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THE IMPACT OF POLYMERIC ADDITIVES (COLOUR) RATIO IN THE PRODUCTION OF IMPORTANT PLASTIC PRODUCTS

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ABSTRACT

High level of scientific data collection by direct recording and statistical analysis was deployed to actually determine the appropriate mixing ratios of the masses of base material virgin polymeric material and the colour additives master batches in the production of various plastic products. At each interval, production of the plastic products are detailed by measurable parameters of masses, the machines operational conditions were reasonably adjusted for maximum performance and these data's were finally evaluated. It is observed that a unit of 10L plastic gallon has values for the master batch additive at 80.68g, when added to 710g mass of the virgin HDPE when blown into a unit finished product. The High quality plastic Executive Hangers produced has a mixing texture (M_t) value of 88363.636 $gm^{-1}min^{-1}$ when 0.64g of colour additive is mixed with 80g of the virgin HDPE with base material yielding two pairs of the Executive Hangers from the 180 tons injection machine of plastic workshop of SEDI ENUGU NASENI. These elevated mass of the additive in the 10L gallon has been attributed to the nature of the production method of blow moulding, thorough mixing and blending. This was achieved before the pressure of 20bars are blown into the mould to form the desired shape of the product. Unlike the 180 tons Injection moulding machine which injects the melted mixture into the mould cavity through injection pressure from the turning hot screws from the barrel. However, at each interval of production process, adequate instrumentation was done to determine these relative important production parameters.

Keywords: Master Batch Ratios, Plastic Products, Polymeric Materials, Aesthetics, Performance Enhancement.

I. INTRODUCTION

Polymeric materials create a versatile substrate for innovation by offering a wide range of properties responsive to various applications. Pucci et al. (2020), thorough selection and operation of polymeric constituents that play a crucial role in outlining the performance and aesthetic attributes of plastic products. Master batches, pigments, additives, and carrier resins, function as catalysts for innovative transformations by empowering manufacturers to excellently tune properties with precision (Gupta & Kandasubramanian, 2018). The mechanisms governing pigment dispersion within polymeric matrices, explaining how variations in master batch composition impact color consistency and vibrancy Rong et al. (2019). It was confirmed that there exist a robust relationship between master batch ratios, aesthetics, and performance enhancement in plastic product production. Furthermore the work of Lee et al. (2021) emphasizes on the importance of optimizing mechanical properties through master batch formulation by highlighting the role of additives in enhancing strength, flexibility, and impact resistance. Beyond aesthetics, the objective of performance optimization encompasses a diverse array of considerations spanning from environmental sustainability to functional durability. The research conducted by niu et al. (2019) underscores the pivotal role of UV stabilization in polymeric materials, elucidating how additives within master batches can ameliorate degradation and extend product lifespan in outdoor applications. Advancements in thermal management underscore the potential of master batch engineering to augment heat resistance and dimensional stability in high-temperature environments, as articulated by Zhang et al. (2022). It is this background that we confined this study to the use of selected base polymeric material which we use in the production of important plastic products such as the 10L gallon, sizeable high quality executive hanger, magnifying lens handle, 10L cap and plastic bowel and various virgin polymeric material such as HDPE, PP,PS,LDPE, LLDPE and GPPS.

Fig 1:

SEDI-ENUGU EXECUTIVE HANGERS

The executive plastic hanger is a high quality, durable hanger designed to support heavier and more delicate clothing items such as suits, jackets, coats, and formal wear. These hangers are often used in retail settings, upscale wardrobes, and by dry cleaners to provide a more refined presentation and better protection for garments. It has a wide shoulder to maintain the shape of jackets, coats and suits its hook even though if fixed to avoid a 360-degree rotation, it is also designed to have notches at the base frame for hanging skirts or garments with straps. It has a polished appearance that enhances the overall look of the closet. It has a unit mass of 0.2 kg (200 grams) made from different polymeric materials such as HDPE, PE, PS, GPPS.

Fig 2:

SEDI-ENUGU 10 LITRE JERRY CAN CAP

The cap of 10-liter jerry can is a vital component that ensures the secure closure and containment of liquids stored within the can. The mass of SEDI-Enugu 10-liter jerry can cap weighed 0.095 kg, or 95 grams and is typically threaded to securely seal the opening of the can. It has features like the tamperproof or seal to prevent leakage, easy dispensing and evaporation of the stored liquid. This Jerry can caps are commonly produced from materials such as polyethylene (PE), polypropylene (PP), or high-density polyethylene (HDPE).

