

## An Analysis of Awareness and Expectations of Industrial Entities with Respect to Rust Prevention Technique Using VCI Technology

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### Abstract

*Corrosion of machinery equipment's or parts is a major problem with the industry at large. Hence protective techniques are deployed by the manufacturing industry to prevent the corrosion. The purpose of this paper is to study about the level of awareness and usage of Volatile corrosion inhibitors (VCI) bags with respect to rust prevention for ferrous components. It also analyses the results after the trials were taken. Exploratory and experimental research is undertaken to study the stated purpose. For the study multi-stage sampling and snowball sampling techniques are used. The data collection is done with the help of structured questionnaire, and scheduling technique is also used. Findings reveal that traditional methods are still widely been used by many industries. VCI in the form of poly or paper provides long term protection to the ferrous components and majority of the customers opined that it is necessary to create awareness of VCI bags.*

**Keywords:** VCI, Rust prevention, Ferrous components.

### Introduction

Volatile Corrosion Inhibitors (VCIs) are also known as Vapour Phase Corrosion Inhibitors (VPCIs). The efficiency of VCIs depends on various factors such as adsorption ability on the metals surface, strength of adsorption, and dependence of vapor pressure on the temperature. However, the corrosion inhibition of numerous components of US military equipment by dicyclohexylammonium nitrite (DICHAN) in 1940s is being considered as first work on VCIs.

Ammonia and lower amines were used extensively for protection of metallic materials in power industry during 20th century. Many formulations were suggested which may protect ferrous as well as nonferrous metals. Thereafter, several VCIs have been developed and employed for inhibition of ferrous and non-ferrous metallic corrosion in their vapour phase.

### Economic Importance

Corrosion is a worldwide problem to be addressed by educational and industrial divisions because it unfavorably affecting the economy of developed as well as developing countries. GDP of India is also being greatly affected due to corrosion as it has been estimated that economic damage of India due to corrosion are Rs. 5,000,000. Nowadays, several

methods of corrosion anticipation are being employed that can reduce the damage caused by corrosion. The damage of corrosion is most pronounced during industrial cleaning processes such as acid descaling and acid pickling of metallic ores to remove the corrosion products collected on the metallic surfaces. During these cleaning processes a huge amount of metallic contents are lost because of corrosive nature of the cleaning media (acidic solutions) and therefore during these processes use of corrosion inhibitors is extremely anticipated. Organic compounds are most frequently utilized inhibitors among the several accessible methods of corrosion prevention such as like coating and painting, anodic and cathodic protections, alloying and de-alloying etc. The criteria behind their commercial uses are based on their easily availability, highly effectiveness and ease of application in addition to their economic synthesis using commercially available raw starting chemicals.

### Factors Affecting Corrosion

Corrosion is an inherent property of pure metals except silver, gold and platinum, and its rate largely depends upon the nature of surrounding environments. Obviously, an increase in the surrounding temperature results into corresponding increase in corrosion rate. Although, presence of organic inhibitors in corrosive acidic environment decreases corrosion rate, however nature of groups exerted most significant role on the inhibition effect of these inhibitors.

The electron releasing groups such as amino ( $-NH_2$ ), hydroxyl ( $-OH$ ) and methoxy ( $-OCH_3$ ) substituents increase the inhibition performance of the organic inhibitors as they increase the electron density at the active sites that favors metal-inhibitor interactions. In contrast, electron withdrawing groups like carboxyl ( $-COOH$ ), cyano ( $-CN$ ), ester ( $-COOC_2H_5$ ), nitro ( $-NO_2$ ) substituents decrease inhibition performance because they withdraw the electron density from the active sites that disprove the metal-inhibitor interactions.

Presence of humidity in the surrounding environment along with organic, inorganic salts as impurities enhances the probability and rate of corrosion because polar (water) and ionic species increase the ionic conductivity of the corrosive medium. Movement of the corrosive medium also plays a potential role of the corrosiveness of the aggressive solution.

