CHAPTER 9

BENEFITS OF RESEARCH, LIMITATIONS OF STUDY AND FUTURE RESEARCH AVENUES

9.1 INTRODUCTION

The Chapter deals with the advantages spawned by this research work, the limitations seemingly experienced while working on this study and the future avenues of research to further the benefits of study.

9.2 BENEFITS OF RESEARCH

Exploration into practical aspects of any scientific phenomena, using systematic methodology, is termed as applied research and provides information and theories for their logical explanation. There are numerous benefits of research. It is used in industries to investigate the problems in quality and design of products/processes. As such, it is the backbone for the industrial growth and enhancement of quality in all the spheres of production. Besides, it is being increasingly used to solve complex business operational problems.

This study will go a long way in improving the reliability of metal-to-carbon relays by reducing their failures, thus enhancing the operational and safety performance of railway signaling systems. The benefits of this research to the society at large, Indian Railways in general and to the relay manufacturers in particular are enumerated in following sections.

9.2.1 BENEFITS TO INDIAN RAILWAYS

Metal-to-carbon relays are extensively used on Indian Railways and performance of these relays definitely impacts the train operations. This research work in the enhancement of the reliability of these relays shall be beneficial to Indian Railways in many ways.

(i) Improvement in train punctuality
The train movement is governed through railway signals, which are operated using metal-to-carbon relays. Poor reliability of these relays produces more number of signal failures, which in turn result in larger train detentions, causing the trains to lose their punctuality.

Indian Railways is engaged in continuous improvement in punctuality of train operations. Improved reliability of metal-to-carbon relays shall go a long way in preventing signal failures, thus minimizing disruptions to the train operations and increase the punctuality of trains.

(ii) Enhancement in train safety

Each signal failure is akin to accident and a potential source of disaster. During signal failure, the train movement is done in manual mode, which creates a possibility of human error, either through negligence or deliberation. This may consequently lead to train accidents involving loss of human life and destruction of property, and is totally undesirable.

Enhancement in safety of train operations is one of IR’s avowed aims. This research work shall enable to enhance the metal-carbon relays’ availability, thus maximizing the overall availability of signaling system. Hence, there shall be no need for resorting to manual operations, resulting in more safe train operations.

(iii) Minimization of financial loss

Any abnormal, out of course detention to train, causes wastage of scarce & costly assets such as locomotives, wagons/coaches, and track capacity. Poor equipment availability consequent to frequent equipment failures adds to this financial burden. More replacements of relays increase the inventory cost. Financial losses to Railways due to unjustified and frequent train detentions are a grave concern.

This research work shall enable the Indian Railways to make maximum usage of its operational assets, especially the signaling equipment, by minimize the needless train detentions. Full utilization of railway resources shall obviate the loss of precious railway revenue.
(iv) **Reduction in maintenance effort**

Frequent failures of signaling equipment like signals / points / track circuits demand recurrent attention for their continual functioning. This not only enhances the maintenance efforts unwarrantedly, but also adversely affects the normal maintenance work, as the staff is mostly engaged in the fire-fighting mode. Besides, due to repeated efforts, the signal equipment maintenance cost, in terms of manpower and material, also increases manifold.

In the interest of operational efficiency, the equipment maintenance efforts and costs should be reduced progressively. This research work shall decrease the maintenance efforts and costs, by providing better quality of metal-to-carbon relays, having longer operational life.

(v) **Customer relationship management**

Abysmal punctuality performance of passenger trains and delayed cargo are major sources of complaints on Indian Railways. The delays / cancelations / diversions, to a large extent, are a resultant of signal failures, caused especially by the poor quality of metal-to-carbon relays. These issues cause passenger grievances and are a big hindrance in maintaining good customer relations of Indian Railways.

With this research work, the quality of metal-to-carbon relays shall improve substantially, and this shall translate into lesser signal failures and lesser train detentions / cancelations. This will result in satisfied customers and eventually shall be a big boost to the image and customer relationship management of Indian Railways.

9.2.2 **ADVANTAGES TO SOCIETY**

Being a state owned carrier, the Indian Railways has a tremendous social responsibility, apart from its own commercial goals. Thus, it goes without saying that improvements to the performance of Indian Railways shall certainly positively affect the society in general.

(i) **Safer & punctual train journeys**
The society desires safe & punctual train journeys; this is the first and foremost requirement, and rightly so. The signals control the train movement, and although train accidents on account of signal gear failures are comparatively less, nevertheless, they need to be controlled. For this, it is imperative that the performance of signal gears, especially the metal-to-carbon relays should be improved.

The present research work shall enhance the reliability of metal-to-carbon relays substantially. This in turn shall reduce the signal failures drastically, consequently avoiding the unscheduled stoppages and unusual incidents; thus enhancing the punctuality and safety performance of Indian Railways.

(ii) **Reduction in public grievances**

Indian Railways is the largest public carrier and any detention to trains, resulting from poor reliability of relays, causes great miseries to the passengers as it disturbs their travel plans. Besides, the freight trains also frequently get diverted / delayed on this account. This creates unrest among rail users and generates a lot of criticism and grievances.

