheduling
13	6.4/mbo.java	Key task programming against management positions
14	6.5/dew.java	Programme for computing. dewatering time of a mine

(b) In favourable conditions, and if we standardize and indigenously manufacture LWPS, it could be the most suitable method in future. IRR should be 12% at 85% production.

(c) In order to achieve very high OMS and profitability, continuous miner technology with roof bolting could be adopted even in geologically disturbed areas.

3. Reorganized projects

In planning reorganized projects from old mines, crossing break even point (BEP) level of production is essential. The researcher has developed 2 data base model programmes, 'BEP' for recalculating BEP, reducing variable cost and 'BEP 2' 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 acompany in 3 different months. Since, fixed costs and variable costs are not indicated so they are computed and entered in the records. Assuming 22% of the annual depreciation + interest and 300 is number of working days in a year, it was found that additional investment of 1 million could be neutralized with additional 2 tpd, e.g. as in the PDV_PDV mine. However, this additional investment and ADDL_PROD required would be higher accordingly. Again, the programme computed revised total break-even point of the colliery. Random checks can be made of any mine in data base for showing TOT_BEP after ADL_INV is made in a mine, without changing data bases. The data base programme run shows BKL_MRA has TOT_BEP: 723 t and even with ADL_INV: of 80 lakhs, like SDL set TOT_BEP increases by only about 56 t

Programme run of 'BEP2' shows KNT_TPS has BRK_EVN_PT of 131.42 with VAR_COS of 131.42. A random run of model programme 'BEP 2' for displaying revised BRK_EVN_PT lessened by 50t, with reducing VAR_COS of the mine is shown without changing data bases. Once, the techno-economics of coal mine, is analyzed, detailed planning and scheduling can be done. Similar exercises have to be done, for all mines of the company from the data base collected.

4. Multiprojects

Opencast and underground projects have different sets of activities; yet have to be structured in common format for computing purposes. Combining clearly different activities in to common packages and running 'mps' for individual projects and then feeding them in to 'mpt' and yielding company-wise output for any month. All the packages are further divided into sub-packages and totaling is made head-wise, applicable for all types of mining, in conformity of budget heads. The model programme 'mps' for computing the entries of a single project and model programme 'mpt' for different projects of a company in a particular month, with budget vs. actual and % schedule vs. % progress for monthly monitoring.

Individual project run data files for the month are named and saved logically, for example like 'rjmju.eqp' file means for project rjm for the month of June and for equipment package, tot_civ is total for civil package and 'jmju.tot' means total of all packages. Next in the programme run for company output data the input file names for each project are input package wise and the programme automatically computes by totalling the figures by mpt.java run and saved in identifiable file code names like 'eclju.srv' for company ECL for June for survey package or eclju.tot for total for the company, 'cmy_mdv' means total for company in mine development. Such single page summary for a month of project monitoring budget, expenditure, and % schedule and % progress and are very useful for top management and ministry for quick review for deciding remedial actions for slippage.

5. Cost benefit for reorganization

Improvement of methods and systems, could plan better projects to schedule and monitor. Cost benefit analysis before planning, with new emerging methods can make successful projects.

5.1 Shaft lining

One of the major causes of deferring deep underground mining has been extremely high cost of shaft sinking and lining. Future possibility of sinking with pre-split blasting with shotcrete lining has been studied as Indian coal-measure rocks are stronger. The model programme 'scl' run makes some projections and coded in this programme 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. The model programme run with different diameters and depths showing the cost benefit by applying shotcrete lining compared to monolithic concrete lining. The savings are higher for larger size shafts. In the programme run, net savings have been computed, from 29.38 million for 5mϕ, 100m depths; to 59.69 million, for 7mϕ, 450 m depth, compared to conventional monolithic concrete lining in shafts.

5.2 Improved track and support

Conservation of forest and timber is required and use of steel or RCC sleepers for track and roof-bolts for support. Most traditional underground mines have track haulage as the main coal production transport system. A S&T project of Ministry of Coal, of which the author was the project leader, model programme 'stl' determined the cost benefit and accordingly scheduling and prioritization of mines for implementation.