### Methods of Corrosion Protection

Corrosion is an extremely destructive problem adversely affecting the economics of most of the developing and developed countries therefore its prevention is highly anticipated primarily during industrial acid cleaning and oil well acidification processes. Several methods of corrosion prevention have been developed depending upon the nature of metallic species and surrounding environments. The methods of corrosion protection can be broadly divided into three categories namely anodic protection, cathodic protection and mixed type of protection, depending upon the mode of action of the inhibitors.

Anodic inhibitors also known as passivating inhibitors those inhibit corrosion by retarding the anodic oxidation reaction through a process known as passivation. In the passivation process these inhibitors retard metal corrosion by adsorption and formation of surface oxide layer (passive) that results into large anodic displacement in the corrosion potential. Several anodic inhibitors have been reported as chromate, nitrite and nitrate those can form passive oxide layer on metallic surface in non-oxygenic environments. On the other hands, there are few other passivating inhibitors such as phosphate, molybdate and tungstate are known those can form passive layer in the presence of oxygenic environment only.

Cathodic inhibitors are chemical compounds those decrease the cathodic corrosion reaction or precipitates on the cathodic sites. The precipitation of the cathodic inhibitors results into sudden increase in the surface impedance because precipitated cathodic inhibitors reduce the rate of diffusion of chemical species responsible for corrosion.

Alloying and de-alloying of the metallic species can improve their corrosion resistance behavior. The use of organic compounds as inhibitors has gained the highest priority because these compounds are relatively economic, effective and can be derived from commercially available starting chemicals. Their high inhibition efficiency is based on the fact that they contain several adsorption centers in the form of polar functional groups and multiple bonds.

### Advantages and Disadvantages of VCIs

The VCI molecules have ability of vaporize and condense on the metallic surfaces in order to make them less prone to corrosion. The VCIs have several advantages:

- i. They can be inserted into adhesives, coatings, foams, powders, plastics and spray,
- ii. They can be employed into packaging to retard the corrosion of stored items,
- iii. They easily vaporize and their vapour moves quickly to cover the metallic surface and empty volume available for them until the saturation is established i.e. VCIs start their work once they are exposed to the environment,
- iv. Generally they fill all the surfaces including crevices, pores and cracks where ordinary inhibitors cannot penetrate,
- v. VCIs form very thin inhibitive film that can be easily removed without affecting the properties of metallic surfaces.
- vi. They can be used as corrosion protectors during the transport of metals and components. The VCI molecules can be used in several sectors such as in the military, nuclear and petrochemical plants, automotive industries, cultural heritage conservators, surgical equipment's, electronic components manufacturers and producers of high precision electronic materials because of their high tendency to adsorb on the metallic surface.

However, at the same time there are a few limitations of the VCIs such as sometime they increase the corrosion rate of non-ferrous metals and alloys.

### Literature Review

#### VCI Bags – Usage Instructions

It is very important when using VCI products is that the VCI vapours must be enclosed or encapsulated in some manner – the more airtight the package the more effective the VCI protection will be. This is not to say that the VCI bag must be completely sealed rather, the VCI bag can simply be folded over and kept closed with box flaps, or the VCI bag can be folded over and taped or stapled to keep it closed. So, unless the parts are going to be subject to a great deal of water spray, rain, etc., they will not be losing any VCI effectiveness by not completely sealing the VCI bag. (Benton Foundry)

Paper relates to a method of protecting metal surfaces from corrosion and to corrosion inhibitor com-Positions. It is a general object of this invention to provide a Novel method for protecting metal surfaces from corrosion involving the

use of a class of corrosion inhibitors whose unexpectedly superior corrosion inhibiting properties were discovered in the course of the experimental work leading to the present invention. . (Frank W. Pfohl, 1952,)

Here the author focusses on Volatile corrosion inhibitors (VCIs) or vapor phase inhibitors (VPIs) that represent a class of compounds that are employed to protect the corrosion or oxidation of ferrous and non-ferrous metals and alloys where other surface treatments are impractical. The VCIs release slowly inside the sealed airspace and actively adsorb and prevent corrosion. Several VCIs have been employed as effective inhibitors for several metals like iron, zinc, aluminium, etc. and their alloys. (F.A. Ansari, 2018)

