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NON-CARCINOGENIC VCI SOLUTION FOR LONG TERM METAL PROTECTION

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Abstract— ***Corrosion is a dangerous and extremely costly problem. Because of it, buildings and bridges can collapse, oil pipelines break, chemical plants leak, and bathrooms flood. Corroded electrical contacts can cause fires and other problems, corroded medical implants may lead to blood poisoning, and air pollution has caused corrosion damage to work around the world. Corrosion threatens the safe disposal of radioactive waste that must be stored in containers for tens of thousands of years. When reduction and oxidation take place on different kinds of metal in contact with one another, the process is called galvanic corrosion. In electrolytic corrosion, which occurs most commonly in electronic equipment, water or other moisture becomes trapped between two electrical contacts that have an electrical voltage applied between them. The result is an unintended electrolytic cell. VCI is the generic term for "volatile corrosion inhibitor" a revolutionary technology that simplifies corrosion protection and is ideal for keeping enclosed void spaces (e.g., packages, equipment internals, or structural metal cavities) rust-free.***

Keywords: Corrosion; VCI; Rust.

1. INTRODUCTION

In industries where metals are exposed to corrosive environments, ensuring long-term protection against corrosion is paramount. Volatile Corrosion Inhibitors (VCIs) have emerged as a vital solution in safeguarding metals from degradation over extended periods. However, with growing concerns over health and environmental safety, the demand for non-carcinogenic VCI solutions has escalated. These solutions offer effective corrosion protection while mitigating risks associated with carcinogenic compounds, thereby aligning with stringent regulatory requirements and sustainability goals. This introduction sets the stage for exploring the characteristics and benefits of non-carcinogenic VCI solutions in preserving metal integrity over time.

2. RAW MATERIALS DESCRIPTION

2.1 LDPE Granules

LDPE stands for Low-Density Polyethylene, which is a type of thermoplastic polymer. LDPE granules refer to small, granular particles of LDPE material. LDPE is commonly used in the production of various plastic products due to its flexibility, transparency, and chemical resistance. LDPE granules can be melted and molded into various shapes using techniques such as injection molding, blow molding, or extrusion, making them versatile for a wide range of applications such as packaging films, bottles, containers, and more.

2.2 LLDPE Granules

LLDPE stands for Linear Low-Density Polyethylene, which is another type of thermoplastic polymer similar to LDPE but with some distinct differences in its molecular structure and properties. LLDPE granules refer to small, granular particles of LLDPE material.

LLDPE is known for its higher tensile strength, puncture resistance, and better environmental stress crack resistance compared to LDPE. These properties make LLDPE suitable for applications where toughness and durability are important, such as in the production of heavy-duty bags, agricultural films and flexible packaging.

Similar to LDPE granules, LLDPE granules can be melted and moulded into various shapes using techniques like injection moulding, blow moulding, or extrusion.

2.3 VCI Granules

VCI stands for Volatile Corrosion Inhibitor. VCI granules are small particles infused with chemicals that vaporize and form a protective layer on metal surfaces to prevent corrosion. These granules are often used in packaging applications where metal components or products need to be protected during storage or transportation.

When VCI granules are placed in the packaging with metal items, the volatile corrosion inhibitors evaporate and form a protective molecular layer on the metal surface. This layer acts as a barrier, preventing moisture and other corrosive elements from coming into contact with the metal, thus inhibiting corrosion.

VCI granules are commonly used in industries such as automotive, aerospace, electronics, and manufacturing where corrosion protection is essential for preserving the integrity and functionality of metal parts and components. They can be used in various forms such as bags, pouches, foam inserts, or incorporated into packaging materials like LDPE or LLDPE films.

2.4 Color Master Batch

A color master batch is a concentrated mixture of pigments or dyes dispersed in a carrier resin, typically a thermoplastic polymer. It is used in the plastics industry to add color to plastic products during the manufacturing process. Master batches offer advantages such as ease of use, consistency, flexibility, and cost-effectiveness. They are widely used in various industries for coloring plastic products like films, bottles, automotive parts, and household appliances.

