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Environmental Conditions and Environmental Performance of Railway Workshop: A Case Study

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Abstract:- **Railway workshops undertake major maintenance activity of the rolling stock over Indian Railways which cater to coach repairs, wagon repairs, locomotive repairs or even combination them. These workshops employ thousands of technical manpower and are energy intensive workshops established mainly during pre independence era. This study has two objectives firstly to understand the environment conditions prevailing in one of the major workshops located in south India and secondly to assess the environmental impact by the workshops due to energy use. Focussed group discussions were conducted with the stake holders of the workshop and a structured questionnaire was compiled. The questionnaire was administered to the technical employees of the workshop duly citing the idea behind collecting the data. The results of 100 respondents from the workshops were compiled and analysed.The results clearly indicate that the environment in the workshops are maintained at very high standards. This is due to high environmental awareness in the workshops and the pro active effortts by the management to maintain high standards of indoor air quality. The study also compiles the annual energy consumption data of the workshops for a period of five calender years from 2007 to 2011, compares them with the annual output and analyses the environmental pollution in terms of GHG emissions.**

Keywords:-- **Indian Railways, Coach Maintenance, Environmental Pollution, Railway Workshops**

I. INTRODUCTION

Transport sector accounts to nearly one quarter of global energy related Carbon Di Oxide (CO_2) emission (IEA-2009) and to achieve necessary deep cuts in Green House Gas (GHG) emission, transport must play a significant role. Average external cost in Euros € per 1000 passenger km which includes climate change, air pollution, noise, nature and landscape, accidents works out to be 72 for car, 52 for aviation, 32 for bus and the least 18 for rail (Union of International Carriers UIC 2004). Indian energy sector is increasing unable to deliver a secure supply of energy amid growing demand and fuel imports. The five main challenges that need to addressed are improving energy companies, commercially viable pricing, sufficient investments, effective implementation of energy policies and strong political will (OECD/IEA 2012). **E**missions and mention that globalization and liberalization policies of the Government in 90's has increased the number of road vehicles nearly 93% from 1980-81 to 2003-04 (T.V. Ramachandran 2009). These road vehicles mainly consume nonrenewable fossil fuels and are a major contributor of GHG particularly CO_2 emissions. They have calculated the country level emissions for Railways, Shipping and Airways based on fuel types and find that road; rail and air are responsible for 80%, 13% and 6% emissions respectively. Past few decades in India a gradual transformation has taken place from rail dominated transport to road dominated transport. Infrastructural problems such as lack of roads and rail network are a limiting factor. They conclude that the passenger traffic in India is likely to grow at 5% a year and freight traffic more than 5% in the period 1990-2021 and hence energy efficiency improvements can reduce future energy consumption and CO_2 emissions by 26% (P. Ramanathan 2010).

ndian Railways (IR) needs to expand its route network, use resources optimally, develop asset base through public private partnership and improve infrastructural facilities (Alivelu, 2010). Literatures cited above clearly indicate that study of IR is justified to ensure growth of not only the organisation or nation but to ensure global development on sustainable basis. According one of the workshops on IR i.e.; the Central Workshop at Mysore (herewith MYSS) in the Indian state of Karnataka has been taken up for study. MYSS was established by the erstwhile Mysore State Railway in 1924. This workshop employs 1800 staff and is involved in Periodical Overhauling (PoH) of broad guage (BG) coaches, up gradation of coaches by implementing new technologies (both AC and Non AC coaches) and manufacture of composite brake blocks and toy trains (Mane & Nagesha 2009). The total installed electrical load of this workshop is 4750 kVA, Contract demand of 800 kVA and consumes on an average 80,000 units per month (MYSS Standard Note, 2013).

