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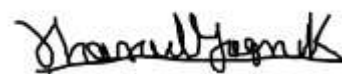
From the Director

It gives me immense pleasure to unveil 2020 Edition of IRIMEE Journal which has been put together by the editor with painstaking efforts. As a learning organisation, this Institute always believes that a platform should be made available to faculty and Trainees, many of them working officers, to pen down their works of explorations into Technology and Management or best practices either done in person or to which they have been witness . Other study subjects which are of immediate interest to the Railway fraternity and academia at large need exploring and expounding to provide an opportunity to the organisation to grow and to the individual for self actualisation of his potential as valuable change agent for the society at large.

I am glad that energetic faculty members and enthusiastic Railway officers who have in some way or the other been in touch with this Institute have agreed to contribute articles to this Journal in this difficult times . The Journal has been brought in digital mode keeping in view the thrust of the organisation on electronic communication and compulsions of the occasion a-la Covid19 .

While all attempts have been made to accommodate original views of the authors, errors inadvertent or otherwise are regretted in advance.

In view of the tight timelines and the overwhelming response, some of the articles which were received well in time have been published in this August Edition. The other articles received have been added to our 'Article Bank' and shall be published in subsequent issues. We request our contributors to be patient in this regard.



**S K YAGNIK
DIRECTOR
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Developing Human Resources ~ The Toyota Way

S K Yagnik,
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Abstract

Toyota is one of the most successful automakers across the globe. Toyota is not just a carmaker, they have also given management concepts to organizations across the world.

This article explores the use of these principles in Human Resource Development, a resource that's perhaps more important than even technology or capital.



In factories around the globe, Toyota consistently raises the bar in the field of Manufacturing Technology, Product Development, and Process Excellence. Toyota Motor Company is known for its quality, cost-consciousness and innovations. Toyota way of manufacturing has resulted in hugely successful business model, steadily improving its market share, dropping of prices and at the same time earning profits

much more than other car manufacturing companies; and in this process earning recognition from business leaders worldwide.

It has market capitalisation greater than the value of General Motors and Ford combined. Company reported vehicle sales of 8.9 Million units and net revenue of 29.9 T yen (Rs 2,065,163 Cr) in FY 2019-20. Toyota's well known secret weapon is the lean Production System- a revolutionary

approach to business processes that was invented by the company in 1950s which has been honed over several decades and is still evolving. **Toyota's Management System**, as it is known today, encompasses 14 principles that drive the Toyota quality and efficiency obsessed culture. One very important distinction which has to be kept in mind while trying to understand the model of the company is the *Human centric approach* with technology playing a secondary role. Emphasis placed on the founding principles of trust, mutual prosperity, excellence and a learning organisation, not only at its production plant but with its dealers and ancillary units, is something which may be easy to describe but difficult to imbibe.

Full understanding of the management philosophy at Toyota may take years to comprehend and even longer to assimilate. The principles of '*Pull*' system, *Hiejunka* or level out, creating a continuous process flow, use of visual controls *Genchi Gembustu* or go and see for yourself, *Kaizen* or continuous improvement, 5S are some of the most talked about features. Very often the reader makes the mistake of assuming these to be management tools whereas actually these are **Value Systems** built into the mind set of the employees at the company. In this article, an attempt has been made to understand the training process adopted in Toyota system which enables the company to mold the new recruits as per its work-culture who become the driving force of Toyota Philosophy.

Inducting Right People

Process of training at the start at attracting right and competent trainable people. Toyota believes that people with right qualities must be attracted so that they can socialize into the **Toyota Way**. Their attitudes must be developed so that they are able to do the job they are assigned to. Toyota production system is famous for **Just in Time** system of material handling, getting the right amount of right part at the right place at right time. The

same holds true for its people value stream. Getting the right people, in right numbers at right time in line with companies needs.

In a normal business scenario, if we pose the question, '*Why does the company hire?*' the standard reply of the HR department will be - Because company has positions to fill. It could be a case where the sales have suddenly increased, some vacancies have arisen due attrition or need for new type of expertise in view of some technical developments which the company aspires to possess. A position opens up and you fill it. It is left to the Hiring manager to search and interview the aspirants and then handing over the best out of the lot to the company management for further utilization of the selected candidate. At this stage task of the Hiring manager ends.

In Toyota also similar approach is taken except for the fact that the HR manager is fully aware that the people at the company will be employed for life. Toyota has one of the lowest turnover rates in the industry. The position, where the employee is expected to join the company is not the one, for which the company is looking forward to for preparing Selection Goal, but what the employee will do few years from now which forms the criteria for setting out the Hiring objectives. In fact even before hiring, it is made very clear by the management that first job of HR manager is to protect the existing staff on the rolls of the company. Even if there is a minimal chance that existing staff can fill up the requirement and on a reasonable long term forecast the first priority will be to retain and engage him. Recruitment is looked upon as an agonizing task to be taken up only as a last resort.

As a prerequisite to building quality cars, recruitment and training process is the primary quality assurance filter for the people value stream. As in many concerns, Toyota is keeping some percentage of workforce as temporary employees also called variable work force to hedge against

the economic fluctuations. The temporary workforce however is treated as inseparable segment the team and same pains are taken in their recruitment as a part of the permanent workforce. In fact, most of them are converted to full time employees at the end of their assignment period which may last couple of years and the attempt of the management is not to let go the temporaries under any circumstance as they are seen as invaluable asset in whom lies experience and commitment .

This selection process in can extend over five stages, and in many cases involves exposure of the perspective candidates to the actual work environment before they give consent to get involved in recruitment process so that they have no doubt about the nature of work they that they will be required to handle and the conditions under which they will work. It is therefore not surprising that candidates choose not to pursue the process further and drop out saving several head-aches to both employer and the employee as seen in many other concerns when candidate after selection and joining decides not to continue due to his in-disposition to the job profile.

Training

Toyota is a learning organization where people have evolved a culture of working together, communicating and solving problems. It would be unwise to assume that people selected for Toyota even if they are the best and with right attitude will simply acclimatize to the Toyota culture without proper training. It is a strong belief at Toyota that Production Staff at the Assembly line are the only ones who add value in the factory and all other supporting staff are there to help them. Like a surgeon in operation theatre, the workers are taught the craft of assembly '**On the Job**' taking increasing responsibility over the time. At the same time as the new hires are learning the basic skills of the job they are also been socialized into Toyota way of doing things. It is not

considered enough to just meet the quality standards and quantitative requirements of the job. The company way of observing, thinking, communicating and behaving must become part of the mental makeup of the employee and this indoctrination starts from day one on the job, in fact at the recruitment stage itself.

Getting started- Team member orientation-

Human Resource Department of Toyota is responsible for new team member for a short stint of 5 week orientation period after which the team member is turned over to the home department where he will be posted. The aim of the orientation is to introduce the new team member to Toyota production environment and culture. It also includes conditioning of the a member for physical tightness or muscle training and endurance as job at the plant can be very demanding physically. Each member during orientation is also made aware of the human resource policies, pays and benefits and growth & career prospects that await him in the future.

Once the member joins home department as trainee, he get exposure on actual production job. Now the member performs actual production line task on simulators, gradually adjusting to processes and quality standards. Team member performs few relatively simple production jobs in simulation area where the orientation program group leader carries out an assessment to ensure that each member is properly using the ergonomic procedures to which he was earlier exposed in the program .

One of the most distinct aspect off the training is emphasis on **Genchi Genbustu** which in general refers to going to the see the actual problem but is a much broader concept reflecting the value on '**getting your hands dirty**'. The founders of the company learnt the art of car business by doing the tasks themselves and getting their hands

dirty. No wonder therefore, the classroom oriented knowledge transfer training is one of the lesser used tools in Toyota culture.

Ohno Circle

In the the early fifties Taiich OHNO ,a plant manager at Toyota system who mastered the principles of Jidoka and one piece flow, would paint a circle at a place in shop floor and ask the trainee to stand there all the day, observe the people and every couple of hours come back and ask what the trainee had observe. Only when the trainer was satisfied that member was deeply observing the process and reporting the waste correctly, would he let then go home. Master would never tell the pupil what reply he expected. He would only keep on asking for the right answer and many of the trainees who stood in the circle described this as one of the most profound learning experience, another means of learning through Genchi Genbutsu. This taught them to develop observation power which enabled them to go far beyond the superficial first impression. This way of teaching is philosophy is similar to Socratic method. Later, he would often ask questions but not give answers, the purpose being to make the student think for themselves. With Rapid growth of Toyota internationally, some elements of classroom teaching have crept in and it is no more looked upon with same disdain and abhorrence as in early days. This is not to be construed as departure from Toyota culture but in fact an extension of it as Kaizen or continuous improvement and adaptation are part of the same culture. It is realized that with rapid growth it is not always possible to assign each person to a mentor and so the new teaching methods which can reach more number of students in less time have been introduced. However, the company has not diluted the essence of it's learning philosophy and shop-floor/ workplace learning by observation still commands a high respect presentation.

After the preliminary orientation, the next

stage includes exposure of student to case studies to check his comprehension of the concepts. Thereafter, his managers from the work area identify real life problems from their region which is handed over to the member to work upon for solutions. In this phase, each member goes to his work area where they are confronted by the real shop floor conditions and the managers who expose them to the finer nuances of the workplace. However, no one gives them any answers. The solution has to be discovered by the student. The classroom training which has now become a part of Toyota Learning System helps the students to learn the 'Why' part of the solution whereas the shop floor learning inculcates 'How'. Shop floor problem solving apart, important trait which the member learns is to develop the interpersonal skills. The member knows that howsoever senior he may be in hierarchy; he will have to talk to many people below and above his rank to find the solution. He cannot work outside the team in any circumstances.

Personal Training Opportunities

Apart from structured 'Must do' training programs, provision has been made in Toyota for personal training opportunities which are usually voluntary self-initiated efforts by individual to address the gap in training which is not covered by the current companies standard training programs. The employee chooses to attend them based on his own perception of what he needs for self-actualization and therefore such programs are called 'Self-Initiated Development'. These training programs can be chosen from within or outside the company and are effective vehicle for cultivating greater sense of involvement & self-motivation.

Examples of internal personal training opportunities include working on project teams, Safety committee or Cost improvement task force. Most common and popular arena is Quality Circles. Any team member of Toyota can volunteer to go through a Paid training course which can

help them become a circle leader. An example of external training activity permitted at Toyota Motors is programs offered by area colleges organizing classes physically or electronically to interested students. Tuition is reimbursement by the company based on the grades achieved by trainee in the class. Courses on Bachelor degrees in Engineering or management are popular. The programs have to be managed outside the working hours by the employees. Nonetheless, it is very much encouraged.

On the Job Development (OJD)

On the Job development in Toyota is a unique process which helps learn real skills. OJD is one of the prime responsibilities of all Managers and company has developed systematic approach to propagate the process. The term used by Toyota is 'Development' and not 'Training' rightly because it encompasses a concept broader than a simple training regime. 'Training' is knowledge / Skill transferred externally so that the employee can perform the job correctly and meet the quantitative objectives. Development is growing the team member so that they become increasingly capable of doing the job and also improving the workplace eventually contributing to growth of others.

Fundamental skill training and GPC

Prior to the engaging on the actual job, the team member participates offline in job task that reflect plant processes performed at the rate that gradually increases from simple to complex production line standards. The scene of action is known as Global Production Centre (GPC) and is a standardized process worldwide in Toyota for the to train new members. GPC center is built around audio-visual instruction module for the new hire with details of specific skills to be learnt at each station. Each work station walks the train through the detailed step of skill sets to be acquired at each workstation. Alongside the video is a set of

written standardized instructions on how to perform each step. The manual is paced and stops as per the convenience of member in order to allow trainee to practice what he just learnt.

It is a student directed system. Once the student understands the skill and practice, he has to demonstrate his ability to the trainer. Standardization is on global levels, best practices from around the world are converted into Training content. It means that all the Toyota trainees across the globe are learning the fundamental skills in exactly the same way. If there is any update at any plant the same is transmitted across the global GPC centers in less than 24 hours.

At GPC centers the trainee not only learn how to complete a job as per standard practice but also within standardized time frame which is essential to maintain the takt time on the Assembly line. Trainers at GPC center are highly experienced and come from the ranks of group leaders on the production shops. It is a rotating arrangement and after few years the trainer goes back to the production shop. This helps in maintaining culture of continuous training on shop floor as the production team leaders gain insight into the training methodology.

Making available training resources

Day to Day Training is a broadly distributed Responsibility in Toyota which is given to each manager and supervisor in his respective areas. The preferred and most common approach is to use actual line side production shop as training ground. It is a challenge to free up line managers and supervisors to provide training during the production time particularly because the Assembly line does not provide any let up. There are two ways in which this problem is addressed.

- i. Have the classes between the shifts or on Saturday
- ii. Utilize the off line managers and

supervisors to help with training.

Summary

Unique feature of Toyota training regime is handling of Training as a continuous process not to be limited to only HR or separate training department but responsibility of each manager and supervisor in same way as the production or quality is. Emphasis on classroom training is limited. For skill development a new employee is free to select Training programs which is very special way of empowering the Team members. The new employee is permitted to move to the shop floor only after he has attained the standardized set of skills and achieved the timing also in their GPC. At the core lies the Toyota culture of standardization for every activity. No wonder when the mothers of Auto Industry in the US and the continent are struggling, Toyota is able to make its presence felt in every continent of the globe as quality Auto maker known for its values .

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Convergence of MGNREGS with Railways

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Abstract

This paper is to bring to light as to how Convergence between two central govt. departments has resulted in better and effective utilization of resources. It also charts the course on how policy was initially formulated by the top management and there after implemented and then evolved after feedback from site. The site under discussion is the jurisdiction of Assistant Divisional Engineer, Ongole Sub-division (ADEN/OGL) which falls under the Vijayawada Division of Indian Railways. This case also elaborates on monitoring systems which have been developed and streamlined to ensure both transparency and accountability of public functionaries.

Introduction

The two departments in conversation are Ministry of Railways and Ministry of Panchayati Raj and Rural Development and the scheme is MGNREGS. A small brief on the two departments and the scheme are elucidated in the upcoming paras.

Ministry of Railways

Indian Railways (IR) is India's national railway system operated by the Ministry of Railways. It manages the fourth largest railway network in the world by size, with a route length of 67,368-kilometre and total track length of 121,407-kilometre as of March 2017.

Indian Railway (IR) runs more than 20,000 passenger trains daily, on both long-distance

and suburban routes, from 7,349 stations across India. In the freight segment, IR runs more than 9,200 trains daily. As of March 2017, IR's rolling stock consisted of 277,987 freight wagons, 70,937 passenger coaches and 11,452 locomotives. IR owns locomotive and coach-production facilities at several locations in India. The world's eighth-largest employer, it had 13.08 lakh employees as of March 2017.