In the model programme, data were the price of TS1 – timber sleeper 0.61m gauge = 20; TS2 – timber sleeper 1 m gauge = 70; SS1 – steel sleeper 0.61m gauge = 300, SS2 – steel sleeper 1m gauge = 500. The 'stl' model programme writes the data according to format statement, like column-colliery, name, TYP – type, NTS – no. of timber sleeper, DCOST – dog nail cost, NSS – no. of steel sleepers = 80% NTS, as life could be 20 years against 4 years of timber found; YRPR – yearly production,and CP – coal price. Then, assignment statement, TC – timber-track cost, SC – steel track cost, type'*' – metre gauge, TTC – total timber-track cost, DSAV – derailment saving, and CB – cost benefits etc. are coded in the programme. It has been established by the computer programme run, that although the price of timber sleeper is 1/5th of the steel sleeper, in the long run the designed steel sleeper is cost effective. It could be observed from the programme run that projected cost saving by adopting steel sleeper was quite considerable and the savings ranged from 1.2 to 4.9 million per year.

5.3 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 high speed belt stowing etc. A committee was constituted to find cheaper alternative with the author as the leader. Dredging of dams and utilization of coarse sand through pipelines, could be multi-purpose cheaper alternative. Approximate capital cost for pumps and pipelines, used in the computer model programme 'dre' run. It could be seen, from the sample run of the model programme 'dre', that annual net saving ranged from 1.3 million for Maithon-BCCL pipeline to 137 million for Maithon-Maithon rivulet pipeline. By pipeline, it is assumed saving of 5 km and 15 per m^3 for 1.0 mill. m^3 per year of 'svtk' = 150 million. Actual gain in saving in hydel generation would be more, as the reservoir is replenished with water after evacuation of sand.

Most of the dams are silted up as per international findings in 40 years and DVC dams have exceeded that period. The silt collected from separator-bunker can be utilized in brick-makingetc. Most of the recent capacity slurry pipelines utilize centrifugal type pumps, mounted on a dredger capable of transporting large size lumps up to 4" size. Discounting all savings in flood control, power generation and truck transport, the cost per m^3 of sand worked out by computer simulation to 10-17 m^3 at peak capacity of pipelines.

5.4 Steep quarry transport

Construction and maintenance of paved haul roads are very costly, especially in small quarries and patch deposits. Specially designed bucket elevator near the box-cut of the quarry can be of great advantage. Several quarries were studied for projecting cost benefits, including saving in diesel cost. Quarry-bed crusher, electrically driven bucket elevator and bunker with screen for steam and slack coal were considered. A model programme 'troq' was compiled and run, with data input of mine name, life, no. of shovels, no. of dumpers, depreciation and interest, fuel and maintenance, dumper cost, truck cost, conveyor length, depreciation and interest, power and maintenance and yearly production.

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. As can be observed from the programme run output, accrued saving ranged from 40.10/t, in RJ-RJM mine to 1175.62/t in MU-SHP mine. Irrevocably the fact stands out that there is considerable justification in reorganization to electricity driven vertical or steep transport in opencast, especially small mines.

6. Underground machinery selection

The most problematic situation today is viability of underground mining and appropriate high productive technology is required for reorganization. The model programme 'eqp' has considered 4 types of face equipment sets, commonly used in Indian coal mines, namely side discharge loader (ESDL), load haul dumper (ELHD), continuous miner (ECHMN) and longwall shearer with power support (ELWPS). Here, 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 and maintenance), SC (store cost), WC (wage cost), OC (other cost), PC (production cost), CP (cost of production), and CB (cost benefit in /t). The cost of equipment have been shown with switchgears and declared in DATA statement, in Rs. millions- ACNV (armored conveyor), BCNV (belt conveyor), CCNV (chain conveyor), SDL, LHD, CNMN (continuous miner) and LWPS. The programme is designed with a sub-routine for selecting equipment type, with 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 programme.

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. For capital intensive LWPS, favourable geological conditions should be ensured before introduction, at least 1 km 2, i.e.100 hectares should be without any major fault. The roof should be cavable and shear strength of roof-stone should be preferably less than 100 kg/cm^2. Table 2 shows algorithm of the model programme 'eqp' for proper selection of underground equipment.

Selection and scheduling would depend upon the amount of likely cost benefit to be achieved, budget position, fund reallocation according to the company's priorities, infrastructure, power, manpower availability, marketability of coal and so on. Pre-feasibility report can be made using the model 'eqp' to select appropriate equipment set. Most important factor is laboratory investigation of rock mechanics properties of the workings.

7. Scheduling and monitoring models

When cost benefit analysis is encouraging by designed programme run with realistic data for a new or reorganized method, then planning for scheduling is next logical step.