In the paper a systematic research on a modified method was developed to evaluate the effectiveness of volatile corrosion inhibitor (VCI) materials was carried out. The experimental results conducted showed absolute alignment with results as calculated by specimen's mass loss for reproducibility of rust appearance and corrosion. The characteristic of the rust appearance based on different VCI formula is reveals that is very important in studying the mechanism of VCI and the synergism of chemical reagent. (Hong-jing, 2005)

A water resistant and vapour phase corrosion inhibitor Composite material for wrapping around metallic items for Protection and to reduce corrosion during Storage and transportation. The composite material comprises a high Strength, tear resistant, flexible Scrim, a low density layer impregnated with a Solid form vapour phase corrosion inhibitor, and a barrier layer to reduce the transmission of water, water Vapour, oxygen and other environmental gases through the Composite material. (Eric Henderson & Lorence, 1999)

## Research Methodology

Exploratory and Experimental research is undertaken to study the research questions. The primary data is collected through the survey method and also scheduling technique is used with the help of a structured questionnaire.

## Sampling Methodology

The area of study was restricted to Belgaum and Pune. The industrial areas covered under the survey were Udyambag, Bhosari, Chinchwad, Chakan, Kondhwa, Katraj and Warje. Multistage and Snowball sampling is employed to collect the data with sample size of the study of 25. The samples were collected from the various manufacturing industries such as machining centres and foundries.

## Objectives of the Study

- To learn the usage techniques of VCI products.
- To create awareness of VCI products usage for ferrous, non-ferrous and alloy components.
- To evaluate the results after usage of VCI products.

## Data Collection

Two methods are used to collect the relevant data pertaining to study:

1. **Primary Data:** Data is collected to obtain desired information through Structured Questionnaire and also informal interview from senior officials were taken.
2. **Secondary Data:** Data is collected through foundry cluster, journals, brochures, and internet.

**Limitations of the Study**

There are a few limitations of the study that may arise. They are as follows:

- Niche segment of VCI bags.
- The study was restricted to Belgaum and its vicinity area only
- Stereotyping – There is chance that some people might have misunderstood or misinterpreted questions and given wrong feedback in spite of explaining them.

**Test of Reliability (Cronbach's Alpha)**

**Reliability Statistics**

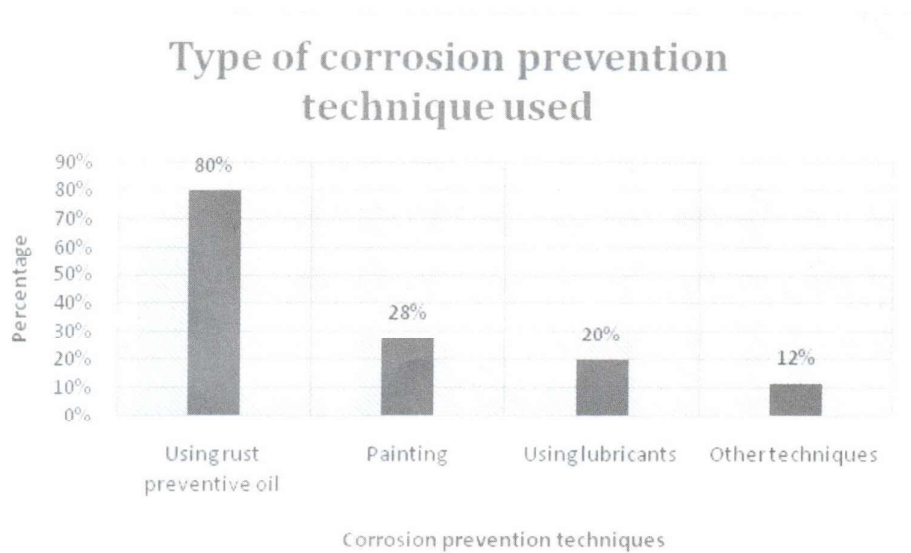
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.759	776	6

Six items were used to measure the effectiveness, economy, awareness, moisture prevention, and convenience of using VCI bags, had a validated reliability measure of 0.759 Cronbach's Alpha which is supported by Devillis (2003) who stated that Cronbach's Alpha co-efficient of a scale should be above 0.7. Hence, items in the study are reliable.