In the year ending March 2018, IR carried 8.26 billion passengers and transported 1.16 billion tonnes of freight. In the fiscal year 2017–18, IR is projected to have revenue of Rs. 1.874 trillion (US\$27 billion), consisting of Rs. 1.175 trillion (US\$17 billion) in freight revenue and Rs. 501.25 billion (US\$7.3 billion) in passenger revenue, with an operating ratio of 96.0 percent.

The organization is rightly termed as the "LIFELINE OF THE NATION"

Ministry of Panchayati Raj and Rural Development

The Ministry of Panchayati Raj is responsible for the work of advocacy for and monitoring of the implementation of Constitution's 73rd Amendment Act, the Provisions of the Panchayats (Extension to Scheduled Areas) Act, 1996. A New Ministry of Panchayati Raj has been created w.e.f. 27 May 2004. As per the amended allocation of Business Rules, "all matters relating to Panchayati Raj and Panchayati Raj Institutions" will be looked after by the newly created Ministry.

The State governments/Union Territory Administrations, at present, are at varying degrees of the implementation of 73rd and 74th Constitutional Amendment Acts. The Ministry, inter-alia, would ensure that they hold timely elections, set up State Finance Commissions and implement their recommendations, constitute the District Planning Committees and empower them suitably to ensure grass-root level planning to feed into State and Central level Planning effectively. One major task of the Ministry will be to ensure that the State Governments/UT Administrations devolve funds, functions and functionaries on the Panchayati Raj Institutions in the spirit of the Constitutional provisions.

The Ministry of Panchayati Raj will also be responsible for formulation and implementation of an Action Plan for seeing PRIs to emerge as "Institutions of Local-Self Government" securing economic development and social justice in their respective areas.

Mahatma Gandhi National Rural Employment Guarantee Scheme

Mahatma Gandhi National Rural Employment Guarantee Act, 2005 is an Indian labour law and social security measure that aims to guarantee the 'right to work'.

It aims to enhance livelihood security in rural areas by providing at least 100 days of wage employment in a financial year to every household whose adult members volunteer to do unskilled manual work.

The act was first proposed in 1991 by P.V. Narasimha Rao. It was finally accepted in the parliament and commenced implementation in 625 districts of India. Based on this pilot experience, NREGA was scoped up to cover all the districts of India from 1 April 2008. The statute is hailed by the government as "the largest and most ambitious social security and public works programme in the world". In its World Development Report 2014, the World Bank termed it a "stellar example of rural development".

The MGNREGA was initiated with the objective of "enhancing livelihood security in rural areas by providing at least 100 days of guaranteed wage employment in a financial year, to every household whose adult members volunteer to do unskilled manual work". Another aim of MGNREGA is to create durable assets (such as roads, canals, ponds and wells). Employment is to be provided within 5 km of an applicant's residence, and minimum wages are to be paid. If work is not provided within 15 days of applying, applicants are entitled to an unemployment allowance. Thus, employment under MGNREGA is a legal entitlement.

MGNREGA is to be implemented mainly by gram panchayats (GPs). The involvement of contractors is banned. Labour-intensive tasks like creating infrastructure for water harvesting, drought relief and flood control are preferred.

Apart from providing economic security and creating rural assets, NREGA can help in protecting the environment, empowering rural women, reducing rural-urban migration and fostering social equity, among others.

The law provides many safeguards to promote its effective management and implementation. The act explicitly mentions the principles and agencies for implementation, list of allowed works, financing pattern, monitoring and evaluation, and most importantly the detailed measures to ensure transparency and accountability.

The Beginning

Between 2014 and 2018, there has been an exchange of letters between the two ministries to finalize the type of works which could be undertaken under the Convergence Scheme. Also, communication was in progress to finalize the financing of this scheme and guidelines for execution of the same. Finally, on 06.04.18, a letter was issued by the Ministry of Panchayati Raj and Rural Development (Letter No. J) which

elaborated upon three important items –

- a. The list of works which could be carried out under this scheme which are listed below –
 - i. Construction and Maintenance of Approach Road to Level Crossings.
 - ii. Construction and Maintenance of Approach Road to Railway Stations.
 - iii. Developing and cleaning silted waterways trenches and drains along the track.
 - iv. Repairs and widening of existing railway embankments/cuttings with clearing of vegetation growth.
 - v. Plantation of trees at extreme boundary of railway land at such location, where sufficient land is available.
 - vi. Protection work of existing railway embankments/cuttings/bridges.

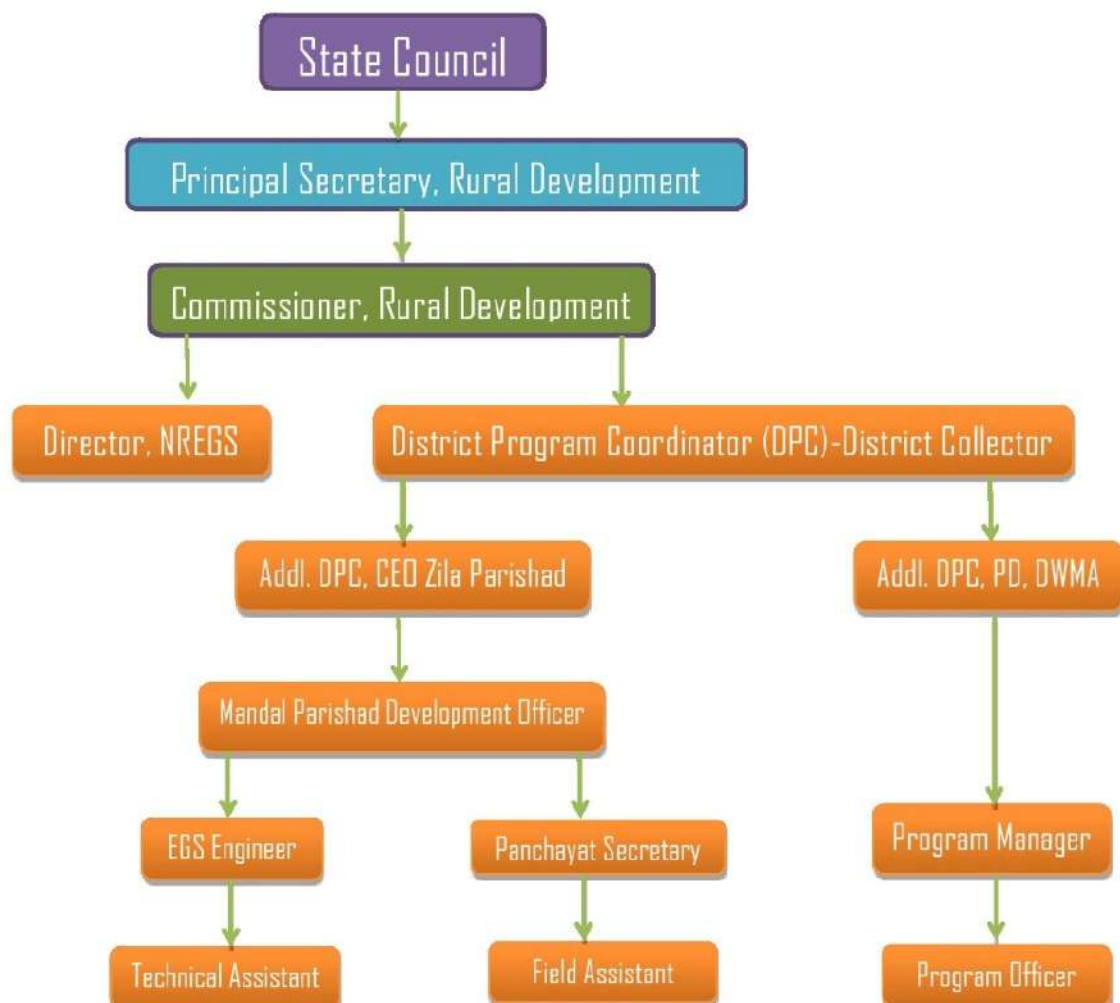


FIGURE-01

b. Labour and Material Component of the works will be met from MGNREGS

c. Gram Panchayat will be the Principal Implementing Agency.

Since this was a letter issued from the ministry, guidelines from the corresponding state government needed to be issued in order to enable the corresponding state

officials to act on the same. South Central Railway managed to secure the same via letter no. Memo.No. 28028/152/RD.II/A/2018 dated 10.09.2018 issued by the government of Andhra Pradesh. The content of this letter was an exact copy of the letter issued on 06.04.18.

The Engineering wing of South Central Railway Administration (in particular



Pic. 1 - Meeting with MPDO/Singarayakonda



Pic. 4 - Meeting with Sub-Collector/Kavali



Pic. 2 - Meeting with MPDO/Ulavapadu



Pic. 5 - Meeting with Tehsildar/Kavali



Pic. 3 - Meeting with MPDO/Ongole



Pic. 6 - Zila Parishad meeting at Tanguturu

Assistant Divisional Engineer, Ongole) now began the exercise of informing each and every individual of the state about the circular. To understand the structure of MGNREGS at state and appreciate the mammoth exercise undertaken, the structure of MGNREGS at state level is given as Fig-1 on Page 4

The Ongole Sub-division is spread over two districts namely Prakasam and Nellore. The officer and staff of the office of ADEN/OGL met almost all officials listed in the above hierarchy of the two districts. Trust Building exercises were also in motion wherein appropriate representation was being made by the railway officials at Gram Panchayat meetings and Zila Parishad meetings. All the six pictures attached below i.e. from Pic. 1 to Pic. 6 on Page 5 reflect upon the trust building exercises as discussed above.

During the course of such meetings with numerous officials, good rapport was developed with one official in particular – Mr Jameel Ullah, who was Mandal Parishad Development Officer at Singarayakonda Mandal (Refer Pic. 1).

This scheme was to be implemented for the first time on Indian Railways and hence there was apprehension about its applicability. Also safety aspect is of paramount aspect in

Indian Railways and any mishap would have shut down this scheme instantly. Hence a pilot project was undertaken wherein 168 labour were allotted for three weeks (by the support of Shri Jameel Ullah) to test the applicability of the six listed works.

Before commencing such works, a safety seminar was conducted wherein all workers were lined up and counseled on safe working beside the track (Pic. 7 and 8 reflect upon the same).

Post work, a review of the work done along with attendance was conducted (See Pic. 9 and 10).

The entire labor unit was split into 3 groups –

1. 50 nos. were deployed for desilting of Bridge no 525A which is a Road Under Bridge (RUB) located at railway chainage 265/6-8 of Vijayawada-Gudur line.
2. 18 nos. were directed for jungle clearance.
3. 100 nos. were instructed to conduct cess repair work.

Pic. 11 and 12 reflect upon the site conditions before the work of desilting was taken up.



Pic. 7 – Aligning labour along the track and counseling them about protection rules



Pic. 8 – Labour listening to track protection and safety rules



Pic. 9 – Review of Field Assistant/Singarayakonda

Post work, a review of the work done along with attendance was conducted (See Pic. 9 and 10).



Pic. 10 – Reviewing Musters



Pic. 11 – Silted up bridge



Pic. 12 – Raincuts resulting in silting up of bridge



Pic. 13 – Labour clearing silt



Pic. 14 – Desilting of bridge under progress

BEFORE TAKING UP WORK PHOTOS

Pic. 13 and 14 reflect upon the site conditions during which the work was under progress.

Pic. 13 and 14 reflect upon the site conditions during which the work was under progress.

Pic. 15 and 16 reflect upon the work of cess widening/strengthening.

Among the six listed works, the top two required policy formulation which is under progress. The next three works could be undertaken with ease. The last listed work of Protection work of existing Railway embankments/cuttings/bridges could not be undertaken as the work required hard physical labour (lifting of 35 kilogram stones and placing them on cess) which could not be undertaken by such workforce.

The challenges and learnings during conducting such works are as follows –

1. This is a voluntary and untrained work force whose work ethics and discipline are very different from the Railway working. They need to be not only counseled but trained a great deal which will involve practical demonstrations before they can be put to work for safety related works.
2. They are generally illiterate and are in tremendously large numbers and hence, lot of supervision is required to manage them during their work.
3. They are not at all aware of any safety rules and were found resting/sitting on the



Pic. 15 – Cess repair under progress



Pic. 16 – Digging of soil to repair cess



Pic. 17 – Inspection with state officials



Pic. 18 – Geo-tagging photos being clicked

track as it is on an elevation and enjoying the panoramic view of the area.

This was the first milestone in the quest for achieving Convergence of MGNREGS with Railways.

The entire exercise was documented and brought to the notice of other state officials of all other mandals. After witnessing the works conducted, a green signal was obtained from all the mandals and thereafter the exercise of conducting joint surveys with state officials of the entire jurisdiction of ADEN/OGL began. Pic. 17 and 18 reflect upon the joint survey undertaken with state officials.



Pic. 19 – Site visit of senior state officials

During inspection of the section and on repeated conversations with state officials, realization came that new type of works could be undertaken. Thereafter a site visit (Refer Pic. 19 and 20) and a joint meeting (Refer Pic. 21 and 22) was conducted in the office of ADEN/OGL which was attended by Additional Commissioner, MGNREGS, Government of Andhra Pradesh Shri Balasubramanyam, Project Director, DWMA, Prakasam District, Government of Andhra Pradesh Shri Venkaeshwarlu, Program Managers, Plantation Managers and TCS Officials.

In this meeting, a new policy was formulated – Circular No. 2777/EGS/SPM(T)/2018



Pic. 20 – Joint inspection with state officials



Pic. 21 – Discussion on new policy



Pic. 22 – Discussion on software

dated 24.11.2018 highlights of which are listed below –

1. All the works were renamed as per Railway terminology.
2. Softwares were developed in consonance with Railway.
3. Four new works were incorporated in this new policy and a previous work was dropped making a total of nine works.
4. Technical details pertaining to all listed works were discussed in detail. Also guidelines on quality of works were elaborated in detail.

The works listed in the new policy circular are –

1. Desilting of waterways of bridges/RUBs/Pipe culverts/Box culverts.
2. Strengthening/widening of Railway Embankment.
3. Trench cutting along railway boundary.
4. Recharge structures to functioning bore wells/dried up bore wells.

