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IMPACT OF EXTRUSION PROCESS ON PRODUCT QUALITY

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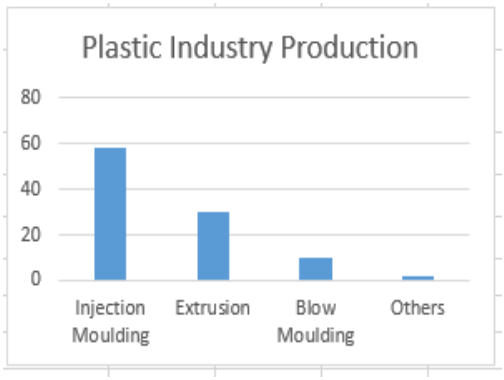
ABSTRACT - This paper is based on impact analysis of extrusion process on quality of product. Approximately large number of manufacturers experienced a problem in product quality in established extrusion pipe manufacturing process to compete the customer demand. To ensure product quality in present extrusion pipe manufacturing process, it is compulsory to identify, control, and regular monitoring of all quality parameters to ensure product quality. Some of the important parameters are based on the condition of equipment used in process, operating conditions, temperatures, pressures, dies quality, and used materials. So many problems faced by the manufacturers to minimize defect in the final products which directly affect the cost of product as well as product life. The purpose of this paper is to focus to analyze the various defects in the extrusion process, to access its impact on the product quality and to suggest the mitigation & remedies for the improvement of extrusion process for better product quality and life.

Keywords: Extrusion process, Defects in plastic pipe, Impact of defect, Product quality

INTRODUCTION

Manufacturing of plastic products in India started 60-62 years ago with the countries. The Indian plastics market is comprised of around 25,000 companies and employs 3 million people. The domestic capacity for plastic production was more than 6.72m tonnes in 2016-17. The State of Gujrat in Western India is the leading plastics manufacturing hub and accounts for the largest number of plastics companies, with above 5,400 plastics firms.

S.No	Type process	Production %
1	Injection Moulding	58
2	Extrusion	30
3	Blow Moulding	10
4	Others	2



The use of plastic products in other sectors such as automobiles, medical and health care, packaging, sports and leisure is also increasing. Plastic products is a thermoplastic composed of 57% chlorine and 43% carbon. It is less dependent than other polymers on crude oil or natural gas, which are non-renewable, and hence plastic products can be regarded as a natural resource saving plastic.Plastic products can be produced from various hydrocarbons including coal, the bulk of the world's plastic products is currently manufactured using ethylene, which is combined with chlorine to produce ethylene dichloride, the raw material for the manufacture of Vinyl Chloride Monomer. The utilization of plastic products in India is expected to increase to 3.3 million mt/year by 2017-18 and the nation's capacity is expected to rise to 1.64 million mt/year. As is evident from the above-mentioned demand and supply numbers, plastic product demand is expected to exceed supply.

Extrusion Process

The extrusion changes a solid plastic material into a molten state and then into a final well finished solid plastic product for use. Equipment of extrusion made of a plastic extruder, die and its assembly, a cooling system, and haul-off or winding accessories.. Extrusion is a continuous process. Extrusion is used for a uniform outside shape like tubes pipes, railing window panels etc. The solid plastic material changes into molten metal in the extruder barrel, by shearing of a rotating