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PoH of coach is undertaken at an interval of 18 months and involves both the body and the two bogies of the coach (CAMTECH, 2004). Intermediate overhaul (IoH) is undertaken for bogies alone at an interval of 9 months and the coach bodies are generally not taken up for repairs. All the components are tested individually, dimensions checked and recorded. Railway steel bodied coaches are having a codal life of 25 years which is standardized through IR (Indian Railways Yearbook 2010). After working for 10 to 15 years the coaches interiors turn out very shabby and need a facelift. Even the body steel components in certain areas especially adjoining toilets get weakened due to corrosion. Hence refurbishment is undertaken to give a new lease of life to the coaches and made suitable for them to run for another 10 years before being put out of service. Major inputs in the form of extensive corrosion repairs, toilet, interior paneling, flooring, seats and berths rexine are renewed during refurbishment.

Manufacturing of brake block at MYSS has been approved by research designs and standards organisation (RDSO) and is most sought after by diesel sheds and carriage shops for their high quality and reliability. These brake blocks are composite material brake blocks and have replaced the conventional cast iron brake blocks due to their technological superiority. They are manufactured using the compression molding technology wherein Liquefied Petroleum Gas (LPG) is used for preheating of the moulds and for the curing process. Electricity is used for the hydraulic presses to compress the mixture and also for baking the brake blocks in the baking oven.

The present study includes two objectives. Firstly to ascertain the environmental conditions prevailing in the workshop and secondly to study the environment pollution emissions from this workshop, for which the annual outturn and the annual energy consumption figures were compiled over a reasonable period of five calendar years from 2007 to 2011. The results were studied based on intergovernmental panel on climate change (ipcc) guidelines the emissions were computed covering the three major energy carriers used by the workshops

II. MATERIALS AND METHODS

To understand the activities and the energy carriers, the workshop management consent was obtained during 2008. Earlier study at MYSS revealed that the average experience of the technical staff in the workshop was 24 years (Mane & Nagesha 2013). Hence the best methodology was to ask the technical staff who work there day in day out for over decades till superannuation about their opinion on environment. Hence focused group discussion was undertaken with experts and a suitable questionnaire devised to record the rating of the respondents. For the first objective of ascertaining the quality of environment in the workshops a simple questionnaire was devised and administered to the respondents who were mainly the technical staff of the workshops. The questionnaire were collected back and compiled to derive inferences. The responses of the technical staff are provided in the subsequent paragraphs under the heading results and discussion.

For the second objective i.e. to determine the pollution emission a detailed study was undertaken .The various activities undertaken by the workshop was studied for a period of five years and the annual output for five calendar years was compiled. The energy carriers utilised to undertake the activities were collected for the five year period of study. Based on the recent IPCC guidelines (IPCC, 2006) the total emissions have been computed and also the emissions per coach PoH activity have also been arrived at.

III. RESULTS AND DISCUSSIONS

3.1 A Survey of Environment in Two Railway Workshops

The above discussions were based on the actual consumption of the energy carriers and the EC potential based on comparison with benchmarks. The opinion of the employees was considered to evaluate their opinion towards the environment and pollution in their respective workshops. Simple questionnaire was distributed in both the workshops to ascertain their opinion and the sample size was 100 respondents in the workshop. The respondents were selected in random and the questionnaire distributed during tea breaks. The respondents were briefed about the motive for the survey and the procedure to fill the form. The responses were collected, compiled, tabulated and analysed. The results of the analysis are provided in the figures 1 to figure 3 in following pages. Spider chart on the responses has been prepared to give the overall perspective of the respondents with all the nine questions.

Many of the respondents have work experience in private sector prior to joining the railways. Hence it is observed that they have given excellent and satisfactory opinion regarding the general cleanliness in the workshops as shown in fig. 1. 58% of the respondents have termed the cleanliness to be excellent and 40% respondents have mentioned it as satisfactory. This clearly indicates that 98% staffs are satisfied due to very high level of cleanliness which has been established and being regularly maintained in the workshops over the years.