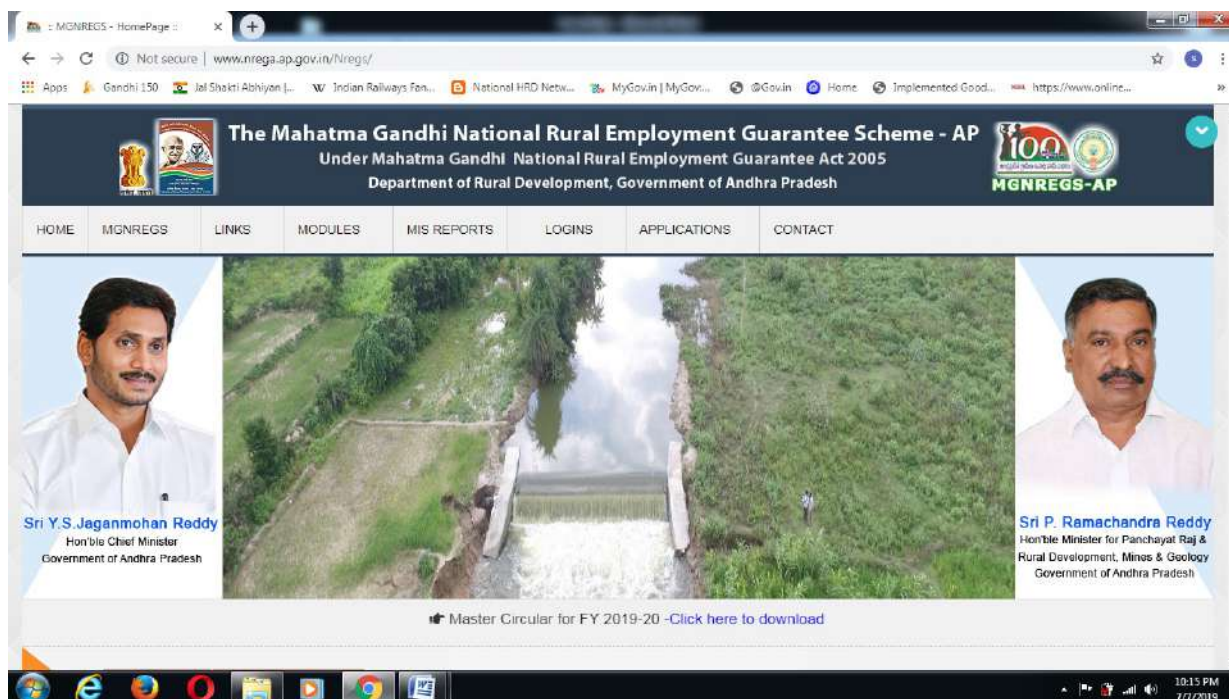
5. Desilting of Open wells.
6. Block Plantation.
7. Village Parks in railway colonies.
8. Linear Plantation
9. Connecting Roads to level crossings upto Bitumen level.

This was the second milestone in the quest for achieving Convergence of MGNREGS with Railways.

Softwares for the above works were created in the meeting and they have been integrated to their mobile application named Planning 2019-20 which can be downloaded from the website

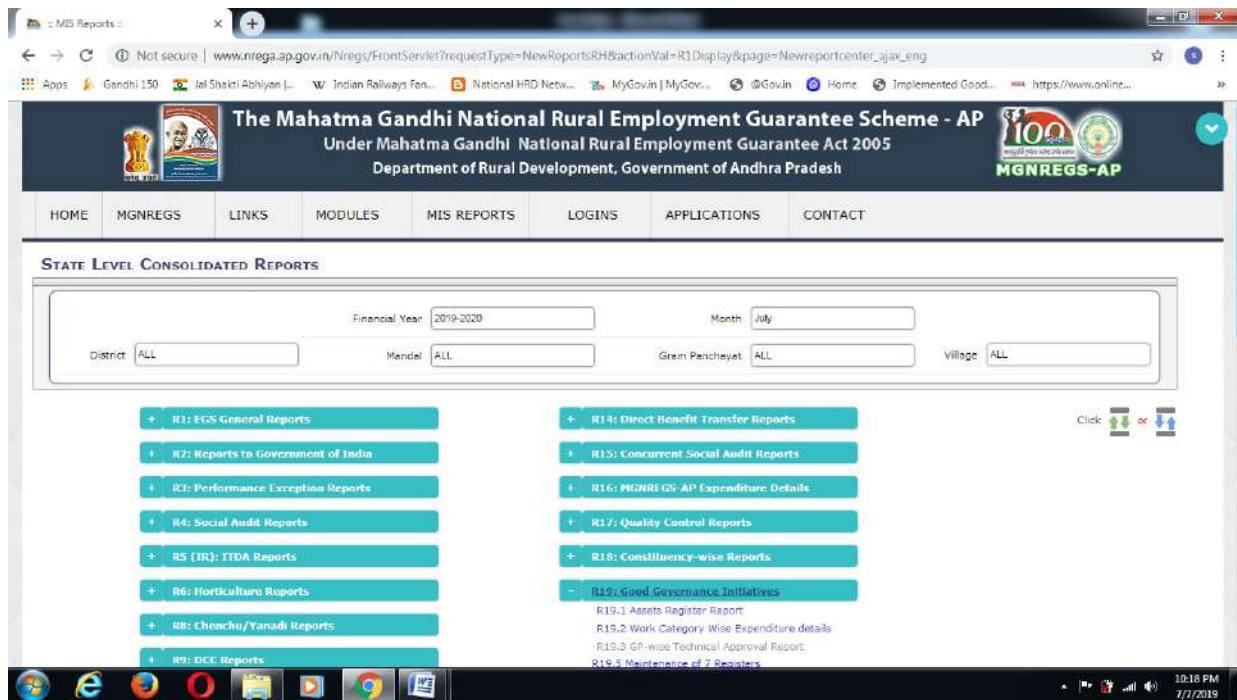
<http://emuster.in/ap/m/NregsApps.htm> . The application is linked to the Engineers CUG number. All data has to be fed from site along with Geo tagged photos.

The third and most significant milestone in this journey has been the creation of a centralized dash board for monitoring all railway works which is elaborated below –



Pic. 23 – Main web page of MGNREGS, Andhra Pradesh

1. The above web page opens up (Refer Pic. 23) when we go to www.nrega.ap.gov.in which is the official NREGA website for the state of Andhra Pradesh. This website is being maintained by TCS.



Pic. 24 – Web page of MGNREGS, Andhra Pradesh

2. On clicking the tab – MIS Reports, the above window opens up (Refer Pic. 24). On clicking the R19: Good Governance Initiatives, a drop down menu appears. On clicking R 19.2, a new window opens up (Pic. 25) which is shown below.

S. No.	Work Category	11702	14272.5	3757.25	18020.75	67.85	1231	245.49	3.25	245.74	1.10	11	0	0.08	0.08	0
4	CHENCHU PROGRAM WORKS															
5	Fisheries work	5072	21475.11	3037.16	25412.27	100.15	2807	3078.33	122.18	4068.56	10.65	35	12.74	2.59	15.33	0.06
6	Greenary works (Chettu)	243165	169520.01	183554.53	353174.59	895.55	183200	2427.02	6400.05	8917.05	12.21	9045	1.18	187.97	189.15	0.01
7	Housing	308052	32252.02	1434.13	33886.15	153.11	177813	4076.7	155.72	4232.42	19.32	38078	827.22	180.55	1006.07	4.01
8	IIP PROGRAM WORKS	4134	0	1474.5	1474.5	0	528	0	0	0	0	24	0	0	0	0
9	IWMP PROGRAM WORKS	30433	45664.43	12504.67	58259.1	233.99	14479	536.25	20.42	555.7	2.53	1348	22.35	2.35	24.7	0.1
10	Institutional Development Works	37007	45712.91	98975.9	147691.81	234.97	11182	557.19	2620.6	3486.78	2.74	359	1.05	197.23	198.31	0.01
11	OTHERS	43768	23840.23	12069.99	35910.21	125.55	20262	2564.91	25.67	2591.59	12.15	13	0	0.77	0.77	0
12	Railway Project	733	4013.55	60.05	4073.54	19.53	103	253.34	0.93	254.27	1.32	0	0	0	0	0
13	Road Works	158477	156078.14	957284.59	111362.69	734.53	66645	5741.02	31385.05	37106.11	26.63	11559	18.22	4050.22	4050.44	0.05
14	Rural Sanitation Works	180511	7191.51	71617.89	79005.5	34.56	56406	75.1	1576.12	1653.22	0.37	16964	138.16	1565.5	1704.06	0.7
15	Sericulture Works	9059	9069.04	13829.38	23090.41	44.04	6210	338.97	269.91	606.88	1.75	197	1.18	2.5	3.78	0.01
16	Soil Moisture Conservation works (Neeru)	64583	81636.92	2112.19	83749.02	383.65	26756	8046.99	77.35	8124.34	29.03	745	95.74	5.64	101.37	0.45

Pic. 26

3. In this new window (Pic. 25), S. No. 12 titled Railway Project needs to be clicked

4. The following screen now opens up (Refer Pic. 26). This is the Central Dashboard for monitoring all works.

The system of monitoring as totally absolute and complete. All required information can be extracted from it.

As of today (23.03.2020), 638 number of works amounting to Rs. 32.11 crores have got sanction and 142 number of works are in progress amounting to Rs. 2.93 crores. 23 works amounting to Rs. 92.21 lakhs have been completed.

With this edifice, works are in progress in entire Andhra Pradesh. In the jurisdiction of ADEN/OGL, works are in progress with close to 6000 labour working every day. A few snaps are attached below (Refer Pic. 27, 28, 29 and 30) –



Pic. 27 – View of finished site



Pic. 28 – Another view of finished site



Pic. 29 – View of work under progress



Pic. 30 – Another view of work under progress

As can be seen from the above photo (Pic. 29), the works are being synergistically carried out with all the works being linked together to ensure effective utilization of resources. The earth excavated from trench cutting work which is being cut along the railway boundary is being utilized for strengthening/widening of Railway embankment. The work of embankment is being carried out in a step formation in order to ensure better retentivity of cess. The trenches serve as water harvesting pits which will help in enhancing ground water. Adjacent to the railway boundary, farmers have their fields and they have expressed tremendous happiness over this work as ground water recharge will help them in better yields.

Railway suffers from a huge problem of encroachments i.e. the farmers have a tendency to uproot the boundary pillar preferably in the middle of night and place them inside railway land. The trenches which have been cut along the railway boundary will serve as boundary protectors. Also owing to the trench cutting exercise, the railway land will not be easily accessible/tresspassable resulting in reduced cattle run-over cases.

Geo tagged snaps of work under progress in ADEN/OGL sub-division (Refer Pic. 31 and 32) –



Pic. 31



Pic. 32

Potential/Achievements -

1. The state administration takes up all the works listed above in a very different manner as the objectives are very different. Example to elaborate upon the same - In case of plantation, in railways, the target is to achieve the number planted without much thought about their survival. Also, it is not the core activity and hence gets sidelined. As per the plantation policy adopted in the state, a 3- year maintenance period is there wherein the state will deploy a watcher to ensure that it is protected from grazing and also watered regularly. The policy also stipulates an 80 % survival rate. The thought is to develop the plantations as an asset.

Now taking forward, one of the works identified was Linear Plantation in which, in consultation with MGNREGS officials, Railways has decided to execute 50 % plantation with timber trees and 50 % fruit bearing. Thereafter, contact has been made with ITC Bhadrachalam and Delta Paper works for utilizing this wood after maturity for commercial purpose. The firms have responded positively and preparation of MOU is underway. This can be further developed as a means to generate Non-fare Revenue for Railways.

2. Trench cutting along railway boundary is an item which was introduced as a means to mitigate cattle run over cases and to reduce trespassing incidents.

3. In case of bitumen road construction, the policy states that for every Rs. 100 spent, Rs. 90 will be sanctioned under MGNREGS and the rest Rs. 10 has to be financed by the converging department. Railway has now begun working on mixing crushed and granulated class 3 rubber pads and putting them as part replacement for bitumen i.e. the 10 % cost will be financed by utilizing class 3 rubber pads thereby enabling cost savings and better waste management.

4. Close liaisoning with state government has resulted in beginning of the closure approval process of 7 level crossing gates in ADEN/OGL section.

Vision –

As per the details shared by the state government, Railways was the 24th department to secure convergence under MGNREGS. Now the vision was to make Railways stand no. 1 in priority for fund allocation and to that effect various initiatives have been undertaken in Ongole sub-division which are listed below –

1. As per the Constitution of India, the Right to Work has been identified as a Fundamental Right and to that effect work has been done to provide facilities which enable Right to work with dignity. All level crossing gates in Ongole sub-division jurisdiction (38 nos.) have been provided with a toilet which is in addition to all station building (9 nos.). The magnitude of this exercise can be appreciated from the fact that approximately 105 kilometers of railway line passes through Prakasam District and 48 LC gates and 18 station buildings have been provided with a toilet which means a toilet at every 1.5 kilometers from the initially one in every 10 kilometers (Refer Pic. 34 to 42).

2. First aid safety kit boxes (Refer Pic. 33) have been provided to all Level Crossing gates and station buildings including ORS (Oral Rehydration Salts) packets.

3. Water supply provision is there at all

Level crossing gates and station buildings in the form of either bore well or municipal supply (Refer Pic. 34 to 42).

4. Gate men work round the clock at Level Crossing gates in shifts and hence in case of any emergency, the gateman can ferry the labour/patient to the nearest district or railway hospital (Refer Pic. 34 to 38).

As can be seen from the above, tremendous support system in terms of better worksite management has been developed over time which will help in seamless integration of MGNREGS with Railways.

A few photos have been attached below -

LC 175 having toilet and municipal water supply LC 180 having toilet and hand pump for water

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3. P. Srinivas, Chief Engineer/Works, South Central Railway “Letter No. W. 399/Genral/MGNREGA dated 26.07.2018”.
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8. Andhra Pradesh Rural Employment Guarantee Scheme Operational Manual 2006.
9. National Rural Employment Guarantee Act of 2005, 05.09.2005



Pic. 33

The above are first aid kit safety boxes



Pic. 34

The green colour structure is Fibre Reinforced Plastic supplied at each and every LC gate toilet which is installed at each and every LC gate. Behind is a septic tank.



Pic. 35



Pic. 36



Pic. 37



Pic. 38

Learning Management Systems~ The IRIMEE Experience

G Venkatesh,
Professor (MIS), IRIMEE

Abstract

Indian Railways is mostly a brick and mortar organization with trackmen patrolling the tracks and C&W gangs walking under coaches and tapping the undergear components. Training Institutes in the Railways also have been mostly built around this concept with huge sprawling campuses, lawns and elaborate sports facilities. In spite of this huge capital investment, the institutes have struggled to attract talent as faculty and senior officials as trainees.