The signal failures will certainly come down, as the quality performance of metal-to-carbon relays will enhance with this research work. Thus, the passenger trains will become more punctual and the freight trains will also reach their destination within the assured time period. This will remove the cause for rail users complaints and augment customer satisfaction.

(iii) **Increase in number / availability of trains**

Consequent to ever-increasing population, there is an overwhelming demand for increase in the number of trains. A large number of signal failures restrict the sectional capacity to run trains and hence, more number of trains can’t be introduced. As a consequent, passengers are not able to travel as per their planned requirements and have to resort to unlawful means for fulfilling their travel needs.

The pioneering work done in this research shall certainly reduce the signal failures and eventually, shall enable railways to run more number of trains by fully utilizing the sectional capacity.
(iv) **Faster Trains (reduction in travelling time)**

With the upward growth of economy, the business community desires faster trains, so that the travelling time between business destinations is decreased. And this requirement is not only for passenger sector, but is valid for freight sector too.

High-speed trains require extremely reliable signaling system. Frequent and numerous signal failures kill the speed of the train, and mar the train drivers’ confidence in operating the train at high speeds. As the signal performance shall become more reliable consequent to the enhancement in quality of metal-to-carbon relay due to this research work, the speed potential of the train system shall drastically increase. This shall enable Indian Railways to increase the speed of trains, thus fulfilling the society’s demands for faster trains.

9.2.3 **PROFITS TO INDUSTRY**

The signaling equipment-manufacturing sector in general, and relay manufacturers in particular, are important stakeholders in the efficient management of train operations. They are an important partner to Indian Railways and play a major role in development of railway signaling technology. Thus, this research in the enhancement of performance of metal-to-carbon relays shall be equally vital for them, in terms of expanded business opportunities and increased personal and customer satisfaction.

(i) **Enhanced Equipment Reliability**

As a responsible and quality conscious industry, the metal-to-carbon relay manufacturers strive for the best performance targets for their product. For consistently first-class performance of these relays, it is not only necessary to improve the quality aspects, but also to enhance the overall RAMS (Reliability, Availability, Maintainability & Safety) performance by adopting new technologies and superior manufacturing processes.

Large number of relay failures reflects poorly on the quality assurance programs of the relay manufacturers. However, the High Contact Resistance phenomenon, which is the major cause of poor quality of metal-to-carbon relays, has not yet been studied in detail,
and hence, even with the most rigorous quality assurance procedures, the relays fail frequently in the field. By adopting the modified relay design as prescribed in this research work, the manufacturers would certainly be able to enhance the overall reliability of relays.

(ii) Mitigation of relay replacement costs
As a statutory requirement, it is the manufacturers' responsibility to replace the faulty relays within the warranty period. Besides, the manufacturers, as a goodwill gesture, replace some of the faulty relays, even when they are out of warranty period. Replacement of relays puts an additional and unwarranted financial burden on the relay manufacturers.

With the enhancement in reliability of metal-to-carbon relays, which this research work shall bring about, the requirement of frequent & numerous replacements of relays will come down drastically. Hence, the additional financial burden on the relay manufacturers shall be mitigated substantively.

(iii) Increase in Business Opportunities
Equipment reliability plays a vital part in enhancement of business and increasing the equipment proliferation. Better availability and low maintainability of equipment translates into increased business opportunities, as IR will certainly wish to implement only those products, which have high MTBF & low MTTR.

Due to their low MTBF, metal-to-carbon relays are not held in high esteem by the signaling department of Indian Railways. This research in the minimization of High Contact Resistance phenomenon shall increase the MTBF. This shall prompt Indian Railways to enhance the usage of these relays in signaling system, thus creating huge boost in the business opportunities for the manufacturers.

(iv) Enhanced customer satisfaction
Presently, the morale of Indian Railways, as a consumer of metal-to-carbon relays, is quite low, as there are large numbers of reliability issues with these relays. High levels of
customer dissatisfaction result not only into fewer business prospects and dwindling revenue, but also generate large number of grievances.

Adoption of modified relay design as promoted in this research work would certainly address the reliability issues presently plaguing these relays and make it substantially better quality equipment. This shall lead to greater satisfaction in Indian Railways, and shall translate into enhanced customer relationship management on the part of manufacturers and result in greater market penetration.

Thus, as can be seen from above discussion, there are multiple benefits from the research on the High Contact Resistance phenomenon in metal - carbon relays utilized for signaling purpose. This shall essentially enhance the reliability of these relays, which shall have large-scale advantages to all the stakeholders such as Indian Railways, society and relay manufacturers. As per the PEST (Political, Economic, Social, Technical) analysis, this research would be beneficial in all the fields such as commercial, socio-cultural, technical, and managerial.

Financially, Indian Railways shall be benefitted by reduction in relay replacement costs / maintenance efforts and enhanced resource utilization. The manufacturers shall get more business and save on replacement costs. Socially, the entire society shall enjoy safer & more punctual train journeys; the number of trains and their speed shall be greatly enhanced. On the technical front, this research shall provide a much-needed deep insight into the phenomenon of High Contact Resistance and help to develop high reliability relays. Managerially, the Indian railways shall enhance their customer relationship management with the rail users.