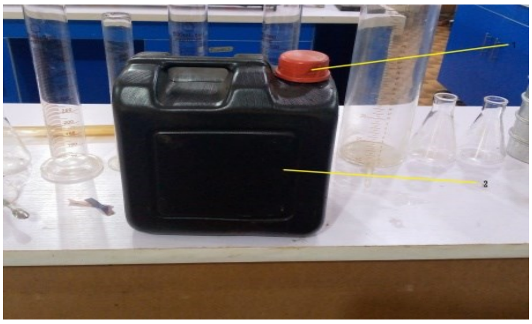

Fig 3:

SEDI-ENUGU 10LITER JERRYCAN

This 10-liter jerry can is a robust container designed for the storage and transportation of liquids such as water, fuel, or chemicals having weight of 500grams. This was made from high-density polyethylene (HDPE) blow or similar durable plastic materials, these containers feature a sturdy construction to withstand rugged environments and harsh handling

Fig 4:

SEDI-ENUGU HANDLE OF MAGNIFYING LENS

This is made from durable plastic materials such as pp. injection. These handles are designed to enhance user experience during tasks such as reading, crafting, or examining small objects through the magnifying lens. In the manufacturing process, injection moulding stands as the predominant process for producing plastic handles where it solidifies to form the desired handle shape. This process involves cost-effectiveness, scalability, and ability to achieve intricate geometries.

Fig 5:

SEDI-ENUGU PLASTIC BOWEL

This was blowned into this shape by the 6ft blowing machine with a one cavity mould into the desired shape. The additive colour was red which was blended homogeneously with the virgin material. It has diameter of 12inches, with thickness 3mm, with volume capacity of 1litre and highly elastic. It was made with HDPE but can also be blown with other polymeric materials such as PE, PS and GPPS, it is mostly used for a variety of purposes in the kitchen.

MATERIALS AND METHOD

The virgin materials used in this work were sourced from Plastic production unit SEDI, the weighing balance is of high precision and of a range of values between 0-2000g. The production machines used were 6ft blow moulding machine, 180 tons injection moulding machine, virgin HDPE, Virgin polyethylene, virgin

The general formula for the determination of the mixing texture

$$M_t = \frac{m_v + m_a}{m_a} X \frac{MFi}{ȶ}$$

Where,

M_t is the mixing texture in grams per meter per 3mins

M_v is the mass of the virgin material in grams,

M_a is the mass of the additive in grams

ȶ Thickness of the products in meters

MFi is the melt flow index of the virgin polymeric material in g/3min

Considering the data and information's given in Table1 where HDPE polymeric material was used in the 180 tons Injection moulding machine to produce the Executive Hangers where m_a= mass of additive blue colour used in the production of one executive hanger, the value of M_a=0.64g, mas of the virgin HDPE used m_v is given by 80g, the thickness ȶ in mm is 5mm, then substituting the values in the equation for determining the mixing texture M_t $= \frac{0.64+80}{0.64}$ x $\frac{3506.4935}{5}$ by evaluating the relation we have M_t = 88363.635 ($gm^{-1}min^{-1}$).

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II. RESULTS AND DISCUSSION

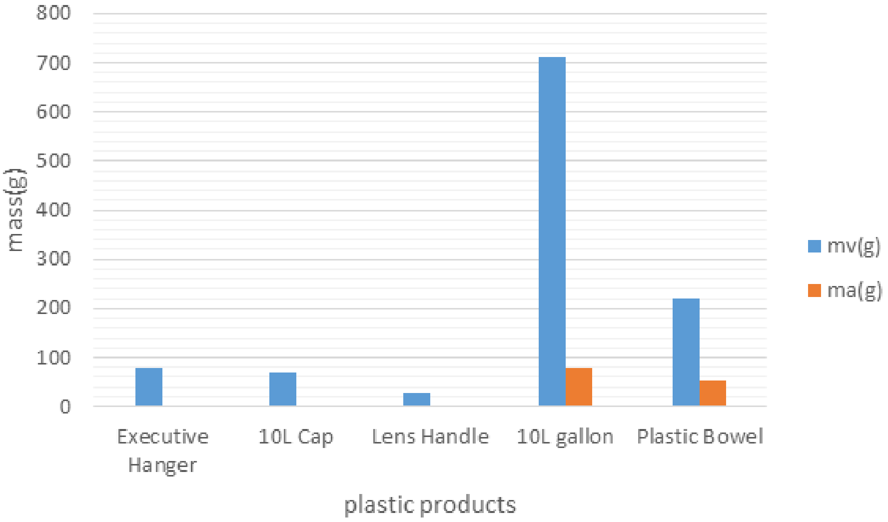

Fig 6: Showing the chart of the masses of the Virgin HDPE material and color additives used with mixing ratios used in the production of plastic products.