Online Platforms have been heavily used by prestigious global universities including MIT and Stanford. It was thus, an enticing proposition to develop similar platforms and connect the 14 Lakh strong Railways into a single learning network. This article traces the journey of IR's oldest Training Institute - IRIMEE in rolling out a low cost web based solution for content sharing and virtual classrooms.

The journey is not just about the technology used, but also about changes in mindset and cultural shifts.

INTRODUCTION

IRIMEE is located in Jamalpur, Bihar. Although this is a densely populated region, road connectivity as well as main line connectivity is poor. The main line from Howrah to Delhi by-passes Jamalpur. As a result, Jamalpur has always had the problems in attracting trainees as well as faculty in attending on site programs.

When I joined this institute in 2017, one of the major points of discussion at the time was the development of a web based portal to facilitate record keeping. At that time the institute was requesting trainees to fill a 6 page Registration Form on arrival and an equally long feedback form at the end of the

course. After every course, these forms would be collected and then they used to move from the Course Director to the Director of the institute. Needless to say, this process used to take a very long time. It was observed that the course feedback might take even as long as two to three months after the end of the course to be put up to the Senior Faculty.

This fact was well known to everybody and hence, the Senior Faculty of the institute had made a habit to visit each course on the last day of the course and personally take feedback on their phone or diary. This enabled them to quickly gather feedback and get a pulse of the Trainees without depending on the file system.

IRIMEE has close to 30 officers and non gazetted teaching staff. In any teaching institute, the main task of the faculty is to engage in teaching but at the same time there are a number of equally important non-teaching activities like Vehicle Management, Mess Management and Hostel Management. It was very difficult to understand or ascertain at a single glance the workload of the faculty members.

Full-time faculty members especially those involved in critical areas like Diesel Technology had a much greater teaching load than many others. This made it extremely difficult for them to concentrate on any administrative activity that may have been assigned to them. Although the total number of officers and staff at IRIMEE was a small number but balancing the workload evenly among the faculty was a critical almost impossible task in the absence of any data. Sporadic attempts had been made to compile the number of classes in Excel. But, these efforts often took a very long time, one one occasion, more than a week. Thus, in the absence of quick flow of information and useful management reports at a glance, IRIMEE was facing challenges in delivering prompt training solutions to its trainees and reducing the drudgery of its faculty.

INSPIRATION

The Indian Railways is a 24 hour organization. There are many officers who proudly tell stories of how they worked for days without even a nap to restore a tricky accident site. Of course, this comes at a heavy long term price in terms of health for a number of them. However, training institutes like IRIMEE are perceived as places where a weekend remains a weekend.

But, this perception was far from the truth. IRIMEE has huge batches of probationers and often their results had to be compiled at a very short notice. Most of their evaluations were objective. But, evaluating over 70 answer sheets was tedious and time

consuming jobs which could consume a weekend.

It was felt by the author of this article, that a software to evaluate these objective questions would reduce unnecessary drudgery on the weekends. There were many proprietary solutions. For example, a team from MGRM visited IRIMEE in early 2018. But, the prices were typically subscription based and the costs ran into several lakhs per year. Spending money for a good training platform was not an issue for IRIMEE. But, an expensive proposal meant several layers of approval and consequent delays. In addition, the SOP of Railways is not exactly tailor made for software projects and more inclined towards brick and mortar situations.

Open Source Learning Management Systems like Moodle and Sakai appeared to be the way to go.

TECHNICAL DETAILS

A lot of Institutes and Officers think that training material can be easily shared over mail or classes can be conducted online by e-mail links of Google Meet or Zoom for every session. Even senior trainers proudly boast that they have moved online with Whatsapp. Almost every training program in the Indian Railways involves making Whatsapp Groups of the Trainees.

The above mentioned activities are very time consuming, require sustained effort and retrieval of reports at a later date is not easy. For the past 10 years, universities have been moving content online to improve their outreach to a greater number of students and democratize access to education.

Learning Management Systems typically have the following facilities:

- Easy Storage and display of PPT/PDF and Videos
- Easy conduct of Quizzes and Assignments

especially multiple choice
Generation of Reports
Transfer of Data from one course to another
Collaborative Learning & Content Management

While the exact choice of an LMS is an administrative decision of a training institute, this article focuses on use of Moodle.

BASICS OF WEBSITES

The basic structure of any website is as follows:

A front end to interact with the user- This is the web page that we see and interact with. This is typically coded in a language called PHP.

A Database to store the data. Typically, this would have many tables like a student table with enrollment id, another with a list of courses and course id. Typically the database used is MySQL.

The website itself runs on a computer. Since, this computer is available online all the time responding to requests, it is referred to as a Server

To get the computer to act as a server and communicate with the clients, the computer must run a software called a web server. Typically, the web server is Apache

Websites generally run on the Linux environment, the entire platform is called a LAMP stack- an acronym for Linux, Apache, MySQL, PHP

Please note that the above descriptions are not textbook definitions, they are simplified descriptions for the layman user. Also, the LAMP web development stack is not unique, there are many other options available in the market. We have described the LAMP stack as it is the architecture that Moodle uses.

The following are the server requirements:

Cloud Hosting or better of any Hosting

Provider like Bigrock or Hostgator
Domain Name, for example www.irimee.in

The above purchases can be made online. The costs vary greatly depending on the configuration chosen. Typically these companies are willing to raise the invoice on Railways and block the order till the payment is credited by the Accounts Department to activate the order.

COSTS

The indicative cost of hosting plans is as below:

Rs 639 per month + 18 % GST for Business SSD for 3 years with a 6 Core Processor
Domain Name cost about 800 to 1000 rs per year

For trial basis, Training Institutes can also hire a hosting plan on Imprest and then move forward on it.

INSTALLATION

The technical process of setting up Moodle is very well described in the following links:

https://docs.moodle.org/39/en/Step-by-step_Installation_Guide_for_Ubuntu

This applies for stand alone computers, Virtual Private Servers and Dedicated Servers ONLY

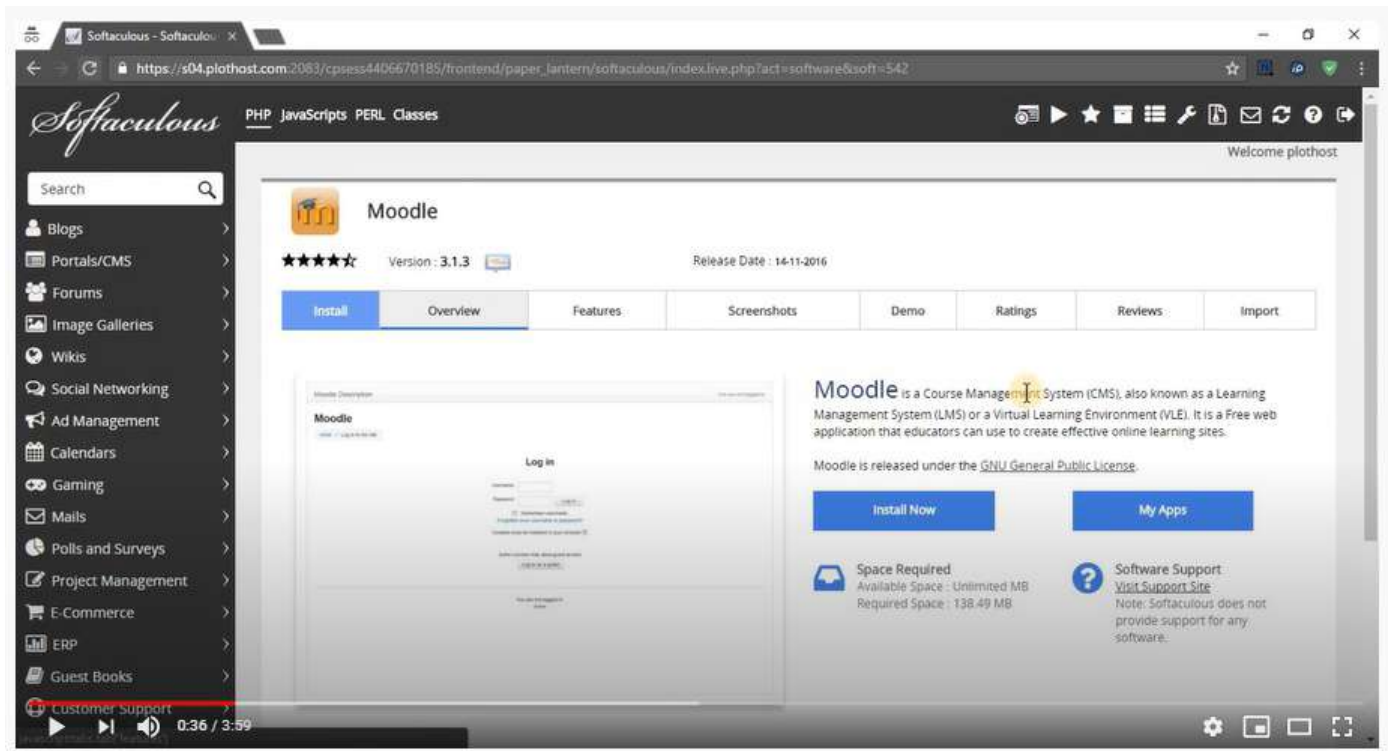
Although the commands may seem intimidating, they only need to be followed verbatim for the installation to work

Softalacious One Click Installation

This applies to Cloud Hosting and Shared Hosting. There is a One-Click Installer and the following Video illustrates this process:

<https://www.youtube.com/watch?v=o6hDC2G5R5k> There are many such tutorials and you are free to use any of them.

The greatest power of Moodle lies in the fact that the software is completely customizable



Pic. 39- Screenshot of Softaculous Installer

by the use of Plugins, which can be installed from the following link - <https://moodle.org/plugins/>

MOODLE FEATURES

I will talk more in detail, about plugins later. I shall detail the features available in the basic features of Moodle first for a better appreciation of the features in this platform:

Quizzes- Single/Multiple attempt, Objective as well as subjective exams

Assignments- Single as well as group with PDF/Docx or Online typing based submissions. There are also possibilities of integrating Plagiarism Plugins

Course Material- Upload of PDF/Video is permitted. In addition, subject pages can also be created without any programming knowledge

VIRTUAL CLASSROOM PLUGIN

A web based platform for learning becomes really effective only when there is an interactive classroom. Technology makes it possible to have Virtual Classrooms with the following features:

Sharing of Screen/Video/Presentation

Breakout Rooms for Discussion

Secure Entry of Participants

Integrated with the Platform- Moodle so that so repeated login or email for classes needs to be sent

A number of institutions use platforms like Webex and Google Meet for classes. But, these technologies involve repeated emails and follow up. Using a Virtual Classroom Plugin makes the entire process very user friendly. The links are auto generated on the Course Page itself and are available only to the ENROLLED USERS ONLY.

The Virtual Classroom used by the institute is an Open Source technology called Big Blue Button. The most cost effective solution for Web Conferencing is to install this software on a Virtual Private Server of at least 4 cores.

The installation process is simple and involves just one command from the following tutorial:

<https://github.com/bigbluebutton/bbb-install-wget>
-qO-
<https://ubuntu.bigbluebutton.org/bbb->

install.sh | bash -s -- -w -v xenial-22 -a -w
The cost of hiring a Virtual Private Server is as follows:

Rs 2399 + 18 percent GST for hiring a USA located server with 4 cores

The technical requirements are therefore, quite simple and cost effective. These can be dealt in house at any training institute by any faculty with good basic computer knowledge.

Stable and reliable automated record keeping

In addition, regular training sessions were conducted on a daily basis to encourage the faculty to use this platform. Local leaderboards were made for the questions developed by faculty members. The training sessions were attended by not just the junior faculty but most importantly by the Senior Faculty of the institute. In addition, the institute was given group awards by Railway



Pic. 40- Screenshot of Course Page

CULTURAL CHALLENGES

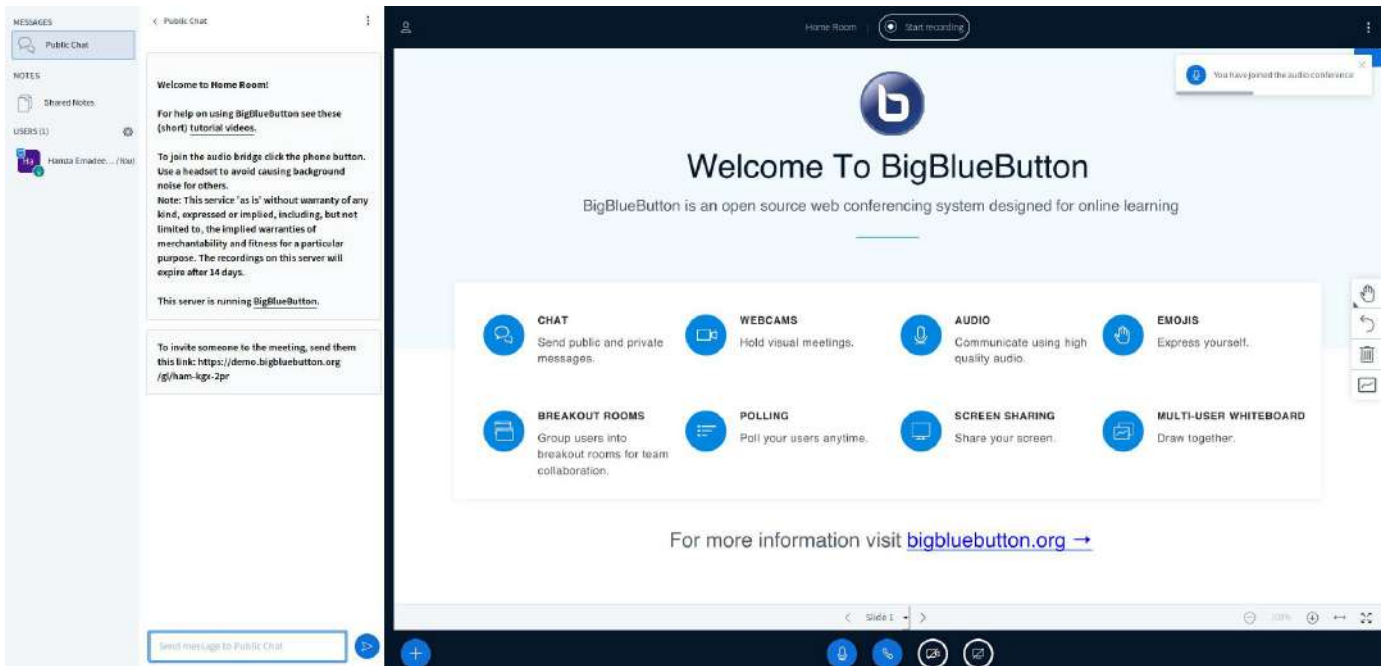
The technical aspects of the platform are not very difficult to replicate. The project is quite cost effective and hence, there are no major financial hassles as well. However, convincing the faculty to see value in the project and involve them in the same is the greatest challenge. Many faculty of the Railway's Internal Training Institute are very conversant in computers. This is not surprising as much of the work in Railways involves real world objects like Wagon or Loco maintenance. IRIMEE made it a point to stress greatly on the following aspects:

Automated Checking of Objective Papers
Good Student Feedback

Board and NAIR at various stages to encourage the process and bring in a sense of ownership.