**Data Analysis and Interpretation**

1. Type of corrosion prevention technique used

**Figure 1. Bar Graph illustrating Types of Corrosion Prevention Technique used in Percentage**



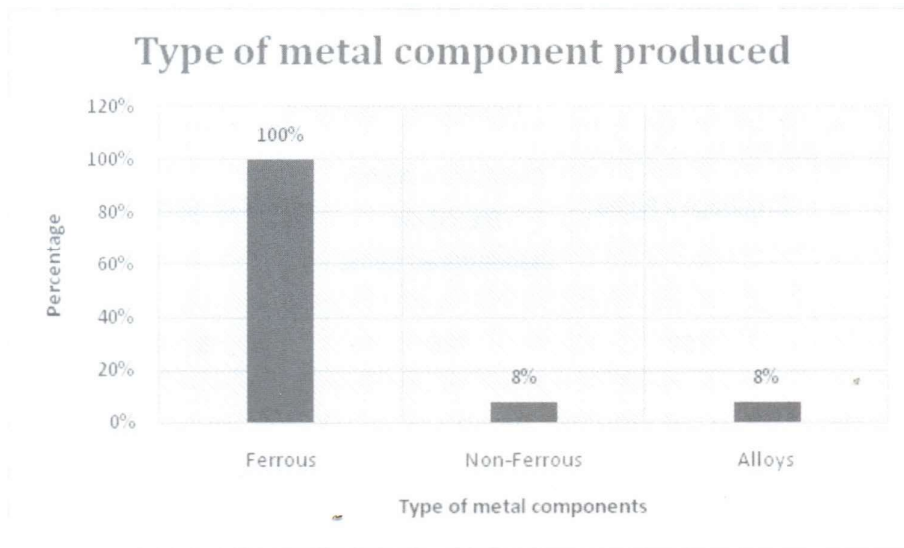
Source: Field Survey

**Interpretation**

From Figure 1, it can be seen that 80% respondents use rust preventive oil to prevent their metal components from rust. 20% of people use lubricants to protect their components. 28% prefer painting method to their metal components to avoid corrosion. 12% of chosen sample use some other method such as packing in LDPE bags, powder coating, anodizing, electroplating and so on.

**2. Type of metal component produced**

**Figure 2. Bar Graph illustrating Type of Metal Component Produced in Percentage**



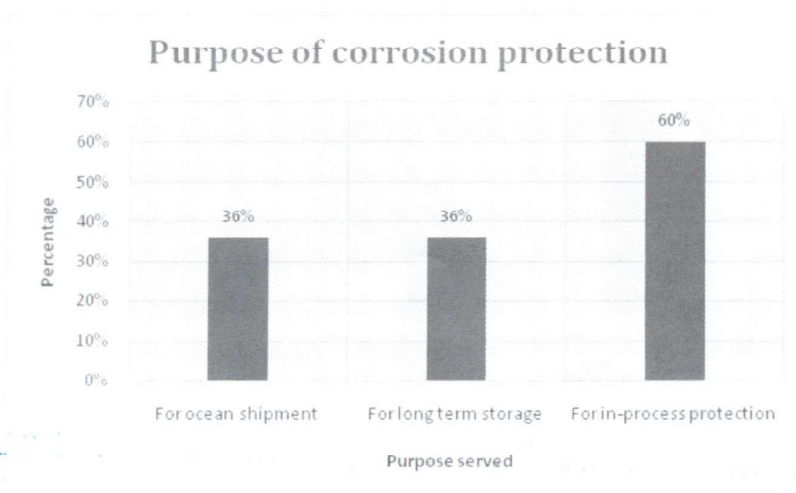
Source: Field Survey

**Interpretation**

From Figure 2, almost all the sample customers contributes 100% level of producing ferrous components in which majority are Iron, Steel and Cast Iron. 8% of the people are in manufacturing of non-ferrous components which are made up of Aluminium, Copper, Lead and Zinc. Another 8% of the customers produce their components which consists of alloys such as Bronze and Brass.