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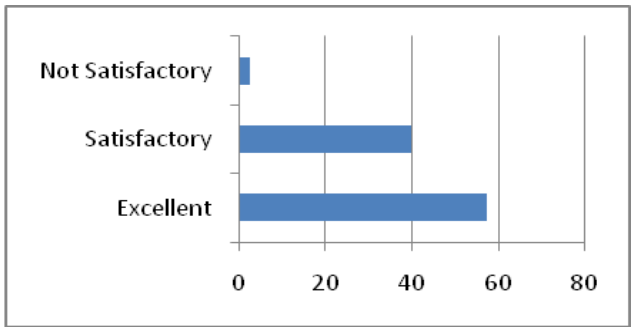

Figure 1: Response in % to general cleanliness in workshops

3.2 Noise Pollution

The workshops generate noise due to operations of various machines, plant and equipment. Noise can be an irritant and can cause damage in a long run if not attended to. Hence the technical staff was asked to clarify their stand on their perception of noise levels within the premises of the workshops. As per fig. 2, 92 % of the staff mentions that the noise levels are tolerable and 8 % of the staff have cited as not tolerable. The workshop management needs address this issue to ensure that the noise levels are within the acceptable limits. In this direction already the workshop has replaced its 500 cubic feet per minute (cfm) capacity reciprocating air compressor with an acoustically enclosed 500 cfm screw compressor during mid 2013 which is almost silently working for the entire day. Even the two numbers of diesel generating sets of 250 kVA procured are having acoustic enclosures unlike the earlier ones

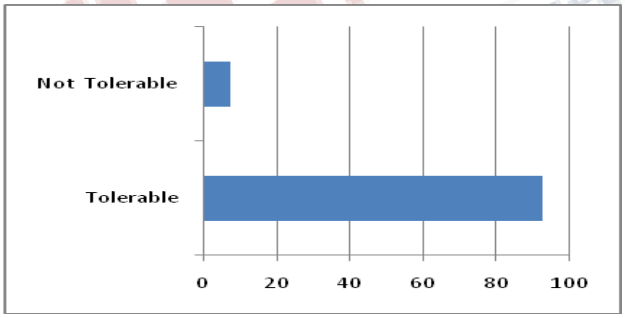

Figure 2: Response in % to Noise levels within workshops

3.3 Indoor Air Quality

Figure 3 gives the overview of MYSS respondent's opinion to all the questions. 95 % employees satisfied with the indoor air quality as per the survey results. The spider chart highlights that majority of the respondents greater than 95% are happy with the environment and the facilities provided

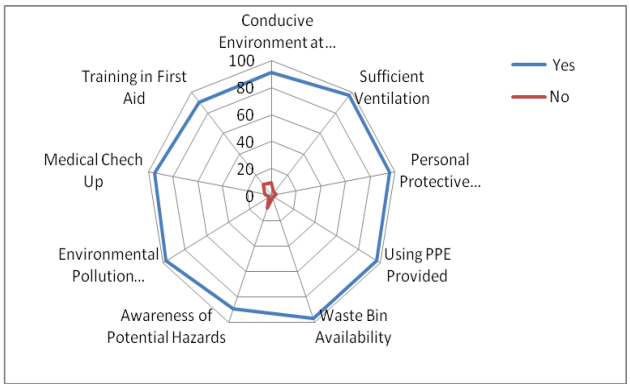

Figure 3: Views of respondents in percentage about various environment issues

The questions once again relate to cleanliness, ventilation, provision of Personal protective equipment (PPE), availability of waste bins, education about occupational hazards and pollution, medical checkups and training in first aid. The employees are educated and are aware of PPE and the hazards of employment in workshops. As many of the employees have previous work experience in the private sector they have ranked the workshops very high as then can make out the difference by comparison. The responses clearly highlight the good working environment in MYSS as it's a government organisation wherein all stipulated and mandated facilities are provided to the work force. Due to increased educational levels amongst the staff, better and labour friendly management policies, the required facilities have been provided by the workshop management which is reflected in the independent responses by the working class. Its due to the good environmental practices the workshop was awarded Environment Management System ISO 14001certification (MYSS PCDO 2008). This clearly indicates the high level of clean environment being maintained in the workshops of IR.