THE COVID EFFECT

India imposed the first of a series of lockdowns to contain the Covid Pandemic in March 2020. IRIMEE's digital platform enabled it to increase its trainee days to 194% or double the original number in June 2020. The feedback from the trainees was uniformly positive. One course on LHB Coaches saw the participation of 150+ trainees in a one week long course and a course of e-office saw close to a 100 participants.



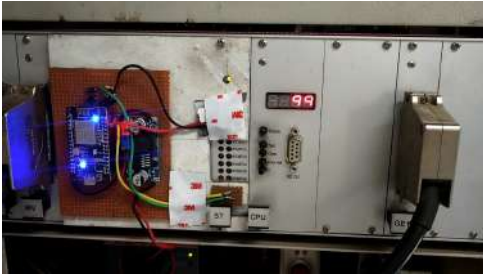
Such participation was unheard of on days of physical training. Not only this, trainees took active part in quizzes and assignments and openly appreciated the platform in their feedback.

As a result of its year long efforts in faculty training, the Institute was not just Covid Ready, but took full advantage of the Online Training Scenario.

DUPLICATING IRIMEE's SUCCESS

Since most of the technologies are open source, it is quite easy to replicate the same, IRIMEE has started handholding STC's. This will toide them through the initial hassles and then, they can become independent in managing their own platforms. The above set up can easily handle up to 200 trainees at one point of time. However, institutes with more than 200 concurrent trainees would need to scale up the BigBlueButton Architecture by adding more servers. This involves setting up of multiple BBB severs and balancing the load between them using a Scalelite Server. However, this is an involved topic and shall warrant another article.

WSPD Online Monitoring System



Fitment on Coach

Gopinath
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Abstract

The Team Leader for this project is Shri Rakesh K. Prabhu Sr. CDO/SBC.

This project on Online monitoring system for "Wheel slide protection system" status in LHB coaches will monitor and record the status of WSP remotely while the coach is on run. This will help in identifying and analyzing the faults in WSP system and reduce sick marking due to wheel shelling.

Problem definition

LHB coaches are provided with Wheel Slide Protection device (WSPD) to control adhesion during brake application. The system consists of a microprocessor, which takes input from four speed sensors and operates four dump valves. WSPD CPU card has an inbuilt display which shows different fault codes different types of faults in the system. This helps in easy troubleshooting of faults in the system.

Currently WSP is being checked during Primary Maintenance under static conditions and if any fault is present then the same will be attended. However, some faults do occur only in dynamic running condition such as sleep mode, fault due to improper sensor air gap etc. Even though WSPD faults are cleared in static condition, again same faults may occur repeatedly while coach is running.

WSPD has inbuilt system to record faults during run, but only fault codes are recorded and displayed in the CPU display. But some important data such as, time of occurrence of the fault, how long WSPD system was in fault mode, are not easily accessible to

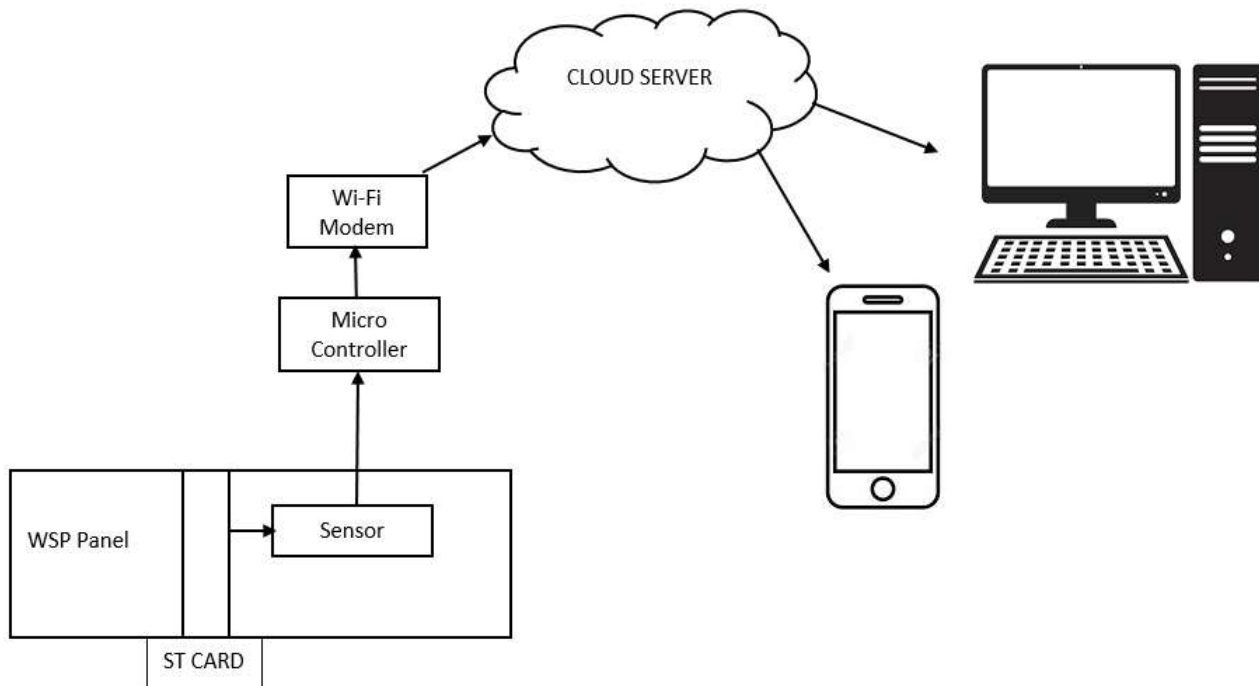
maintenance engineers. This hinders the possibility of analyzing the reasons behind the fault and rectifying the same. WSP fault mode causes wheel shelling which in turn causes several other problems such as spring breakage, grease oozing, damper leakage etc.

Proposed Solution

An online monitoring and WSPD status monitoring and recording system has been developed in house by Bengaluru Coaching Depot. A prototype circuit has been developed to read the status of WSPD in Faveley KES Make WSP.

The system consists mainly of three important parts, namely

- a) Status monitoring device, which is mounted on the ST card in the coach
- b) Server, which communicates with the device and stores the data sent by the monitoring device
- c) An app, which takes the data from the server and displays to the user



Pic. 41- Block Diagram

Status monitoring device

It is provided with LDR (Light dependent Resistor). With the help LDR sensors, this circuit will read the WSP status from ST card in WSPD panel. Three different status are recorded, WSP off (Code 0), WSP in fault mode (code 72), WSP OK (Code99). The microcontroller will take the data from the sensor and upload to cloud server through Wi-Fi modem. The WSPD status is updated to cloud once in every 15 seconds, or whenever there is a change in the status of the signal. Each status of the WSP is recorded with a time stamp for accurate tracking of the faults.

Circuit has two LDRs . LDR1 senses the fault LED. IF there is any fault in the WSP 6th LED in RE column will glow. This will be sensed by LDR1. LDR2 senses the power supply to the CPU unit (5Volt LED), which will glow when CPU is in on condition. So by taking these two inputs status of WSP can be determined by using simple logic in micro controller.

The monitoring device communicates with server through Wi-Fi modem, which has internet access. The WSP status code along

with time stamp is uploaded to the server. Time stamp contains date and time of the fault. Therefore, if any fault occurs exact time of fault will be recorded in the server. In addition, how long the WSPD system was in fault mode, can be determined.

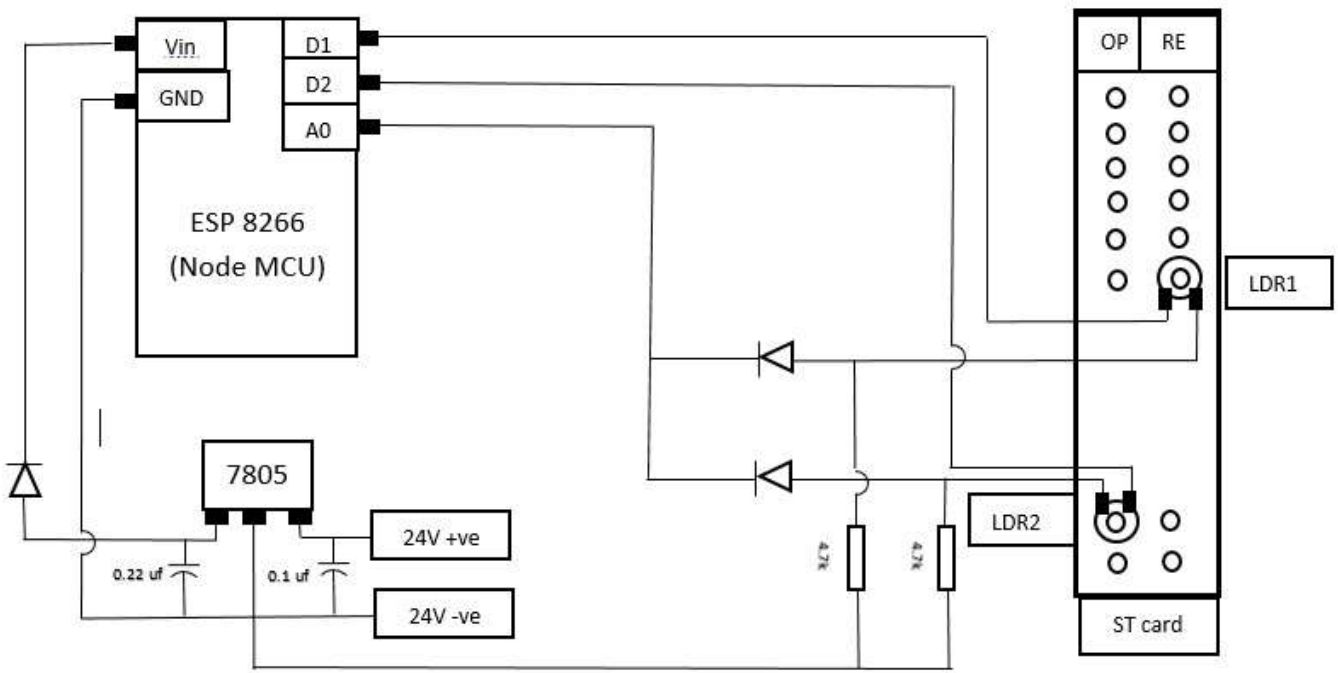
This scheme is illustrated in Figure 42.

Server for Storing data

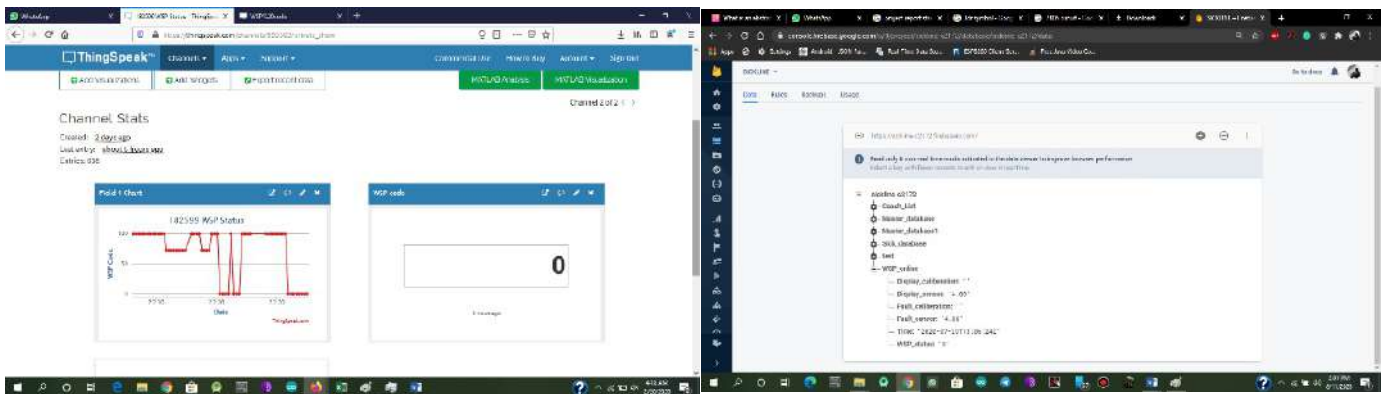
The data sent by WSP monitoring device is sent to "Thingspeak server". WSPD status can be monitored through any smartphone or computer with internet access in real time by connecting to this server. Thingspeak server offers real-time web access of the current data, also the historical data can be accessed, the same can be exported in excel format for further analysis. The WSP monitoring device updates its time by accessing NTP server. 'Thingspeak' server allows data upload only once in 15 seconds. So, for quick update of data Google firebase database is used.

Android App

An android app is developed to see if the current status of the WSP and also present



Pic. 42- Circuit Diagram of Monitoring system



Pic. 43 & 44- ThingsSpeak Server & Firebase Server

the past history. So, data can be monitored online and if a fault is recorded then the same can be informed to next TXR point or escorting staff. Some minor faults such as cards loosened due to vibration or cable loose, can be attended. If any serious faults are present, decision may be taken by concerned to send the coach in isolation to prevent wheel shelling.