**3. Purpose of Corrosion Protection**

**Figure 3. Bar graph illustrating Purpose of Corrosion Protection in Percentage**



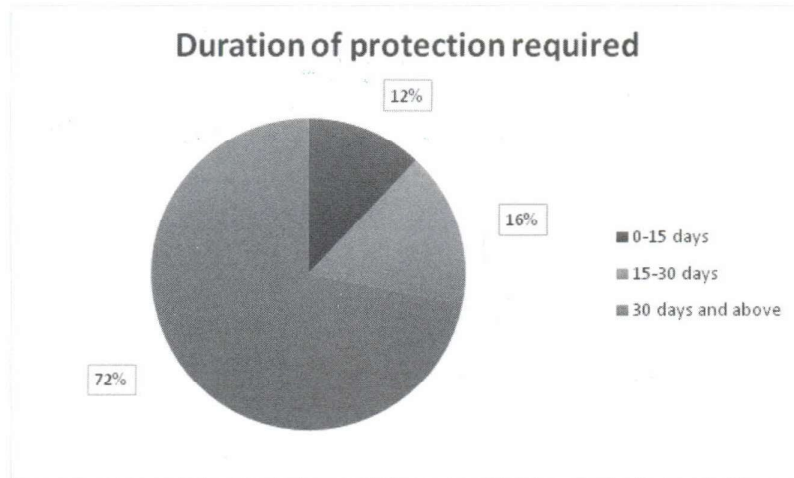
Source: Field Survey

**Interpretation**

From Figure 3, it is observed that 36% of the customers serves the purpose of corrosion protection for ocean shipment. Another 36% customer requires corrosion protection for long-term storage purpose. Majority i.e. 60% of customers utilizes corrosion protection for in-process protection.

**4. Duration of Protection Required**

**Figure 4. Pie chart illustrating Duration of Protection Required**



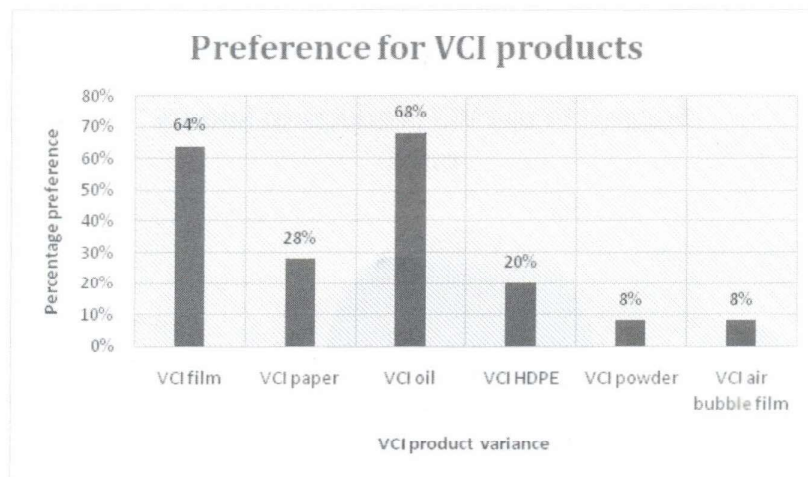
Source: Field Survey

**Interpretation**

From Figure 4, it can be clearly observed that 72% of the customers require duration of 30 days and above for their metal component protection. Other 16% require 15-30 days of protection for their products. Another 12% require protection duration of 0-15 days. Protection required for products to be exported is 30 days and above that ranges from minimum of 45 days to maximum of 180 days.

**5. Preference for VCI Products**

**Figure 5. Bar Chart Showing Preference for VCI Products in Percentage**



Source: Field Survey

**Interpretation**

From Figure 5, we can say that VCI oil is preferred by maximum sample people contributing 68%, followed by VCI film which has second highest contribution of 64%. VCI paper preference is 28% which is majorly required for gear manufacturing and tool manufacturing companies from the sample. 28% preference is given for VCI HDPE by the sample customers. The equal share of 8% is preferred by some of the customers for VCI powder and VCI air-bubble film each.