IV ENVIRONMENT POLLUTION AT MYSS

The annual outturn of the core activity of PoH of coaches by MYSS is given in figure 4. The figure gives an average outturn of 684 coaches PoH per annum (p.a.). The major outturns of the workshop are as shown in fig. 4. To undertake these activities energy is essentially required and the annual overall consumption of the three energy carriers in the workshop was collected and computed which are shown in table no 1. Figure 4 shows the actual output of MYSS in the calendar years from 2007 to 2011. All the major activities are shown and their annual output is depicted year wise. In terms of quantities Composite brake

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block manufacturing activities ranges between 50,000 to 60,000 per annum. Highest numbers of coaches were overhauled in 2009 and there is a downward trend thereafter.

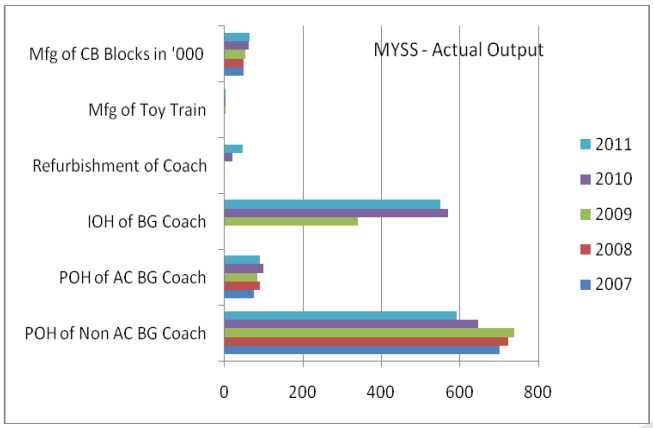

Figure 4: Output of MYSS in the calendar years from 2007 to 2011 in numbers

Table 1 MYSS: 2007-2011, Annual consumption of various forms of energy

Energy Carrier/ Year	2007	2008	2009	2010	2011
Diesel in litres	43,161	58,090	71,500	70,266	65,600
Electricity in kWh	10,49,265	9,23,563	9,19,153	9,37,260	6,85,963
LPG in Kgs	27,462	27,762	28,536	30,426	30,500

4.1 Electricity Usage

Electricity is mainly used by various machines, cranes, for welding, for lighting purpose and running water pumping motors, for operating their test equipments, etc. Standard conversion factors are adopted for converting the energy carriers in thermodynamic units as shown in fig. 5. Diesel is considered having a specific gravity of 0.84 and calorific value of 44 MJ/kg (BEE 2012). Electricity conversion was undertaken at 3.6 MJ/ kWh and LPG was considered having a calorific value of 46 MJ/kg (Environment Handbook 2010).

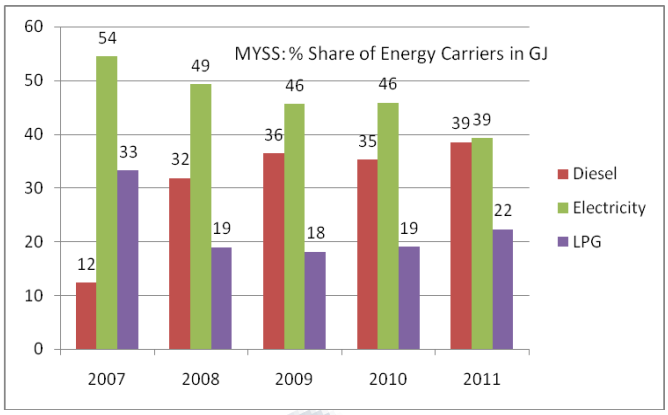

Figure 5: 2007-2011, % Share of major energy carriers in GJ

V THE EMISSION ESTIMATION PROCEDURE

Energy consumption in any industry is associated with negative environmental implications and railway workshops are no exception to it. The major environmental contamination in railway workshops is in the form of "Air Pollution" and the pollution caused during coach cleaning process is not attributable to energy use. Air pollution caused by workshops is mainly associated with their energy use. Accordingly, we are estimating air pollution in a detailed and systematic way. These emissions due to energy use are estimated using IPCC guidelines. Basically, these emissions depend on the type of energy carrier and the fuel combustion technology adopted. The emission factors are compiled separately for each energy carrier in the workshop referring IPCC (2006). Kyoto protocol covers the following six GHGs viz. carbon dioxide (CO_2), methane (CH4), nitrous oxide (N_2O), hydro fluorocarbons (HFCs), PerFluoroCarbons (PFCs), and sulphur hexafluoride (SF6). In this study we have calculated the emissions of first three GHG as their share is large and omitted the last three as their emissions are insignificant. Table 2 gives the emission factors for the various energy carriers used by the workshops.