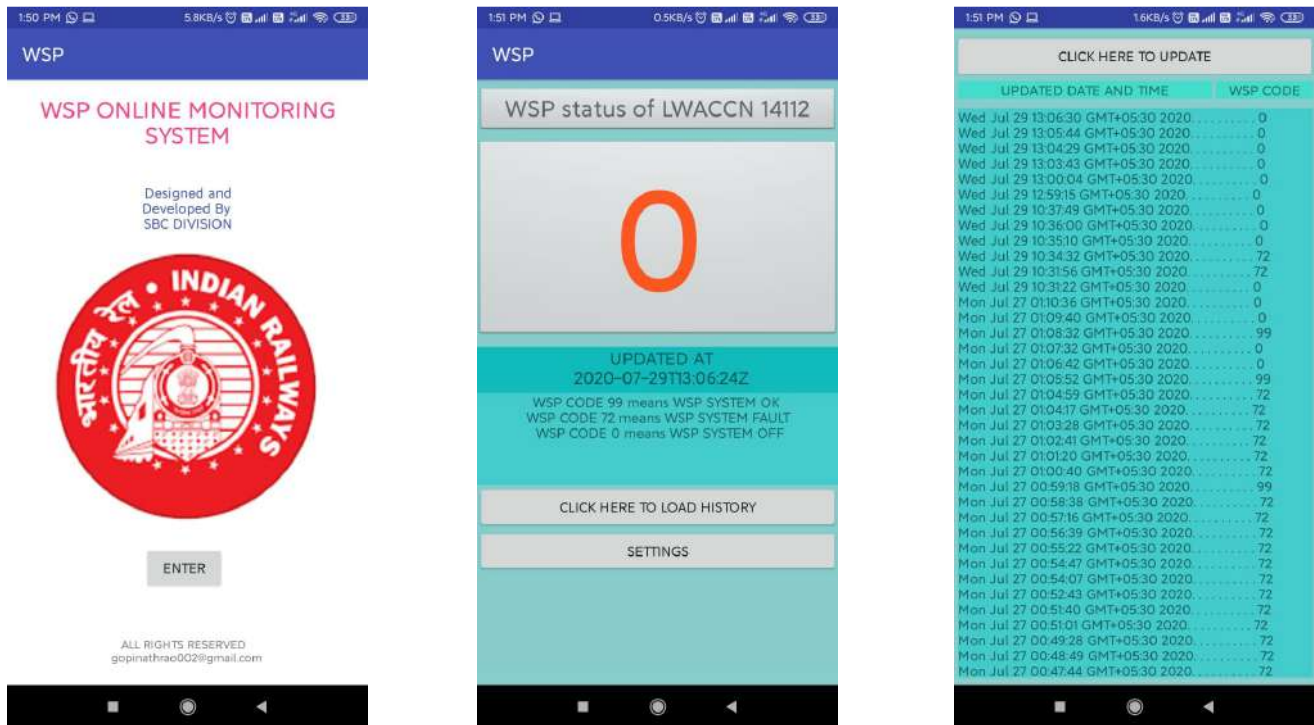
Presentation of Data

Trial run of the system was carried out in train number 12028, coach LWLRRM 182599 on 20/02/2020 for one week. System successfully recorded WSPD status during the entire journey. After rake reached MAS station, a fault was created for few minutes

and later cleared by escorting staff, and the same was recorded by the system.

The system has following advantages:

- 1) Remote Monitoring: WSPD status is recorded continuously while the coach is running, and the same can be monitored remotely through a mobile or computer. If WSPD fault is logged, then corrective action can be taken en-route if feasible, to prevent wheel shelling.
- 2) Data Recording and accessibility: The WSPD status is recorded with a time stamp. The data can be viewed in excel sheet and WSPD status and faults can be analyzed. WSP status history can be viewed through



Pic. 45-47- Screenshots of App

any smartphone or computer. Easy access to failure history will enable maintenance engineers to analyze the root cause for WSP faults and wheel shelling.

3) No interference to existing system: The sensors used to sense the status from WSP ST Card are non-contact type. In addition, there is no physical or electrical interference by this system to WSPD. Therefore, it will not cause any hindrance to normal working of WSPD.

4) Cost Effective: Cost of the total system for a single coach is approximately Rs. 1800. An open source cloud server is used which is available free of cost.

Discussions

System can be further developed to monitor coach speed also. Faiveley KES model ST card displays 4 speed levels through LED's.

- Speed less than 5Kmph
- Speed more than 5Kmph
- Speed more than 30Kmph
- Speed more than 50 Kmph

By reading the status of these LEDs speed range at which fault was created can be monitored. This will help in analyzing the type of faults. For example, if sensor gap is

more than limit then, fault will be recorded only when speed exceeds 5Kmph. So, if we are recording a fault when speed is more than 5Kmph then we can conclude that sensor is in good condition, only sensor gap must be adjusted. Also, a similar system can be developed for other makes of WSP to monitor the WSP status. This can, in turn reduce wheel shelling, and man-power needed for WSP attention. Also, if a serious WSP fault is detected en-route, decision may be taken to isolate the coach to prevent further shelling of wheels.

Conclusion

With online monitoring and fault recording, dynamic WSPD faults can be analyzed and wheel shelling can be reduced.

References

- 1) Arduino code:
<https://docs.google.com/document/d/1VLUnaR6tvxYucWRzi-u7lvGST9YDYdbS09a6KOF31Q/edit?usp=sharing>
- 2) Device fitted on coach

“Greenathon” “Towards a Greener Future, Green is my way forward”

Shashi Kiran,
DGM, North Western Railway

Abstract

With increasing pressure on organizations to respond to environmental challenges, it is essential to incorporate 'green thinking' in every aspect of decision making.

Introduction

With the ever increasing trend of urbanization and associated challenges, it has become inevitable to find ways for a healthy life. Due to changing habits of inhabitants, an alarming stage has been reached for the society when it has become very necessary to address serious issues like climate change and its effects on humanity worldwide.

Concept of “Green Rating” has come up as hope in this direction which specifies some basic requirements to achieve this status. This system analyses an organization on the basis of actions it is taking to mitigate environmental impacts arising out of its activities & operations. The certification mainly cover the assessment of parameters having direct relations to environment improvement such as Energy conservation measures, use of renewable sources, water recycling/rain water harvesting, waste management and its disposal, tree plantation etc. An intelligent effort would not only provide for a substantial saving in energy, fuel and water and other benefits of environment conservation but also establish

image of organization as a “Green Organization”.

Quest of the people towards growth, competitiveness and global excellence; pursuing "Green" has now become the new driver for companies. With globalization, the world today has been converted into a village where nobody can separate oneself from her duty to adopt measures for a sustainable environment and therefore, has put them on radar of common cause. With number of businesses going green on the rise and several initiatives on different areas evokes a spark in an individual's mind on "How Green is the organization".

What is Green building certification and why is it required?

Whether Green buildings are really green, is to be decided against the predefined rating systems. There are three primary Rating systems in India.

1. **GRIHA (Green Rating for Integrated Habitat Assessment)**
2. **IGBC (India Green Building Council)**
3. **BEE (Bureau of Energy Efficiency)**

We can define Green Buildings as structures that ensure efficient use of natural resources like building materials, water, energy and other resources with minimal generation of non-degradable waste. Technologies like efficient cooling systems have sensors that can sense the heat generated from human body and automatically adjust the room temperature, saving energy. Green buildings have a smarter lighting system also that automatically switches off when no one is present inside the rooms. Simple technologies like air based flushing system in toilets that avoids water use by 100%. Use of energy efficient LED's instead of conventional incandescent lamp, new generation appliances that consume less energy, and many other options help in making the buildings green and make them different from conventional ones.

Methodology & Certification

The Green Rating System for Companies advocates a performance based approach. It aims to provide leadership and guidance to businesses on how to implement green strategies. These strategies are designed based on an iterative and consultative process that includes building partnerships with stakeholders and employing their cumulative knowledge and experience to address issues related to ecological sustainability. The rating system employs a holistic approach, wherein, it not only advises businesses on strategy and actions required but also provides mechanisms to quantify the impact of such actions and make course corrections if required.

Weightage (points) are assigned to varying degrees of goals that are set for each of these parameters. For example, the points are awarded for reducing energy consumption. But points awarded will be higher for a business that demonstrates a higher degree of reduction in energy consumption compared to another business that demonstrates a lower degree of reduction in energy.

The Criteria and Weightage for such certification include the parameters such as Energy Efficiency (150 points), Water Conservation, Renewable Energy, GHG Emission Reduction, Material Conservation, Recycling & Recyclables, Waste Management, Green Supply Chain, Ventilation, Site Selection & Innovation (each 100 points), Product Stewardship, Life Cycle Assessment (both 75 points) etc.

Moreover, the threshold criteria for different certification levels for Greenco rating system are as > 750 points for Platinum rating, 650 - 749 Points for Gold Rating, 550 - 649 Points for Silver Rating, 450 - 549 points for Bronze rating and 350 - 449 points for just certified.

The rating is valid for 3 years and at the end of 3 years the organization will have to apply for the rating again. In between, if the company feels that they have improved their performances they can apply for a fresh rating. During the period of rating, the companies can use 'Greenco' certified company in their letterheads and other corporate communications.

Indian Railways as an organization, sensitive towards Environment and to reinforce IRs image as a "Green Transporter has also decided to take initiatives for undertaking Green rating Certification for its Railway establishments.

For this an MOU between Confederation of Indian Industry (CII) and Indian Railways has been exchanged for achieving green building ratings for its various categories of establishments. Indian Green Building Council (IGBC), a part of CII has developed various rating systems indigenously keeping in mind India's climatic conditions, building codes and bye laws and would be conducting these certifications.

Status/Achievements by North Western Railways:

An indicative timeline has been framed over

**Pic. 49**

To start with, Carriage workshop Ajmer, after implementing suggestions on the basis of feasibility study by Indian Green Building Council for this certification, has been awarded "SILVER" Green Co Status on this year's World Environment Day i.e. 5th June'2017.

In its continuance, Railway Station Jaipur has achieved the same status in the category of stations and awarded on 5th Oct'2017 on the occasion of 15th edition of "International Green Building Congress" held at Jaipur. It is worth to mention that Railway Station, Jaipur is the first ever in its category in India which is evaluated according to the "Green Railway Stations Rating System".

**Pic. 50**

NWR to cover existing establishments in a time bound manner and efforts are on in this direction.

With ongoing pace, it can be hoped that North Western Railway will definitely achieve Green rating of 08 more establishments

within this financial year and share Indian Railways' responsibility in transporting goods & passengers in future in a greener way by complying with all the requirements of these rating systems and fulfilling responsibility towards environment protection.

Integrated Water Conservation & Waste Management System at Mechanized Laundry

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Abstract

The Coach Maintenance Depot, Kamakhya has a Mechanized Laundry of 5 ton capacity and it is the largest mechanized laundry in Assam state or NE India. Huge quantity of diesel is used for heating water to generate steam for washing linen. This paper explores the scope of saving of both water and diesel in an integrated conservation system.

A closed loop water recirculation system has been developed to utilize waste water, steam exhaust and rain water to reduce fresh water input in the laundry.

With the help of an incinerator, solid waste management of dry solid waste at stations, colonies, pitlines and offices is burnt in PCB approved manner and the heat is utilized for waste to energy conversion leading to saving of diesel used in boilers in laundry.

INTRODUCTION

The Coach Maintenance Depot, Kamakhya is the first LHB depot of NF Railway with holding of above 400 coaches. It has a mechanized laundry functional since 2010 with 5 ton capacity. The linen requirement for trains running from KYQ stations is about 4-5 tons per day and it is completely fulfilled by the mechanized laundry at KYQ depot. It may be not operating as on publication of this article due to constraints imposed by the COVID-19 pandemic but in normal operation, the consumption of water is about 22000 litres per ton of linen washing with about approx. 200 litres of diesel consumed for generation of hot water and steam required by the washer extractors, driers and ironers. About 15000 litres of waste water is drained from washer extractors per ton of linen washed which approximately works out to 75000 litres per day. There is substantial

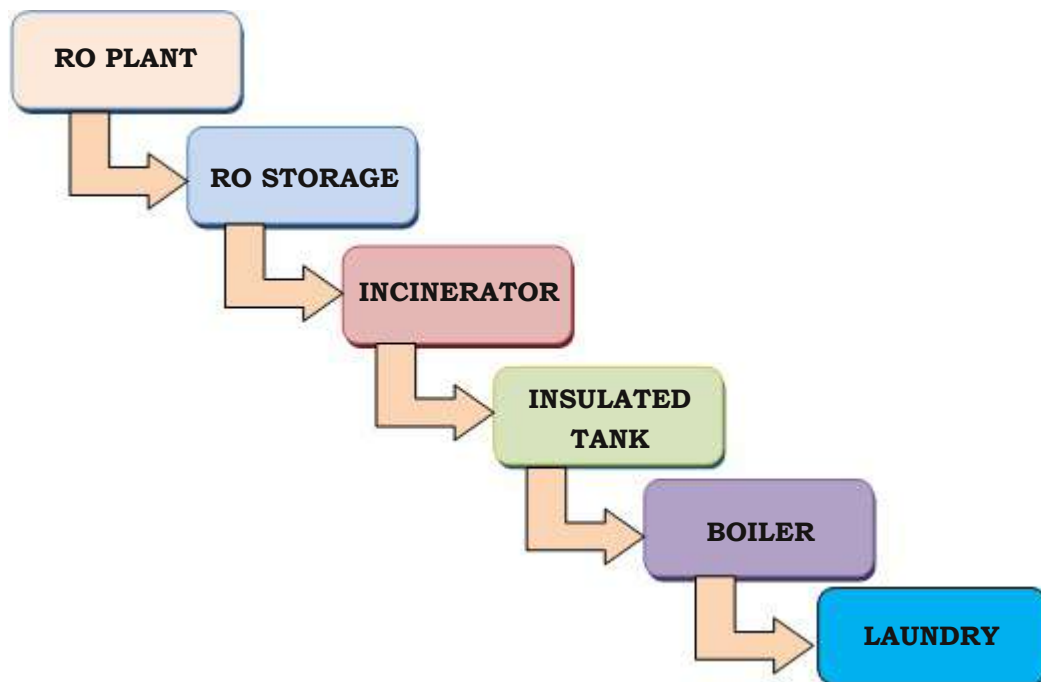
roof area in the laundry which helps in collection of about 100000 litres of rain water per year considering the average rainfall in Guwahati. Apart from utilizing the water output from laundry, the incinerator plant has been commissioned with a view to dispose dry solid waste and at the same time, to convert this waste to energy in form of heated water and steam thereby, reducing the diesel requirement in boilers in the laundry.

SOLID WASTE INCINERATOR PLANT

There is huge generation of dry solid waste in various Railway establishments (Stations, HQ, Pitlines, etc.) and colonies (GHY, NGC, PNO and MLG) in Greater Guwahati area and taking initiative as a part of Swachh Bharat Mission to promote Green Environment with aim of achieving waste to

energy, a Solid Waste Management waste to energy recovery system near Mechanized Laundry was commissioned in the month of February, 2020.

results. To harness this net energy contained in this condensate, steam recovery system has been installed at Mechanized Kamakhya Laundry.