Thus, this research study shall engender the full bouquet of tangible and intangible benefits to all the interested parties and hence, is fully justified.

9.3 LIMITATIONS OF STUDY

Every research conundrum has numerous facets and multiple ways of tackling the problem. All the features and connotations of a research enquiry can’t be studied in entirety and there will always be some issues / aspects which remain unexplored. Thus,
every research study, no matter how thoroughly it is conducted, shall always have some shortcomings. Besides, the experiments may involve only a specific group of people, certain particular situations, or only some of the possible variables. Hence, the findings cannot be generalized to all the situations and this shall create limitations in the work. Thus, limitations are the shortcomings, conditions or influences that are beyond the control of researcher and which place restrictions on the research methodology and conclusions.

In the present research study of the metal - carbon relays’ reliability issues, particularly the High Contact Resistancesingularity, the following constraints were felt:

9.3.1 QUALITY OF RELAY FAILURE DATA

Relay failure details from all the sixteen zonal railwayswere studied. The failure information management system is not very well organized on Indian Railways and the compilation methodology and failure details collected vary widely over various zonal railways. The cause wise classification of failures is also diverse. This lack of uniformity adversely affected the accuracy and quality of data. Thus, there is a possibility of imperfections in the analysis of relay failures in this research study.

9.3.2 IMPERFECT RELAY FAILURESIMULATION

In order to study the failure mechanism of metal-to-carbon relays, the field conditions in which these relays work were simulated in laboratory. The relays were serially interconnected as per the logic of signaling circuit as is generally available in the field. However, this test set-up may not exactly mimic the field conditions, and due to this, the precision of test results could have been marginally flawed.

9.3.3 ANALYSIS OF OTHER TYPES OF METAL TO CARBON RELAYS

The metal - carbon relays are of many types, based on their usage, configuration, and AC immunization. There are more than twenty varieties of relays such as QN1, QNA1, QSPA1, QTA2 and many others. This research study was confined to QN1 type of relays, as they are the basic building block of signal interlocking and as such are most prevalent.
Thus, the research results may not be perfectly generalized for other type of metal-to-carbon relays.

9.3.4 CHEMICAL / METALLURGICAL ANALYSIS OF LIMITED SAMPLES

The chemical and metallurgical analysis of silver and silver impregnated graphite contacts was conducted on limited number of fresh & failed samples. This was because large numbers of failed samples were not available; besides, due to time constraints, it was not possible to analyze substantial quantity of samples. Consequently, a deeper study and holistic comprehension of the film formation mechanism in terms of its rate of formation, detailed formation process, and factors affecting the formation of film deemed restricted.

9.3.5 RELAY FAILURE DATA FROM OTHER COUNTRIES

Besides Indian Railways, these relays are used in signaling systems of other countries' railways such as United Kingdom, Singapore, Japan, Thailand, and Australia. This research study was confined to performance of metal-to-carbon relays on Indian Railways only. Hence, results of the research study would have been more inclusive if the relay failure data and failure mechanism from these countries was also taken into consideration.

9.4 FUTURE SCOPE OF RESEARCH

Every scientific research, while solving a problem, often gives rise to many new queries. These new issues, as well as some earlier unresolved ones, constitute the future latitude of study. It provides a beacon to the prospects / kind of work required on the subject. Besides, future scope of work, also aims to mitigate, if not fully, then substantially, the limitations felt in the contemporary research work.

In the current body of work, the experimental approach had largely been qualitative in nature, and was therefore restrictive. Laying equal or more emphasis on quantitative analysis in future works shall deliver a more universal understanding of the failure mechanism of metal-to-carbon relays. Additionally, the experimental test setup should be
made more realistic and closer to the actual field conditions, in which the metal-to-carbon relays work. The actual signaling circuits should be implemented to help understand the true modus operandi of the failure of these relays in a better way.

The future studies may be also be conducted by employing large numbers of used and failed samples of silver and SIG contacts, preferably from all the other types of relays. Chemical & metallurgical investigations of substantial number of samples shall lead to a larger analytical database. This shall certainly enhance the knowledge levels regarding the film formation process.

Besides, another avenue of future research on this subject is exploration of usage of other materials for the contacts. Any other combination of materials, like silver / tungsten or silver / copper flushed graphite, which are not readily amenable to formation of films on their surface, and are good electrical conductors, can be investigated for possible use as contacts. This shall favorably enhance the reliability of metal-to-carbon relays.

Another dimension regarding future work may involve acquiring the experiences of various other foreign railways regarding the reliability of metal-to-carbon relays, so that a more detailed study can be attempted.

Exploiting any or all of the aforementioned possibilities of future research shall certainly provide a better understanding of the subject matter of study and yield more substantial results. This may also alleviate some of the restraints envisaged during this work and go a long way in promoting the reliability of metal – carbon relays, and inter alia, the overall availability of railway signaling systems to the highest possible levels.

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