**6. Extent to which VCI Products are Required**

**Figure 6. Pie Chart Indicating extent to which VCI Products are Required in Percentage**

**Extent to which VCI products are required**



Source: Field Survey

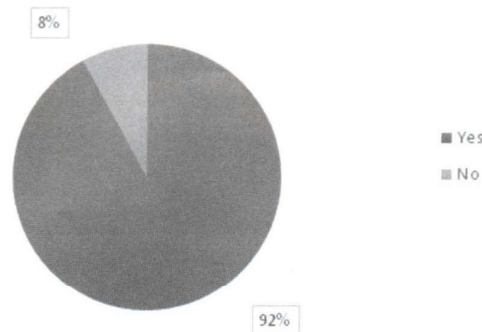
**Interpretation**

Figure 6 illustrates extend to which VCI products are required where 88% sample customers can use only for their few components. The requirement of VCI products for all the manufactured components is only 8%. The remaining 4% of the sample customer does not require VCI products at all.

**7. Suggest to use VCI Products to Known ones**

**Figure 7. Pie Chart illustrating Suggestion to use VCI Products to Known Ones**

**Suggest to use VCI products to known ones**



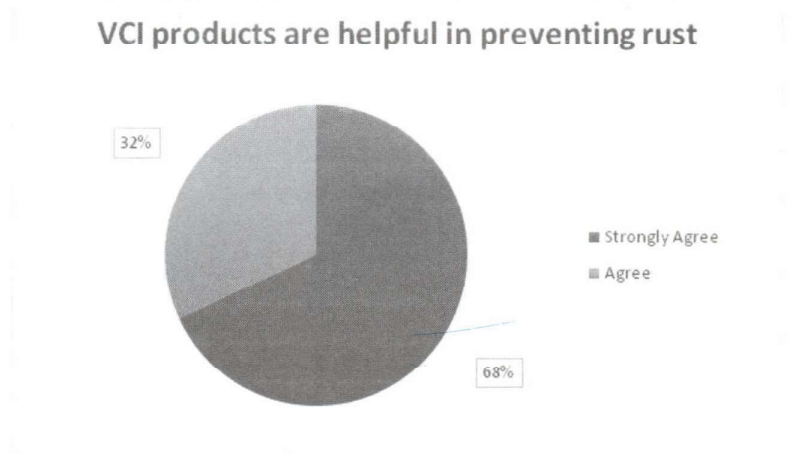
Source: Field Survey

**Interpretation**

From Figure 7 it can be observed that many favoured in response to suggest use of VCI products to known ones comprising to 92% and remaining on negative side. This indicates that more and more awareness can be created by one way i.e. by suggesting to use VCI products to known ones.

**8. VCI Products are Helpful in Preventing Rust**

**Figure 8. Pie Chart indicating VCI Products are Helpful in Preventing Rust in Percentage**



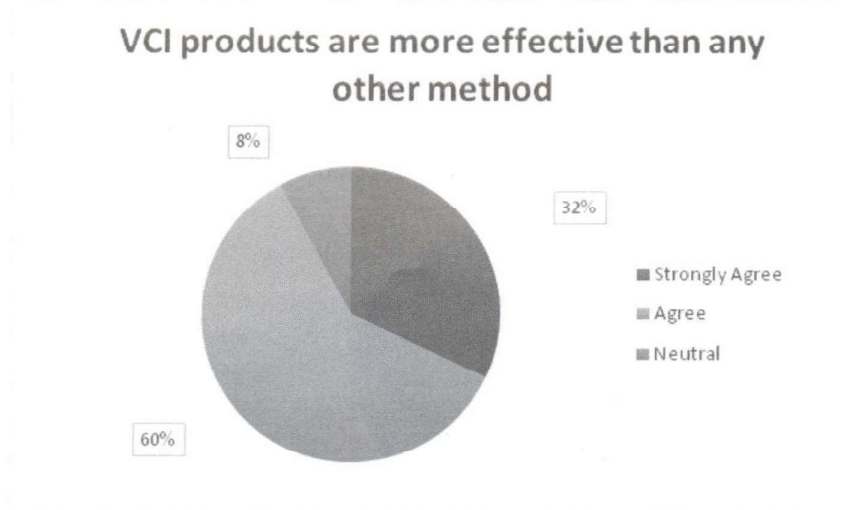
Source: Field Survey

**Interpretation**

From Figure 8, it is clearly observed that 68% of the sample customers are strongly agree and 32% of them are agree with respect to VCI products which helps in preventing rust. There is no any disagreement seen from the sample customers for the said statement.