2.5 Micrometer or Thickness Gauge

A specialized thickness gauge designed for films is typically used to measure the thickness of LDPE (Low-Density Polyethylene) film accurately. These gauges are calibrated and optimized for measuring thin films and may include capacitance gauges, beta gauges, ultrasonic gauges, or mechanical gauges. When selecting a thickness gauge for LDPE film, factors such as accuracy requirements and ease of use should be considered. It's essential to ensure that the gauge is properly calibrated and suitable for the thickness range of LDPE films being measured.

3. WORKING

3.1 Working principle

In the extrusion process, a combination of LDPE granules, colour master batch, and VCI granules is carefully fed into the hopper. The mixture undergoes controlled heating and is then extruded, taking the shape of a balloon. This method enables the creation of a desired form with specific material properties. Low-Density Polyethylene (LDPE) blown film extrusion is a manufacturing process used to produce thin plastic films. LDPE resin is melted and then extruded through a circular die, forming a tube. Simultaneously, air is introduced, inflating the tube into a bubble. The bubble is then cooled and collapsed, creating a flattened film. LDPE blown films are known for their flexibility, transparency, and moisture resistance. Common applications include packaging materials like bags and wraps. This cost-effective and versatile process is widely employed in the plastic industry to meet the demand for various LDPE film products.

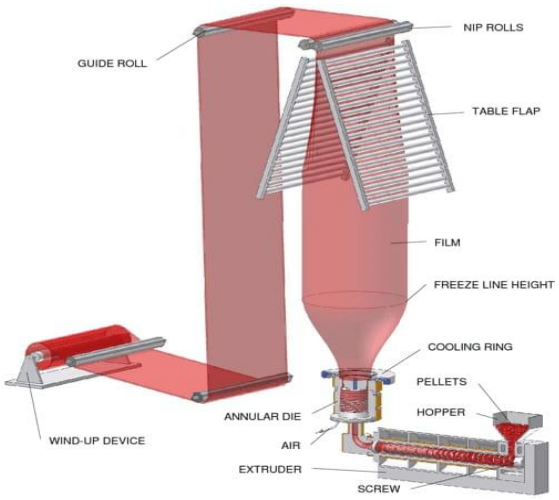

Fig.1 *Extrusion Process*

LDPE blown film extrusion is a process used to produce plastic films. It involves melting LDPE resin pellets in an extruder, then forcing the molten plastic through a circular die to form a bubble. The bubble is inflated with air, cooled, flattened, and wound onto rolls to create thin LDPE films used in packaging, agriculture, and construction.

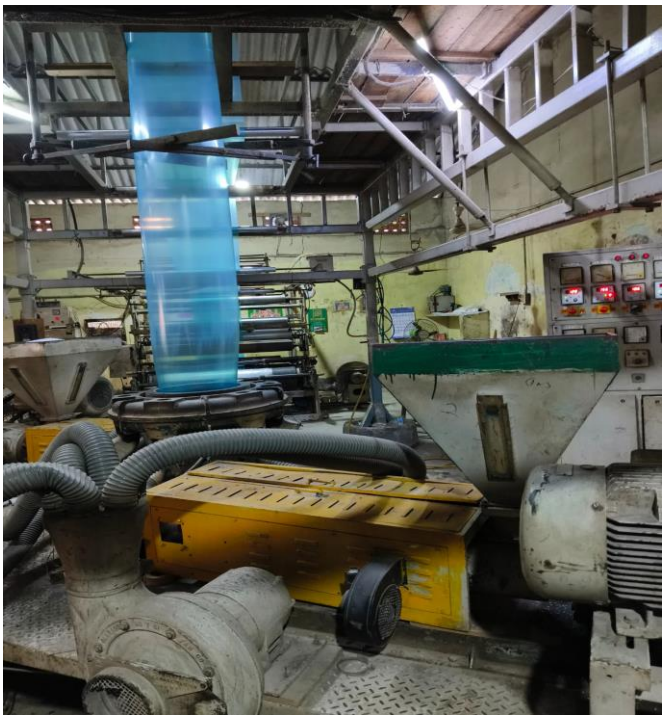

Fig.2 *Blown Film Extrusion Machine*

3.2 Construction

The key components of an LDPE blown film extrusion machine listed succinctly;