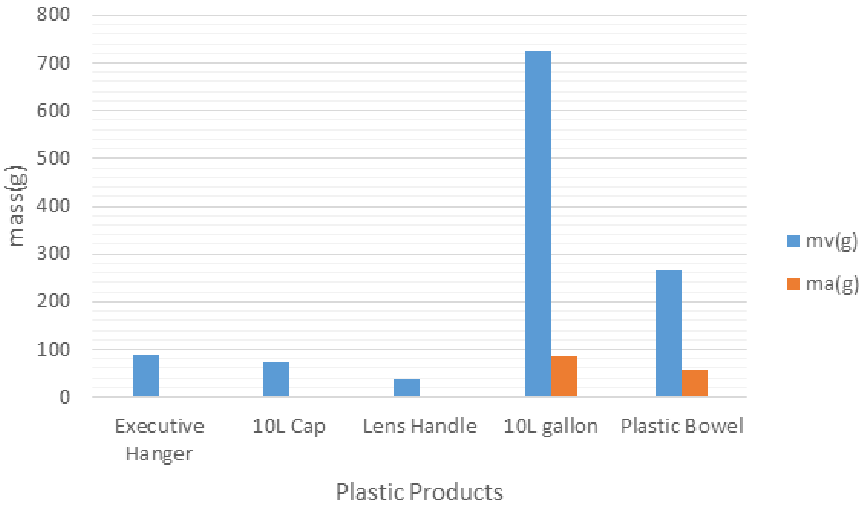

Fig 7: Showing the chart of the masses of the Virgin PP material and color additives used with mixing ratios used in the production of plastic products.

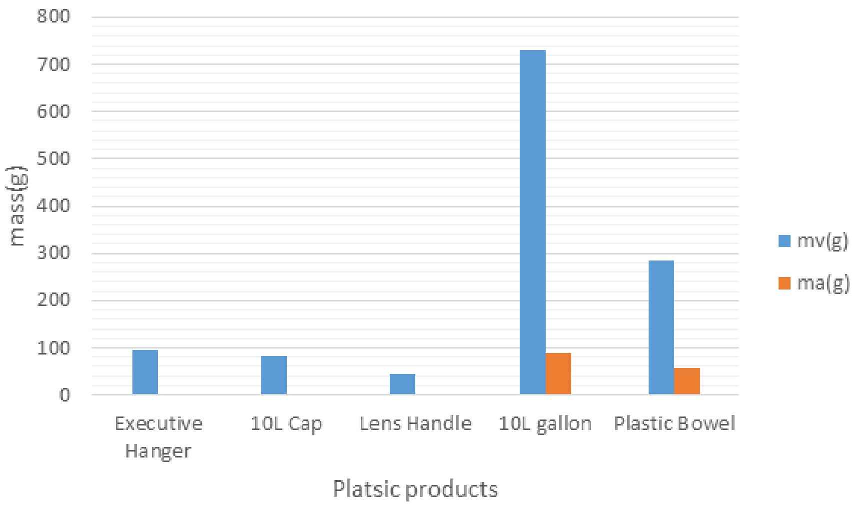

Fig 8: Showing the chart of the masses of the Virgin PS material and color additives used with mixing ratios used in the production of plastic products.