7.1 Opencast project monitoring

The VAX computer used for the exercise was installed at CMPDIL, at Gondwana Place, Ranchi. The mainframe computer had much software, including two software packages on project management, CPM and VUE, of which VUE had additional graphic network capability and so was chosen for developing a large opencast coal mine project scheduling model. Computerized AON PERT diagram, created by the same set of input data of SNB project based on flowchart of monitoring of the opencast project network. The activity name is followed by duration in brackets, e.g. coal production sec-A. 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 barchart, as computed by the compiler

Although, most mainframes are not working, in some places serving as an archive, as better mini and PC are coming up with improved versions of software. New techniques were applied by the researcher for numerous advantages of reviewing computerized networks. Review could be done any date; activities could be split, deleted, inserted or even relocated with change of dependencies, with change of start dates and resources, the compiler automatically computes, all remaining parameters of the network.

7.2 Underground project monitoring

Combining all activities in a system of packages, a project network of an underground mine code named SAT, was computerized. The project was designed to produce 1.2 Mt of coal per year. 2 new shafts, 7.2 mϕ had been sunk and were being equipped. All activity bar chart of SAT project, with McProject programme of Apple McIntosh PC was designed. The activity table of SAT project, with resources and responsibility. Activity bar chart of skip installation with MS-project Windows programme with computerized PERT network with MS_PROJECT and difference in design was noticeable. Critical path method was indicated rescheduling was planned. Individual scheduling activity data can be entered from any scheduling software into summary single page project monitoring report in 'mps' and then for company 'mpt' model programme runs.

7.3 Capital budget monitoring

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 financial scheduling of projects of a subsidiary coal company, as proposed monthly, with names of the mines coded, for obvious reasons. The spreadsheet columns and rows are required to be updated every month, a model 'macro' programme has been designed by the researcher with minimum keystrokes for automatic cursor movement, for input of data, saving and printing.

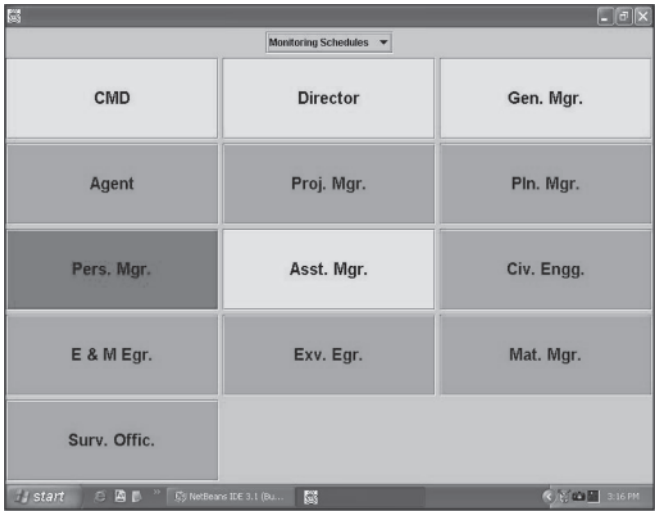
Moreover, in the spreadsheet, cell formulae have been incorporated for automatic computing of the assigned variable, totals etc. Monthly financial scheduling, showing the columns that need not be changed every month of all projects of a company. In multi-project financial allocation, as per priority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

7.4 Project responsibility scheduling

In large projects, overlap of duties and functions create confusion among executives and performance suffers. A model programme 'mbo' was created, for charting the key tasks for different management positions according to conditions in the coal mine project. Decision chart and the query based computer programme is able to produce a revised decision chart, of any month for any project. On detail studies, outcome of this process is to standardize coal project 24 keytasks against 13 different management positions in coal industry.

Job effectiveness description (JED) of a mine project manager is developed by the researcher, based on study. Model programme run of 'mbo' for a particular project for the review month was obtained. 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 for this key task and concentrate on their routine duties. Objective setting by action plan, responsibility scheduling with decision chart by confidence factor (CF) and result is exemplified. In coding 'mbo' 24 key tasks for 13 different management positions were taken by the researcher and sample run mbo.bat displays for a particular project for certain month.

TABLE 2: SAMPLE PROGRAM RUN OF MBO.JAVA



7.5 CRISIS MANAGEMENT SCHEDULING

Quick scheduling of activities is very important in any disaster or crisis on strategies with 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. 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 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 and B and lower workings of the mine.

Based on data collected from the mine a computer programme was coded for calculation of dewatering-time of a flooded mine, in crisis scheduling for PC application. In model programme '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 programme, with incremental dewatering and flow-back rates of water, showed ALT_NO 10 in the programme run came close to reality, when after about a month, 6 dead bodies were recovered.