Extruder: Melts LDPE pellets;

Die Head: Shapes molten polymer into a tube;

Air Ring: Cools and solidifies the tube;

Cooling System: Provides additional cooling;

Nip Rollers or Collapsing Frame: Collapses the tube;

Winder: Winds the flat film onto rolls;

Control System: Monitors and adjusts parameters.

3.3 Working procedure

Material Preparation- LDPE, LLDPE, VCI & Colour master batch resin pellets are loaded into the hopper of the extruder.

Melting and Mixing- The pellets are heated and melted inside the extruder barrel through friction, mechanical shearing, and external heating elements. This creates a homogeneous melt.

Extrusion-The molten pellet is forced through a circular die at the end of the extruder, forming a continuous tube of plastic

Bubble Formation-As the hot plastic emerges from the die, it is drawn upwards and inflated by air blown into the centre of the tube, forming a bubble.

Bubble Cooling-The inflated bubble passes through a set of cooling rollers or a water-cooled tower to gradually cool and solidify the LDPE film.

Bubble Collapse-Once the film has cooled sufficiently, the bubble is collapsed using nip rollers, flattening the tube into a two-dimensional film.

Film Thickness Control-The film thickness is controlled by adjusting the extrusion rate, air pressure, and by varied temperatures.

Winding-The cooled and flattened LDPE film is wound onto rolls for storage or further processing.

Quality Control-Throughout the process, various quality control measures such as thickness measurement, visual inspection, and testing for properties like tensile strength and clarity are conducted to ensure the film meets specifications.

Trimming and Finishing-Any excess material or irregularities are trimmed from the edges of the film, and the rolls are labelled and packaged for shipment or storage.

4. EXPERIMENTATION & RESULTS

Fig.3 *Temperature display board*

These are the 6 different thickness measured for 6 different temp. using a thickness measuring scale.

Temperature	Thickness
128	76
156	77
186	78
189	79.2
203	80

Table 1: *Results based on the six thickness based trials conducted on LDPE Blown Film.*

Fig 4: *Real test readings pictures*

	TEST VALUES			
	PARAMETER	UNIT	STD. VALUE	RESULT
1	Thickness	Mic.	100 (+ / - 5)	98 to 103
2	Width	Inch	1250 (+/-1%)	1250 to 1255
3	Corrosion test	-	SP-VCI-08	Passes
4	Color	-	Std Yellow	Yellow

Table 2*: Results based on the corrosion test conducted on LDPE blown film*

Conducted a corrosion (Cyclic test) test with LDPE blown film which was manufactured in the blown film extrusion machine. The product passed the corrosion test giving desired results. Test results are shown in the above mentioned Table 2.

5. CONCLUSION

Comprehensive testing of the non-carcinogenic VCI solution for long-term metal protection has yielded promising results across cyclic, salt spray, tensile, and tape tests.

The solution has demonstrated exceptional efficacy, compatibility with our products, and durability, making it a reliable choice for industries seeking sustainable corrosion protection methods.

With its proven resistance to corrosion & environmental factors our VCI solution stands as a testament to our commitment to innovation and environmental stewardship.

Moreover, its non-carcinogenic nature aligns with our commitment to safety and health standards, ensuring peace of mind for both users as well as the environment.

As we continue to advance in sustainable solutions, our non-carcinogenic VCI stands as a beacon of progress in the realm of metal protection.

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