**9. VCI Products are More Effective than any other Methods.**

**Figure 9. Pie Chart Showing Effectiveness of Using VCI Products over other Methods in Percentage**



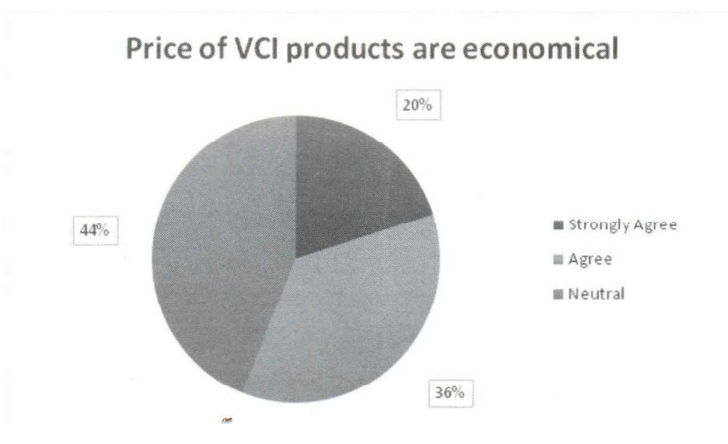
Source: Field Survey

**Interpretation**

After the trials were taken of VCI products the sample customers were satisfactorily happy on the effectiveness after using these products over other methods. From Figure 9, nearly 32% of the sample customers are strongly agree on the effectiveness of VCI products and 60% are agree. The remaining 8% of the people found out the effectiveness of VCI products to be OK and has given neutral as their feedback.

**10. Price of VCI Products are Economical**

**Figure 10. Pie Chart Representing Price of VCI Products are Economical in Percentage**



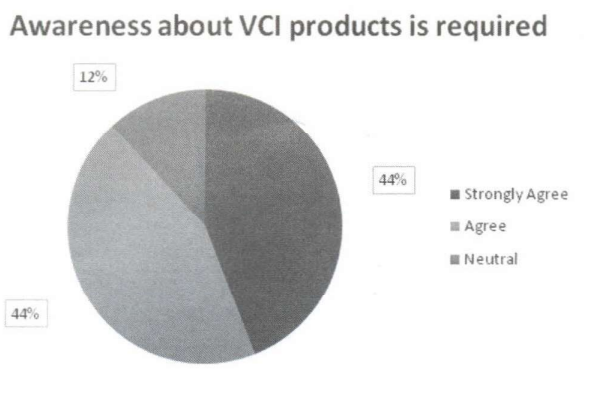
Source: Field Survey

**Interpretation**

A very crucial part regarding VCI products is about pricing. Price ranges from product to product. From Figure 10 it is observed that 44% of the sample customers have given response such that they are neither fully agree nor disagree. They found the pricing is reasonable and hence recorded their response as neutral. 36% of people has reverted on agree side whereas the rest 20% marked their response as strongly agree towards the price of VCI products which are being economical.

**11. Awareness of VCI Products is Required**

**Figure 11. Pie Chart Showing Requirement of Awareness of VCI Products in Percentage**



Source: Field Survey

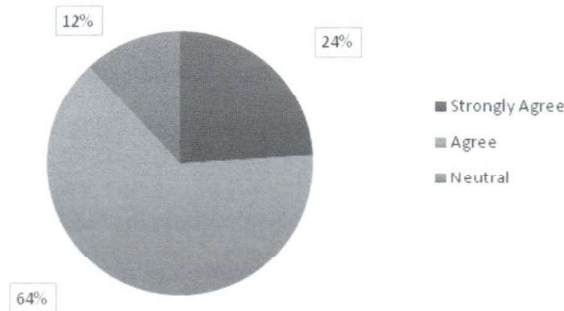
**Interpretation**

This statement satisfies the primary objective of this research work as it is clearly observed from Figure 11 shown above that total of 88% sample customer recorded their agreement level in which 44% people are strongly agree and rest 44% agree to the statement that awareness about VCI products is required. The remaining 12% people registered their view as OK and has marked their opinion as neutral.