- The installed system burns 150 kg of solid waste per hour
- Generates 900 litres of hot water per hour with average temperature of 80°C
- This hot water is directly supplied to boilers of Laundry
- This reduces energy required for heating of inlet water
- This results in saving of diesel of 40 liters per ton of linen production in Boiler operation

STEAM CONDENSATE SYSTEM

Mechanized laundry at Kamakhya operates in a two cycle of 8 hours each per day for production of 3.5 tons of linen. During this process steam generated at boiler after passing through different laundry machines (Washer Extractor, Fat work ironers etc) goes to condensate line. Average generation of condensate is approximately 900 lts. per hour at average temperature of 80° C. Prior to the implementation of the steam condensate recovery system, this heat energy used to get wasted, literally ending up in the drain without yielding anything useful



Pic. 52 INCINERATOR CHAMBER

In this system, the steam after its final use is collected in a common header which accumulates in an insulated tank situated underground. This is then pumped by hard water pump to an insulated tank of 5000 Lts. connected to the incinerator plant which is then fed to boiler inlet, thus reducing the heating requirement of steam in diesel boiler.

Average amount of recovered condensate is

approximately 4000 Lts. per ton of linen production. This saves around 15 Lts. diesel consumption per day.

EFFLUENT TREATMENT PLANT

The Effluent Treatment Plant (ETP) is a key operational control implemented in the N.F.



Pic. 53 Steam Condensate Collection Pipeline



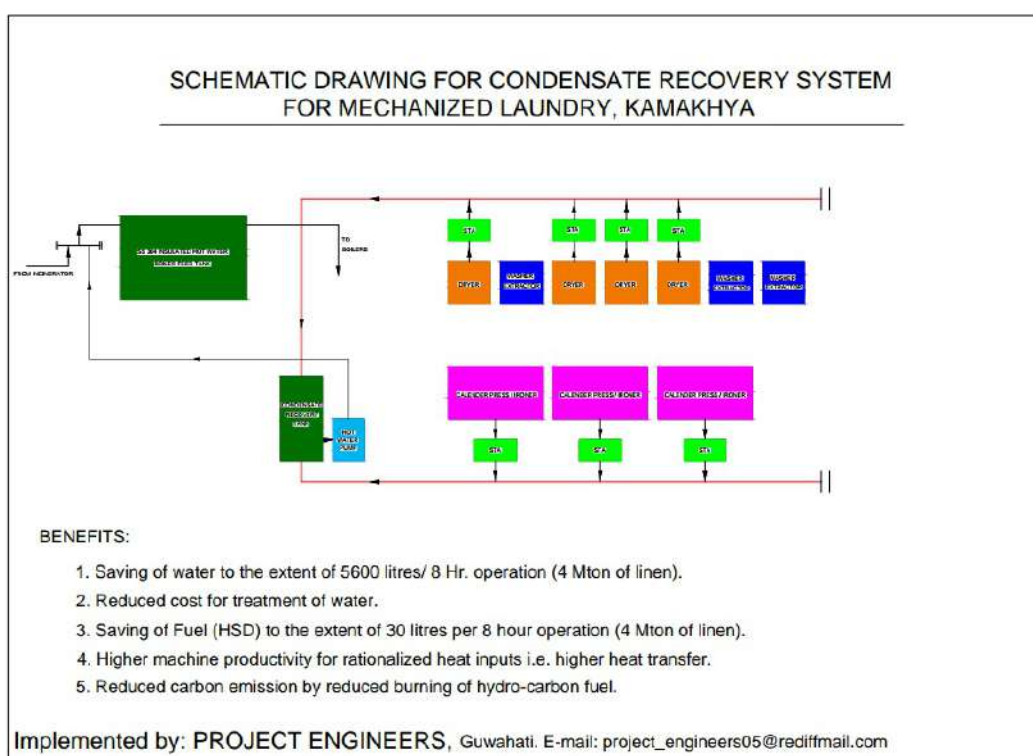
Underground
Reservoir tank for
steam collection

Steam collection
pipe from Ironers
& Washers



Underground
Reservoir tank for
steam collection

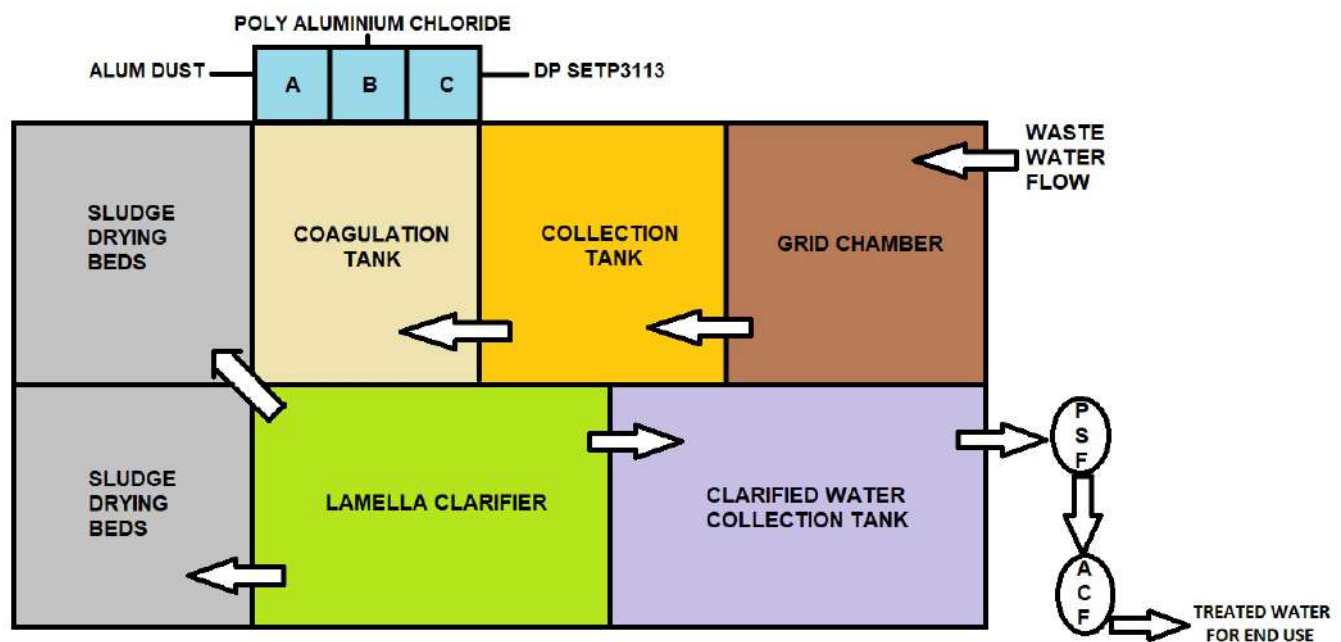
Steam collection pipe
from Ironers & Washers



Railway at Mechanized Laundry of Coach Maintenance depot KYQ to reduce the pollution load of its wastewater to the extent to meet the legal standards for the wastewater discharge. The approximate area of the ETP is 380 sq. ft.

The waste water coming out of the washer extractors is treated in effluent treatment plant (ETP) before discharge to drain. An average of 90000 litres of water is used per day for washing out of which 75000 litres approx per day is released to ETP for treatment in ETP so as to avoid water pollution. In future, this treated water is planned to be used in Automatic Car Washing Plant being installed at KYQ coaching pit line.

The functioning of the ETP is explained as



EFFLUENT TREATMENT PLANT MECHANIZED LAUNDRY KAMAKHYA

under:

a) The waste water comes out of the laundry passes through the grid chamber where the solid waste material are restricted from entering into the ETP chamber.

b) After, passing through the grid chamber the waste water is collected to the collection tank.

c) From the collection tank the water moves to the Coagulant tank where following chemicals are added for purification:

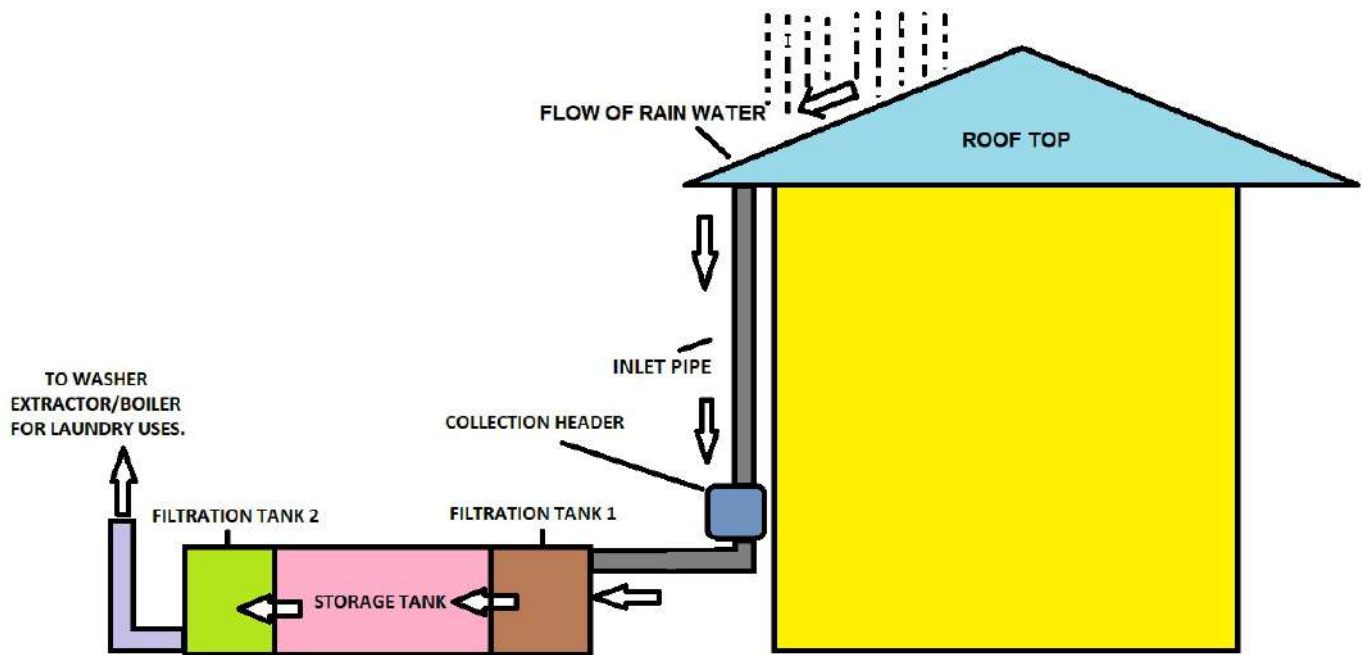
- A. Alum dust
- B. Poly Aluminum Chloride
- C. DP SetP3113

d) After that the overflowed water is collected to the Lamella clarifier chamber. This is a compact, inclined plate type of clarifier. It is used for clarification of water, waste water and liquid having suspended and colloidal particles.

e) The clarified water from the lamella clarifier tank is collected in the clarified water collection tank, from where the water is drained out to the environment.

WATER HARVESTING SYSTEM

Mechanized Laundry at KYQ has installed capacity of 5 ton and average production of laundry is approx 4 ton per day. During the process of production approx 5330 liters water per hour is consumed. In spite of availability of provision of Incinerator and steam condensate recovery system still there is scope of reduction water consumption and



RAIN WATER HARVESTING SYSTEM AT MECHANIZED LAUNDRY KAMAKHYA

thereby to increase water use efficiency water harvesting system for tapping water received from annual rainfall during rainy season. Average rainfall of GHY is 1699 mm and considering these potential almost 100000 liters of water can be tapped for use in laundry during rainy season with rain water harvesting arrangement at laundry area. Hence, in future Rain Water Harvesting is being planned at Mechanized Laundry Kamakhya for tapping potential saving of water during rainy season.

CONCLUSION

The Coach Maintenance Depot, Kamakhya is the first depot to install integrated water and energy conservation project of this scale for achieving environmental sustainability and converting waste to energy. Laundry being intensive water and energy consumption centre, it has immense potential for water conservation as well as energy conservation. It not only reduces cost but also contributes to environmental sustainability. With the climate change being a real threat, such initiatives to reduce resource strain on our planet are needed at all units.

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Conversion of Diesel-Electric locomotives to Battery Electric Locomotives in Indian Railways

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Abstract

Indian Railways has planned to achieve 100% electrification of BG rail routes by 2021-22. This rapid electrification has rendered a large number of Diesel Locomotives surplus. A Diesel Electric Locomotive is already an electric vehicle (EV) from a design point of view since in it the internal combustion engine is used to drive a generator and provide electrical power for the traction motors and to charge the battery. The traction motor is the only power supply unit with a direct connection to the wheels. However, the size of battery is small to provide power only for starting the Diesel Engine and to run auxiliaries. But if the size of the battery is increased to run the traction motors the Diesel Electric locomotive would become a series hybrid electric vehicle (HEV). The advantage of an HEV is that the internal combustion engine can be operated at its most efficient point to generate the necessary current for driving the traction motor or charging the battery. Therefore, in some way if Indian Railways could adopt the EV technology on a large-scale, it would create a big impact leading to revolution in this field. This would also be in line with the policy of the Government of India to promote Electric Vehicles in a big way. In this context phasing out of Diesel Electric Locomotives provides just the right kind of opportunity.

This paper discusses the conversion of Diesel Electric Locomotives to Battery Electric Locomotive in Indian Railway. The Goods/Mixed locomotives can be coupled in a multi-unit (MU) formation of two locomotives for utilization in Goods services. In each MU, one of the locomotives may be converted to be provided with Battery pack, Battery Charger and Battery Management System by removal of Power Pack, Cooling systems, etc and the other locomotive may be suitably converted by retaining Diesel engine to work in this MU. The Battery Pack may be directly charged from an external power source on 440V, 3 phase AC as well as from the Diesel Engine on the coupled locomotive. The Battery Pack will provide the current to start the Diesel Engine, for control circuits and to run auxiliaries on the coupled locomotive. In the beginning, both Locomotives will provide the tractive effort to start the train. During the acceleration phase also both Locomotives will provide the power, the mix being decided by the intelligent controls. However, the power requirement from Diesel Engine would reduce and as soon as balancing speed is reached, the Diesel engine will be switched off and the entire power requirement would be met from the battery pack. The Battery pack can also be charged through regenerative braking.

The calculations show that a fully charged 50 ton of battery pack alone can provide a range of 212 KM to draw one full rake of BOXN wagons. However, since the battery pack will be charged

by regenerative braking and there is also a Diesel engine in the coupled locomotive, the trip can be completed with much less consumption of Diesel and without having to charge the battery pack during the trip. The cost of a 50 ton battery pack is expected to be about Rs 11 crores. With about 1000 charging cycles possible, the cost is expected to be economical over the life cycle of the battery pack.