Table 2: Emission factors in workshops (Source: IPCC, 2006)

Sl No.	Pollutant	Emission Factor		
		Diesel kg/Tonne	LPG kg/Tonne	Electricity kg/kWh
1	CO_2	3164	2600	820
2	CH_4	0.133	0.024	0.0081
3	N_2O	0.4	0.108	0.0135

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The environmental pollution has been evaluated annually energy carrier wise based on the current IPCC conversion factors and later on consolidated for the entire workshop. The emission per standard coach shall be computed and based on the average emission. GHG by the consolidated use of three major energy carrier's viz. diesel, electricity and LPG. We look into the emissions considering the overall usage of all energy carriers and compute the annual emissions of CO_2, CH_4 and NO_2 due to the usage of these energy carriers by the workshops. Based on the annual output of the workshops and the annual emissions the emissions per unit of outturn are estimated.

The emissions of GHG are computed by using the following relation.

Emissions $_{GHG, fuel}$ = Fuel Consumption $_{fuel}$ x Emission Factor $_{GHG, fuel}$

Where:

Emissions $_{GHG, fuel}$ = emissions of a given GHG by type of fuel (kg GHG)

Fuel Consumption $_{fuel}$ = amount of fuel combusted (MJ)

Emission Factor $_{GHG, fuel}$ = default emission factor of a given GHG by type of fuel (kg gas/MJ).

CO_2 emissions are the major GHG emissions and hence are dealt with in the beginning. Diesel fuel is considered having a specific gravity of 0.84 and the combustion of diesel results in 2.664 kg of CO_2 emissions as per the IPCC guidelines of 2006 for mobile combustion the current level of combustion efficiencies.

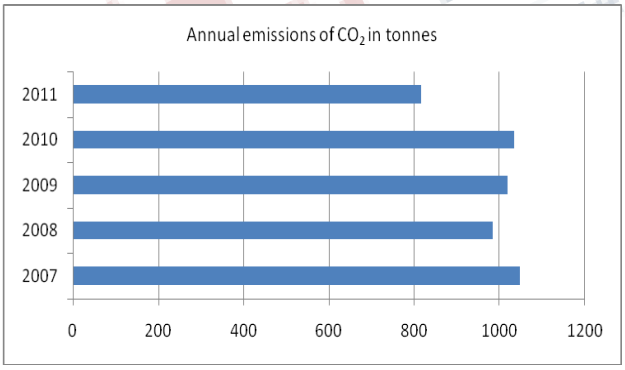

Figure 6: Annual emissions of CO_2 by MYSS in tonnes p.a.

On an average the workshops contribute to 150 tonnes of CO_2 emissions annually and considering 41 such workshops on IR the annual emission from IR workshops amount to more than 6000 tonnes. The emission of methane CH_4 is considered with a factor of 0.000133 kg of CH_4 per litre of diesel being combusted per the IPCC guidelines of 2006 for mobile combustion. The emission of CH_4 has shown increasing trend in MYSS from 2007 to 2009 and thereafter stabalised and reduced in 2011

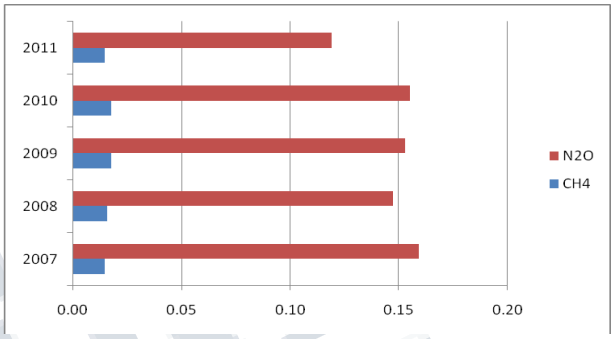

Figure 7: Annual emissions of N_2O and CH_4 by MYSS in tonnes p.a

The total CH_4 emissions from IR workshops shall not exeed 0.5 metric tonnes annually.