Disaster management scheduling, as accomplished, between 13/11/89 and 16/11/89, was recorded. The researcher's contribution was acclaimed by international journals like Reader's Digest, June '91 issue in English, Oct '91 issue in Hindi, January'92 issue in Dutch and in many other languages. Mahabir capsule rescue is still a world record of its type, 65 employees in 4 days, in contrast to rescue of the 33 miners trapped deep underground for 69 days, in a mine of Chile, on 5 August and brought up on 14 October 2010.

7.6 CLOSE MONITORING OF PROJECTS

Mine projects are based on detailed geological investigations and report and feasibility or project report can be widely different depending upon the features of mineral deposit. After going through several levels of scrutiny, the feasibility report is finally sanctioned as project report. Schedule of activities and milestones are outlined in the project report with estimated cost, spread over a few years of construction. It has been found very often that because of geological anomalies and operational problems the activities have to be rescheduled. This is usually done, while framing the annual plan, with budget reallocation, but monitoring continues on monthly basis.

Because of ease of rescheduling and monitoring, computer applications are being developed and used apart from utilizing off the shelf project/portfolio software. Usually, quarterly MIS report of large projects are to be sent for company headquarters and the ministry.

8. Conclusions

All algorithm, flow chart and programme runs could not be included in the paper. The major delays and problems identified are given below:

1. The researcher has analyzed the results of hundreds of World Bank aided projects, indicating that success or failure is often beyond the control of project manager.
2. The results of the experiments using optimizing techniques, in multi-project scheduling of resources, indicate that only heuristic based procedures are realistic for practical problem solving.
3. Master control network originally provided in project reports, has to be revised for various reasons – geological anomalies, delays, failures etc.
4. Due to frequent rescheduling of activity, especially in critical path, schedules are upset and can be modified with programme.
5. Coordination of activities between various agencies and supply of timely inputs suffer, because of procedural delays in a public sector set up.
6. Due to escalation of prices of essential inputs as also change of activities, revised cost estimates have to be made and sent for approval of government.
7. Monitoring packages, sub-packages and activity has to be done properly as critical activities require crashing with extra cost.
8. Recommends 3 levels of monitoring based on master networks – (i) L-1 network with emphasis on package and milestones on graphic level, (ii) L-2 network is more detailed and resource based and (iii) L-3 network with detailed sub package and activity for review, and remedial action.

9. Acknowledgements

Thankfulness is expressed to Prof. A. K. Ghose, former President of MMGI, IEI and Advisor of the Journal of Mines, Metals & Fuels. Gratitude is conveyed for help and guidance

to late Dr. D. K. Sinha, former Director, ISM, Dr. A. S. Prasad, Chair Professor, ISM, late Dr. K. K. Guin, Head VGSOM, IIT, Kharagpur, Dr. A. B. Samaddar, former Director, MNNIT and many others. The author is also indebted to Prof. Dr. D. C. Panigrahi, Director, ISM, Prof. Dr. Phalguni Sen, Prof. Dr. V. S. N. R. Murthy, HOD(ME) IIT(ISM), Dhanbad.