Other countries like the USA, Brazil, etc are also developing Battery Electric Locomotives. It is a great opportunity for Indian railways to venture in the field of this sunshine technology.

Electrification in Indian Railways and Diesel Electric Locomotives

With a view to reduce the Nation's dependence on imported petroleum based energy and to enhance energy security to the Country, as well as to make the Railway System more eco-friendly and to modernize the system, Indian Railways have been progressively electrifying its rail routes. By March'2019, electrification on Indian Railways has been extended to 34,319 RKM's out of the total rail network of 67,415 RKM's. This constitutes 50.91% of the total Railway Network. On this electrified route, 65.4% of freight traffic & 56.2% of Passenger traffic is hauled with fuel cost on electric traction being merely 33.2% of the total traction fuel cost on Indian Railways. Further, Indian Railways has planned to electrify balance BG rail routes by 2021-22 to achieve 100% electrification of BG rail routes.

However, this rapid electrification has rendered a large number of Diesel Locomotives surplus. The useful life of ALCO locomotives has been reduced to 31 years from 36 years. This will phase out 403 diesel locomotives. In all, approximately 1,000 diesel engines in full working condition are "stabled" or grounded so far.

If these engines are sold off as scrap, they would, at best, fetch between Rs 25-50 lakh each. On the other hand, the cost of refurbishing 4,000 diesel locomotives for possible export to Asian or African countries would work out to Rs 8,000 crore at the rate of Rs 2 crore per loco. Since, only a few countries run broad gauge trains the demand for such locomotives in the international

market is rather low. In the last 20 years, India has managed to sell less than 1,000 such locomotives to countries such as Tanzania, Vietnam, Sri Lanka, Bangladesh and Pakistan.

The railways had planned to convert diesel locomotives to 'dual mode' that could run on both diesel and electric traction. With this technological breakthrough, scrapped diesel engines could also be put to use. However, the first prototype could not be prepared in the last three years. Also, the estimated cost of dual mode locomotives is likely to be very high Rs 18 crore.

Another option is Conversion of Diesel Locomotives into Electric locomotives. Conversion of 200 diesel locos (100 HHP & 100 ALCO locomotives) into electric locomotives has been sanctioned in Pink Book 2018-19. Two ALCO type WDG3A Diesel Engines have been converted into Electric loco WAGC3. The loco has completed its oscillation trial and presently under operation over IR. Further, another set of two ALCO locomotives is under conversion at DMW/PTA. Another set of two HHP locomotives have been converted into Electric loco WAG-11 by DLW. The loco is under speed and oscillation trial with RDSO. However, the cost of conversion of Diesel Locomotives is high, almost equal to purchase of new locomotives. Hence, this plan has also not been adopted on a large-scale.

Meanwhile, the decision to abruptly remove 4,000 diesel engines from mainline operations will necessitate the manufacture/purchase of an equal number of

electric engines. At an average cost of Rs 12 crore for each electric loco, the total cost will come to Rs 48,000 crore, plus the loss incurred on the diesel locos, which could end up being about half that figure.

Diesel Electric Locomotive as an Electric Vehicle

There are different types of Electric Vehicles (EVs), though the word 'electric vehicles' normally refers to battery electric/all electric/plug-in electric vehicles. The types of EVs are hybrid electric vehicles (HEVs) (series, parallel, series-parallel type), plug-in hybrid electric vehicles (PHEVs), battery electric vehicles and fuel cell electric vehicles. On the basis of the hybridisation rate, the hybrid electric vehicles can be further divided into micro, mild and full hybrids. In case of micro and mild hybrids, the electric power is not large enough to propel the vehicle alone. The battery size and electric drivetrain power progressively increase as you move from a hybrid vehicle to an all electric vehicle. The benefit of the PHEVs and HEVs compared to the BEVs is that the range anxiety is overcome for long distance drives due to the diesel or petrol powered internal combustion engine.

A Diesel Electric Locomotive is already an electric vehicle (EV) from a design point of view since in it the internal combustion engine is used to drive a generator and provide electrical power for the traction motors and to charge the battery. The traction motor is the only power supply unit with a direct connection to the wheels. However, the size of battery is small to provide power only for starting the Diesel Engine and to run auxiliaries. But, if the size of the battery is increased to run the traction motors the Diesel Electric locomotive would become a series hybrid electric vehicle (HEV). The advantage of an HEV is that the internal combustion engine can be operated at its most efficient point to generate the necessary current for driving the traction motor or charging the battery.

EV Policy of Government of India

As per Niti Aayog's document the key objectives of the EV policy are:

1. Reduce primary oil consumption in transportation.
2. Facilitate customer adoption of electric and clean energy vehicles.
3. Encourage cutting edge technology in India through adoption, adaptation, and research and development.
4. Improve transportation used by the common man for personal and goods transportation.
5. Reduce pollution in cities.
6. Create EV manufacturing capacity that is of global scale and competitiveness.
7. Facilitate employment growth in a sun-rise sector.

However, the same policy document underlines the fact that Two-wheelers and Economy four-wheelers (cars costing less than ₹1 million) comprise 79% and 12% of the total number of vehicles. It is not easy to persuade these customer segments to adopt EVs because of the initial high costs.

Therefore, in some way if Indian Railways could adopt the EV technology on a large-scale, it would create a big impact leading to revolution in this field. In this context phasing out of Diesel Electric Locomotives provides just the right kind of opportunity. This will increase the acceptability of this technology and would also lower the cost of battery, which is the biggest cost driver of an EV, by bringing a big economy of scale.

The presence of world-class technology will help India build a world-class ecosystem for high-quality components and subsystems usable for all kinds of vehicles. In the longer term, India would be able to establish technological and manufacturing leadership in the economy segment of the market. The prevalence in India of small vehicles such as two-wheelers, three-wheelers, economy four-wheelers and small goods vehicles is

unique among large countries. These small vehicles require a unique set of technological and industrial capabilities. Here, India has an opportunity to take a leadership role in the electrification of small vehicles. India's potential volumes for these vehicles as the nation grows, lays the foundation for transformational manufacturing and industrial policy.

Once the unit cost of batteries is lowered India can explore several pathways to reduce it further: a. Selecting appropriate battery chemistries b. encourage manufacturing of such battery cells in India. India is already making battery packs (cell to pack).

Conversion of Diesel Locomotive into Hybrid Battery Electric Locomotive

As on 01.08.2020, there are total 4668 Diesel Electric Locomotives (1112 WDG3A, 1065 WDM3A, 502 WDM3D, 23 WDM2, 217 WDG4G and 1749 WDG4), which are in Goods or mixed operation besides 809 locomotives (60 WDP1, 39 WDP3A and 710 WDP4) in purely Passenger services.

The Goods/Mixed locomotives can be coupled in a multi-unit (MU) formation of two locomotives for utilization in Goods services. In each MU, one of the locomotives say Loco 1 may be converted to be provided with Battery pack, Battery Charger and Battery Management System by removal of Power Pack, Cooling systems, etc. The other locomotive say Loco 2 may be suitably converted to work in this MU. The Battery Pack may be directly charged from an external power source on 440V, 3 phase AC. The Diesel Engine of Loco 2 can also charge this Battery Pack. The Battery Pack will provide the current to start the Diesel Engine and control circuits, eliminating the need of Auxiliary Generator in Loco 2. In the beginning, both Loco 1 & Loco 2 will provide the initial torque to start the train. During the acceleration phase also both Locos will provide the power, the mix being decided by

the Control Circuit. However, the power requirement from Diesel Engine would reduce and as soon as balancing speed is reached, the Diesel engine will be switched off and the entire power requirement would be met from the battery pack. The Battery pack can also be charged through regenerative braking. Therefore, there will be no need for Dynamic Braking Grid and Blower Motors in both locomotives.

Details of modifications required in Locomotives are as under:

Loco 1 modifications

1. Nose compartment: Remove DBR grid, DBBM
2. Drivers' cabin: Additional gauges for battery & operation
3. Control panel: Modifications may be required
4. Drivers' cabin: Additional gauges for battery & operation
5. Control panel: Provide onboard Battery charger and Battery Management System
6. TG compartment: Remove Traction Alternator, Exciter, Aux Generator and FTMB drive
7. Engine room: Remove power pack and provide battery pack with suitable cooling arrangement
8. Expressor compartment: Remove Compressor
9. Radiator compartment: Remove Lube Oil Cooler, Rad fan drive arrangement
10. Under truck: Remove fuel tank and provide alternative arrangements to drive Traction Motor blowers

Loco 2 modifications

1. Nose compartment: Remove DBR grid, DBBM and Air Brake panel
2. Drivers' cabin: Additional gauges for battery & operation
3. Control panel: Modifications may be required
4. TG compartment: Remove Auxiliary Generator
5. Engine room: nil

6. Expressor compartment: nil
7. Radiator compartment: nil
8. Under truck: nil

Battery Specifics

Battery costs, which are the single largest driver of TCO (Total Cost of Ownership) for EVs, have seen enormous technological advancement in recent years, in both improving battery performance and reducing cost. Most of that progress has come in advances in Lithium-ion batteries which have become the batteries of choice for electric vehicles, largely because of high specific-energy, the ability to charge rapidly and their long cycle-lives which is considered over after a battery degrades to between 75-80% of original capacity.

Lithium-ion batteries used in EVs have different chemistries and with specific characteristics. The most suitable one is the NMC-Graphite battery cell. These battery-cells use Nickel-Manganese-Cobalt (NMC) chemistry as cathode and Graphite as anode. They are most commonly used EV batteries today as they provide specific-energy of 200 Wh/kg or more and the cell-costs are in between \$150 to \$200 per kWh. They are typically charged at 1C or 1.5C and are used with a discharge depth of about 80%. When charged and discharged at 25°C, they would typically give 2500 life-cycles. The cell-chemistry, however, has safety issues at high-temperatures and generally not recommended to be used as cell-temperatures, touches 55°C to 60°C. When charged or discharged at 45°C or at 3-C rate, the life-cycle may reduce to as low as 500 cycles. Thermal design incorporating heat-dissipation is therefore an important element of battery-packs.

Calculation for Requirement of Battery Pack

The calculation for requirement of Battery pack and its cost is shown as under:

SEC for Goods Train= 10 Kwh per 1000 GTKM1

One BOXN rake = 4700 ton

Energy requirement per KM = $4700 \times (10/1000) \text{ KW} = 47 \text{ KWH}$

Average Lead = 605 KM1

Average Energy requirement for one trip = $47 \times 605 = 28435 \text{ KWH}$

Required weight of battery pack = $(28435 \text{ KWH}) / (200 \text{ WH/KG} \times 3) = 142 \text{ ton}$

The initial calculation shows that to provide an average lead of 605 KM entirely on Battery power, 142 Ton of battery pack would be required. However, since the battery power will be used in conjunction with the Diesel Engine, the weight of the battery pack may be kept at around 50 Ton.

When fully charged the battery pack alone can provide a range of 212 KM to draw one full rake of BOXN wagons as per calculation shown below:

Energy provided by 50 ton battery pack = $200 \text{ WH/KG} \times 50000 \text{ KG} = 10000 \text{ KWH}$

Range possible = $10000 \text{ KWH} / (47 \text{ KWH per KM}) = 212 \text{ KM}$

The present cost of Battery pack will be around ₹11 Crores.

Cost of battery pack = $(28435 \text{ KWH} \times 50 / 142) \times (\$150 \text{ per kWh} \times 3) = \$15,01,848 = \text{Approx. ₹11,16,02,369 Crores}$ (@Exchange Rate of 74.31 on 26.08.2020)

In 2010, the price of a lithium-ion battery was \$1100/KWh, which has sharply declined by 87% to \$156/KWh today. Battery prices are anticipated to fall further by 6-8% every year, with the introduction of new pack designs and falling manufacturing costs. By 2030 the price can come down to \$61/KWh, pushed by reducing manufacturing capital expenditures, new pack designs and changing supply chains.

Considering the rapidly falling price of battery pack and low cost of ownership the initial

high investment of ₹11 Crores seems viable.

Development of Battery Electric Locomotive in other Countries Brazil

Progress Rail has announced EMD Joule, a lithium-ion battery shunting locomotive which it hopes to make available to the global market in early 2021. The Caterpillar subsidiary is working with mining group Vale to develop the 100% electric locomotive, in a project which has brought together Progress Rail and Vale engineering teams in both Brazil and the USA. Manufacturing is being undertaken at the Progress Rail plant in Sete Lagoas. The 3000 hp shunter will have a battery capacity of 1.9 MWh, with option to increase this up to 2.4 MWh. It would be able to operate for up to 24 h between charges, subject to utilisation.(5)

USA

Wabtec has started conducting factory testing at its Erie plant of a prototype 4400 hp battery locomotive, ahead of trial operations with BNSF that are planned to take place in the final quarter of this year. BNSF and GE Transportation (now Wabtec) began development of the battery-electric locomotive in 2018, supported by a grant from the California Air Resources Board as part of its Zero & Near Zero-Emission Freight Facilities programme. The BNSF prototype is fitted with a lithium-ion energy storage unit with around 20 000 cells containing a combination of nickel, manganese and cobalt. While BNSF and Wabtec have previously tested a battery shunting locomotive, this will be their first test of a main line design. Testing is to be undertaken on a 560 km route in California.

The battery locomotive will operate in multiple with conventional diesel-electric locomotives between Barstow and Stockton, where a charging station will be installed at BNSF's Morman Yard. While the fixed charging station will provide an initial charge, the locomotive has been designed to capture kinetic energy through dynamic braking every time the train slows. The locomotive

will use an advanced version of Wabtec's train energy management software to look at the route ahead and calculate how to best use the available power to reduce the train's overall fuel consumption. Operation on battery power in yards will also enable the other locomotives to idle or be shut down, reducing local emissions and noise.(6)

Conclusion

The calculations show that a fully charged 50 ton of battery pack alone can provide a range of 212 KM to draw one full rake of BOXN wagons. However, since the battery pack will be charged by regenerative braking and there is also a Diesel engine in the coupled locomotive, the trip can be completed with much less consumption of Diesel and without having to charge the battery pack during the trip. The cost of a 50 ton battery pack is expected to be about Rs 11 crores. With about 1000 charging cycles possible, the cost is expected to be economical over the life cycle of the battery pack. Further, the energy density of lithium ion cells is improving very fast and the cost of battery packs is also falling. It will make this technology even more economical within the next 5 to 10 years.

Other countries like the USA, Brazil, etc are also developing Battery Electric Locomotives. Indian Railways should also quickly start a pilot project for conversion of Diesel Electric locomotive into Battery Electric Locomotive considering the huge economical benefits besides the obvious environmental benefits.

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