The emission of N_2O is considered with a factor of 0.0004 kg per litre of diesel being combusted as per the IPCC guidelines of 2006 for mobile combustion. The emissions of NO_2 are quite low as seen from the fig. 7 cited above.

The emissions of CO_2, CH_4 and NO_2 due to use of all the three energy carriers per coach PoH is given in fig. 8 and fig. 9 respectively which is calculated based on annual energy consumption divided by the number of coaches overhauled during that calender year

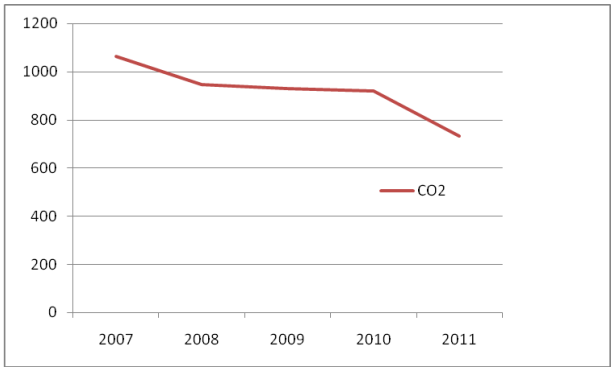

Figure 8: Emissions of CO_2 in kg per Standard Coach PoH

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Figure 8 which describes the CO_2 emissions per coach PoH gives a healthy declining trend for all the five years of study. The figure shows a declining trend from 1050 kg to 780 kg of CO_2 per coach by MYSS

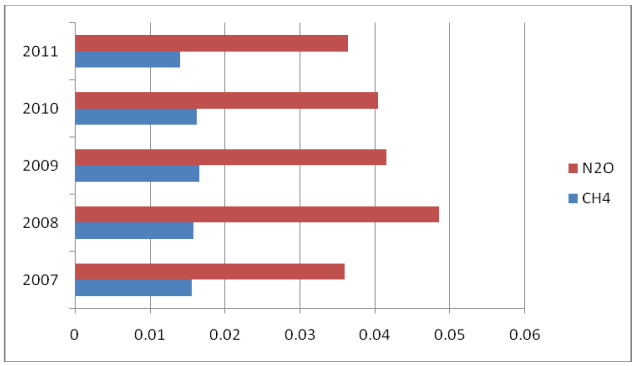

Figure 9: Emissions of CH_4 and N_2O in tonnes per Standard Coach PoH

Figure 9 which describes the CH_4 emissions and NO_2 emissions per coach PoH gives a healthy declining trend for all the five years of study. MYSS show a declining trend over the five year study period from 0.016 tonne to 0.014 tonne of CH_4 per coach PoH. MYSS shows NO_2 emission at 0.37 tonne per coach in 2007 which increases to almost 0.05 tonnes and again stabilises back to 0.037 tonne per coach during 2011.

VI DISCUSSIONS

The study about environment conditions in railway workshops indicates that workshops over IR are well organised which not only meet the statutary requirements but also satisfy the technical workforce by providing conducive work atmosphere**.** This study shows very little scope for improvement and the areas like noise pollution can be tackled locally. The respondents clearly find the establishment quite satisfactory which is evident from their responses. The environment pollution due to energy use shows considerable CO_2 emissions and the judicious use of energy can lead to reduction in the carbon foot prints of the railway establishments. By and large due to being large government organisations the workshops environment is certainly better compared to any small or medium scale industry as the state of art machinery and plant are procured and utilised by these workshops.

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