**12. VCI Products provides Moisture Barrier in Addition to Corrosion Inhibitor**

**Figure 12. Pie Chart Indicating VCI Products providing Moisture Barrier in Addition to Corrosion Inhibitor in Percentage**

VCI products provides moisture barrier in addition to corrosion inhibitor



Source: Field Survey

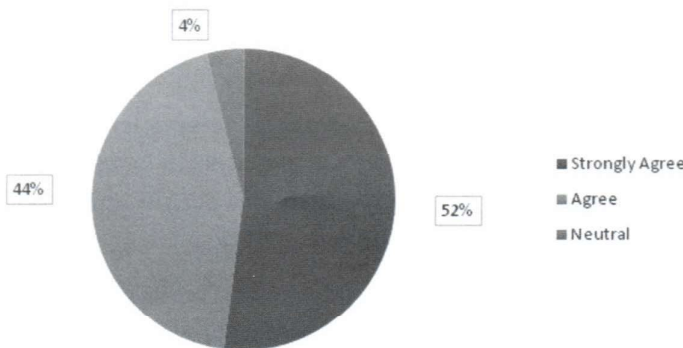
**Interpretation**

From Figure 12 we find that agreement level shown by the sample customers is 88% in which 64% contribution of the customers is towards agree and 24% is towards strongly agree. 12% of the customers have submitted their response as OK and recorded opinion as neutral to the statement of VCI products provides moisture barrier in addition to corrosion inhibitor.

**13. VCI Products are Convenient to use**

**Figure 13. Pie Chart Reflecting Convenience of VCI Products to use in Percentage**

VCI products are convenient to use



Source: Field Survey

## Interpretation

Figure 13 shows convenience to use VCI products. 52% of the sample customers are strongly agree towards the statement and those of which 44% are agree while recording their opinion. The rest of the customers are satisfactory towards the convenience of VCI products to use and they contribute only 4% in their neutral response. Thus, this statement helps in proving that VCI products can be used easily without any harm as they are eco-friendly.

## Major Findings

- During the study, it was found that majority of the manufacturing industries use rust prevention oil, followed by painting and lubricants.
- Most of them opined that, they want long term rust protection (more than 30 days)
- Everybody agreed that they would like to suggest this technology to acquaintance.
- All of them were agreed that VCI bags are helpful in preventing rust.
- Most of the chosen population agreed that rust prevention using VCI technology is better than any other method.
- More than 90% of the respondents said that, it is necessary to create awareness of VCI bags.
- It was agreed that VCI bags provides moisture protection along with rust prevention.
- Findings of the study reveal that, VCI bags are convenient to use.

## Recommendations from the Study

- To participate in industrial exhibitions such as Pack Plus India, Pro-Pack India so as to enhance the promotional activity.
- To conduct seminars by inviting major group of companies from Indian Institute of Foundry-men by targeting various chapters of it such as Belgaum, Kolhapur, etc. which will help them to get more and more enquiries for their products as packaging is a major concern for many manufacturing companies nowadays.
- To increase the dealership network in major industrial hubs in the states like Karnataka, Telangana, Andhra Pradesh, Madhya Pradesh, and Haryana which will help in improving distribution channel.
- To work on 5S activity and also to conduct 5S audit so as to improve productivity.

## Conclusion

During the study, it was noticed industrial owners were eager to learn, try and accept new ideas and appreciating the work of apprentice while some were rigid, uncooperative and hesitant to adopt new technology, which helped in understand different leadership styles and qualities. Experts took sole decision to use/not to use VCI products and also experts who had to address their seniors for decision making.

In the research project, most of the selected samples showed positive response for creating awareness about VCI products. Most of them agreed that usage of VCI products helps in preventing rust in the long run and have agreed to prefer and use VCI products over traditional method.

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