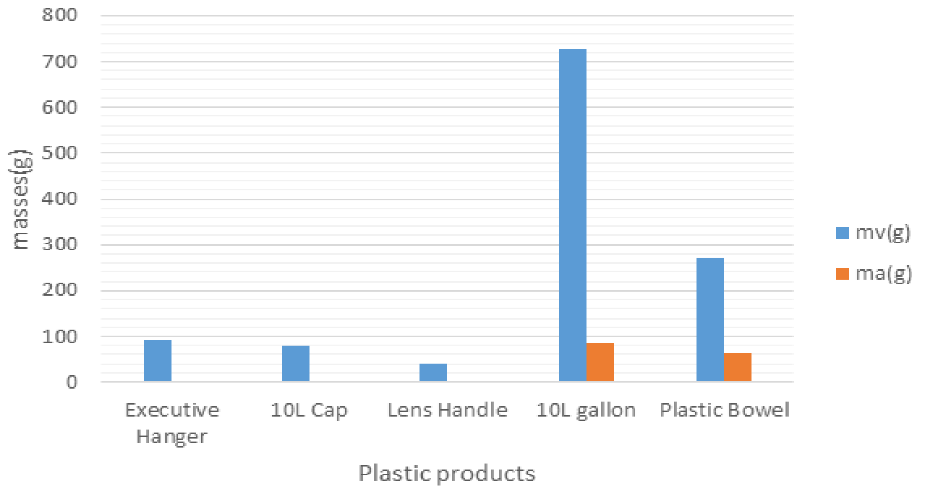

Fig 9: Showing the chart of the masses of the Virgin LDPE material and color additives used with mixing ratios used in the production of plastic products.

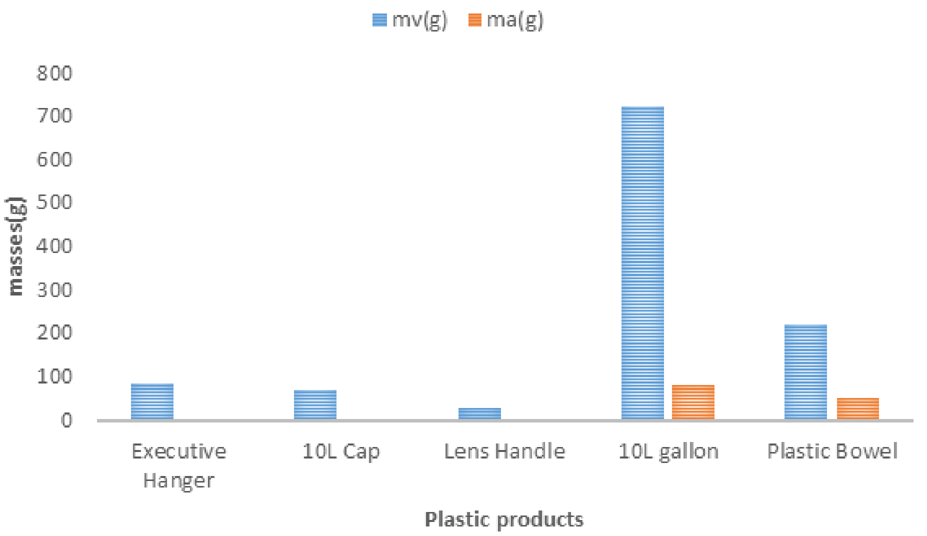

Fig 10: Showing the chart of the masses of the Virgin LLDPE material and color additives used with mixing ratios used in the production of plastic products.

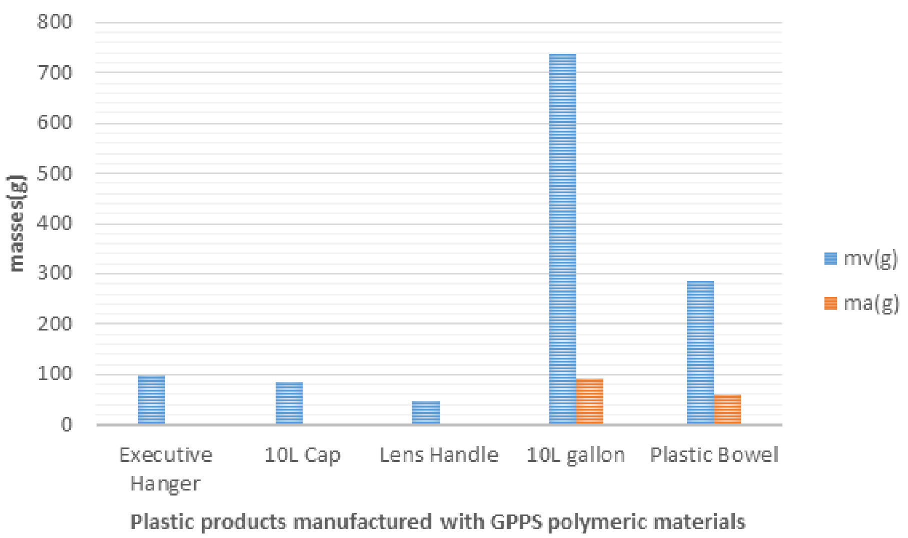

Fig 11: Showing the chart of the masses of the Virgin GPPS material and color additives used with mixing ratios used in the production of plastic products.