References

1. Ghose, A. K. (2004): Serendipity, Innovation and the Evolution of Mining Science; Foundation Day Lecture, CMRI, Dhanbad.
2. Anderson, D. and Verna, A. (2005): "Project Management is a capital investment process;" *Journal of Management & Engineers*, Oct 2005, Vol.24, No.4, - ISS0742-597X.
3. Covey, Franklin (2008): Project Management and Task Management; San Francisco, CA, USA.
4. Dinsmore, Paul C. and Cabanis-Brewin, Jeannette (2009): AMA Handbook of Project Management; American Management Association, USA.
5. Furman, U. (2007): "Improving Network Access in the Mining Sector;" *Aust MM Bulletin*, No.1, Jan/ Feb 2007.
6. Glasserman, P. and Staum, J. (2003): "Resource Allocation among Simulation Time Steps;" *Operation Research*, Nov & Dec, USA.
7. Goel, Anita (2012): Computer Fundamentals; Pearson Education India. Copyright.
8. Method 123 (2003): Project Management Hand-Book; ISBN 0-473-10445-8.
9. Mitchell, Paul (2011): Achieving Major Capital Project Effectiveness and Corporate Performance; Effective Capital Project Execution Mining and Metals, Ernst & Young, © 2011; EYGM Limited. Australia.
10. Panigrahi, D. C. (2012): Sustainable Mining and Environment - The Indian Context; 4th Asian Mining Congress, 29-31 January 2012, Kolkata, India: The Mining, Geological and Metallurgical Institute of India (MGMI)
11. Rajaraman, V. (2012): Computer Oriented Numerical Methods 3Rd Ed; PHI Learning Pvt. Ltd.
12. Samanta, B. K. (1998): "Computerized Coal Multi-project Monitoring;" *Minetech*, Vol. 19,No.6, Nov- Dec.'98.- CMPDI, Ranchi.
13. Samanta, B. K. and Samaddar, Dr. A. B. (2002): "Formulation of Coal Mining Projects by Expert System;" pp. 202, *Journal of Mines, Metals and Fuels*, ISSN 0022-2755, Kolkata.
14. Samanta, B. K. (2005): Coalnet- A Developing Intranet; XXXVII National Convention 2002 of Computer Society of India, October 29th to 31st 2002, Bangalore, India. No.42, pp251, Tata McGraw-Hill Publishing Company Limited, New Delhi.
15. Samanta, B. K. (2005): Mine Project Responsibility Scheduling; International Symposium on Advances in Mining Technology and Management; IIT, Kharagpur.
16. Samanta, B. K. (2006): Advances in Computerized Project Scheduling & Monitoring; All India Seminar on Advances in Computer and Information Technology-IE(I), Dhanbad Chapter, ISM GJ Auditorium, 11-12 March, 2006.
17. Samanta, B. K. (2007): Emerging Computerized Project Scheduling Networks; Recent Advances on Information Technology (RAIT-2007); Proceedings of the National Seminar, Allied Publishers Pvt. Ltd-Department of Computer Science & Engineering; Indian School of Mines University, Dhanbad-826004, Feb 26-27, 2007.
18. Samanta, B. K. (2012): Developments In Computerized Multi-Project Management For Sustainable Mining; 4th Asian Mining Congress, Sustainable Mining in Asia - Challenges and Opportunities, The Mining, Geological, & Metallurgical Institute of India (MGMI), 29-31 January, 2012, Kolkata.
19. Samanta, B. K. (2012): Mining Multi-Project Monitoring Computer Model For Summarized Assessment; National Convention of Mining Engineering; National Convention of Mining Engineering of IE(I), Kolkata in collaboration with BESU.
20. Samanta, B. K. (2017): Multi Criteria Decision Model for Mining Projects; Journal of Modern Project Management, www.journalmodernpm.com/; published on peer review; Google Scholar Citation, January-April 2017; pp.113.
21. Samanta, B. K. (2017): Environment & Safety Challenges in Oil & Gas Projects; International Conference on Challenges and Prospects of Petroleum and Processing Industries, PEDJP-2017, 12-14 January; IIT (ISM) Tech Session VI-PEDJP/098.
22. Samanta, B. K. (2017): "Strategies to Achieve National Demand of Coal and Mineral Production;" *The Indian Mining & Engineering Journal*, www.theimejournal. com/ January 2017.
23. Samanta, B. K. (2017): "Coal Project Responsibility Scheduling Model," *International Journal of Engineering Trends and Technology (IJETT)*, V44(4),146-152 February 2017. ISSN:2231-5381. www.ijettjournal.org. published on peer review; Thomson Reuters affiliated.
24. Samanta, B. K. (2017): "Underground Mining Project Equipment Selection Model," *International Journal of Computer Trends and Technology (IJCTT)* V44(1):50-57, February 2017. ISSN:2231-2803. www.ijcttjournal. org. Published by peer review; Thomson Reuters affiliated.
25. Schwechel, John (2010): Ten Keyes for Project Success; Retail Process Engineering, LLC.
26. https://www.apm.org.uk/book-shop/planning-scheduling-monitoring-and-control-the-practical-project-management-of-time-cost-and-risk/
27. https://www.apm.org.uk/sites/default/files/2015/psmc_secure.pdf.
28. http://omec.eu/pmi-pmbok/planning-scheduling-and-monitoring-project-progress.
29. https://www.researchgate.net/publication/241703187_Project_scheduling_and_monitoring_Current_research_status,

Printed by Pradip Kumar Chanda at The Indian Press Pvt. Ltd. 93A Lenin Sarani, Kolkata 700 013 and published by him for Books & Journals Pvt. Ltd. from 6/2 Madan Street, Kolkata 700 072.