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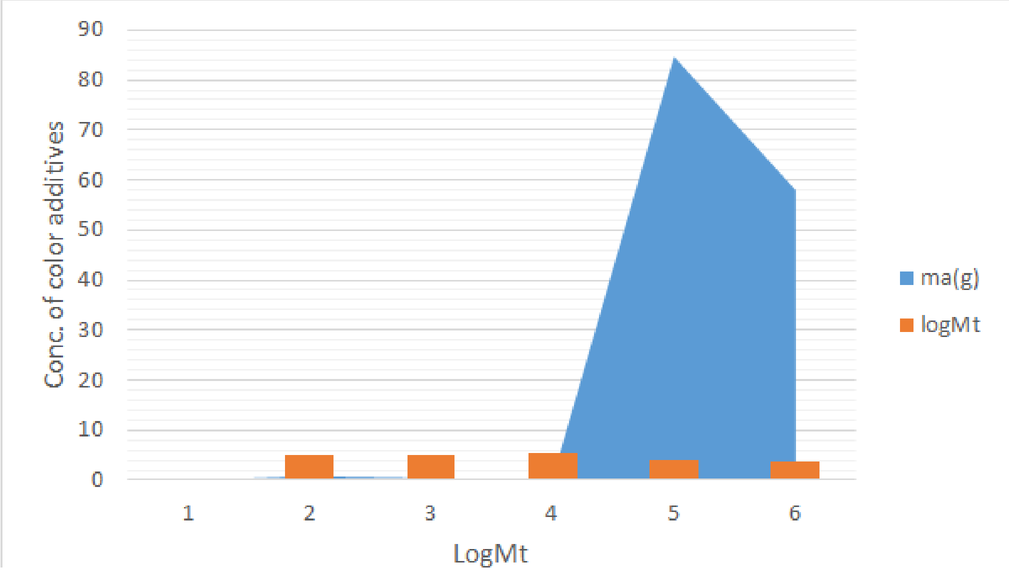

Fig 12: Showing the mass of colour additive and the LogMt

Colour additives has played a significant role in the determination of the textures of the plastic products manufactured in this plastic production unit. They serve multiple purpose beyond mere aesthetics, contributing to the overall performance and durability of materials.

Fig 6 to Fig 11 shows that the masses of the virgin materials used and the masses of the additive used in production of various plastic products were observed. 10L gallon has values for the additive at 80.68g, 84.68g, 89.20g, 87.10g, 80.68g, and 89.20g respectively. Since the production process is the blow moulding method the elevated values of the masses of the additives is no doubt a strengthening factor.

It is also for a heat resistant, chemical resistance and also to optimize the mechanical properties of bending modulus, elasticity and processability resulting in more robust and versatile 10L plastic gallon for the end users.

For the Plastic Bowel produced with the same production method of blow moulding the values is seen to be elevated as well having values: 52.0g, 58.0g, 58.0g, 62.00g, 50.0g, and 58.0g respectively. Similarly, considering the executive hangers produced in the plastic production unit, the masses of the additives in the virgin materials used in the production of this economic plastic products were seen to be relatively small with values ranging from 0.64g in Fig6, 0.78g in Fig7, 0.87g in Fig8, 0.82g in Fig9, 0.64g in Fig10, 0.87g in Fig11 respectively.

The small ranges of values of these colour additives is due to the production process of Injection method of extrusion mechanism passing from the 180 tons injection machine in the plastic production unit. However, the nature of the products in terms of its mechanical properties are also influenced when a mixable ratio is adopted to improve the elasticity, the density of the finished produced executive hangers and the reduction of rigidity hence making the overall properties of flexibility to be improved and elongating the life span.

Fig 12. Shows the colour additives and the LogMt values, here LogMt was deployed to reduce the escalated values gotten from the evaluation of the mixing texture. The masses of the additives were seen to cluster at the LogMt values of 4, 5 and 6 respectively. These logMt values were the ones used for the 10L gallon and the plastic bowel produced in the plastic production unit. It is in conformity to the aforesaid discussion about the consideration of 10L gallon and the plastic bowel method of production because the heating nozzle of the barrel for the 6ft blow moulding machine is set to a very high temperature and the pressure is also set to an elevated Mpa and the die head must convert the mix to a parison of homogenous mixture before the pressure pin blow the air into a mould cavity.

III. CONCLUSION

We have seen that Plastic products made from the same base material with their design functionality, and typical applications vary significantly due to the various ratios of the additive added for the mixing texture (M_t). So an equilibrium ratio is of paramount in the production process to optimize cost, reduce waste and for quality product.

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