screw and the heat is taken from the heater having electrical resistance which is assembled to the outer side of the extruder barrel and die. The solid plastic changes into a hot molten material due to shearing action of screw and heating action of electrical heaters. The screw extrusion and ram extrusion are main two type of plastic extrusion. This review paper studied about the screw extrusion .In Screw extrusion a helical feed screw rotates into a barrel which is known as feed screw or the extruder screw which has single shaft with helical flights. For better mixing two screws are used. The screw pushes the material through the barrel where material is heated and compressed. The extrusion process have two main purposes: 1 the plastic material is heated above its melting point and puts the melt under pressure. 2The molten plastic material is pushes and passes through a small hole called as orifice, of die. . The extrusion process is used for pipe, tubing, window panel, flat products (thin film to heavy sheet), coatings for paper and other substrates, insulation for wire, cable jacketing, and monofilaments, all synthetic fibers., blown film for bags, cast film for packaging materials, tubing for catheters, wire insulation for telephone wire, rod for glue guns, profiles for window frames, and monofilaments for fish line. In the plastic extrusion process plastic is changes into raw material called as pellet or powder, after that powder is melted and compressed via the extrusion process, passes through the die and changes into final finished desired product.

Defects' in Extrusion PROCESS

The main defects in plastic extrusion process are due to mould design, wrong material selection, and wrong processing l. Main defect due to processing are rough surface of product, surging of extruder, variation in thickness, unevenness in wall thickness, variation in diameter, centering defect. .Processing defects are mainly due to non-understanding of the processing method, use of inefficient or too old machines, untrained staff, break down of machines, and inappropriate working environment.

The general defects in extrusion are: wrong selection of System Engineering or its installation, wrong Operation, Defects in resin, Materials Addition of material, Surging, Poor blending, fracture or toughness of melt , Overheating, Moisture release, Trapped air, Contamination.

Wrong selection of System Engineering/Installation

- Wrong used clamp or high tightness of Clamps.
- die setting is wrong
- Die alignment is not proper
- Improper fire caulk used.
- Outside pipe contact with incompatible material like solder flux.

Remedies

.Die setting may be adjusted

- Checking of alignment
- Die heating uniformity should be checked

Mall Functioning/operation methods

- Freezing temperatures exposure is without freeze protection
- Over pressure means pressure is more than normal pressure
- Pressure of water is fluctuating

Remedies

- Digital Pressure gauge should be used
- Proper and Digital temperature sensor should be used

Defects in Resins

- There is defects of occlusions, char particles, voids
- Distribution of filler/pigment is not proper and well distributed
- Defects in resins due to mixing of resin and additives is not proper
- Defects in resins due foreign contamination
- Defects in resins due to over heating

Remedies

- The resign material screening
- Resin material (Mixing percentage) is not exact

IMPACT ON P[RODUCT QUALITY AND DEFECT

S. No	Defect	Impact on Quality
1.	Improper System Engineering/ Installation	Centring problems Chatter mark on the Product
2.	Improper Operation	Uneven wall thickness
3.	Resin Defects	Blow holes Formation on the product
4.	Improper Materials Addition	Material absorb the moisture from the air which can cause bubbles
5.	Surging	Variation in the thickness of the product
6.	Poor mixing	This Problem create the clogging in the extrusion
7.	Melt toughness or fracture	This refers to fine ridges or rough surface seen when the melt comes too fast out of a narrow die
8.	Overheating	This create the problem in the Cooling of product
9.	Moisture release	The result is a pattern of dotted lines, long bubbles, and pits
10.	Trapped air	A trapped-air surface shows bubbles and pits, but little, if any, dotted lines

MATERIAL ADDITION NOT PROPER

There are a large no problems due to the processed raw material. There will be problems if raw material is not up to specification. Regardless of any quality assurances by producer of raw materials and countless programs such as ISO 9000 reengineering, plastic batches and even bags or boxes within batches have their characteristics. The tubing or sheet will have a different look for different extrusion parameters, bend, colour, or shape. These problems do occur on the floor during processing. In spite of all the computer programs and hardware designed to maintain the quality constant, there will be so many variations arise. Many plastic materials such as polyurethane, nylon and others, are hygroscopic (they absorb moisture from the air).the presence of moisture content in product is undesirable and can create bubbles in the melt can decrease barrier properties. To prevent form such type of problems the polymer should be proper sealed in bags nitrogen-purged whenever possible. Though, some plastics can absorb critical amounts of moisture in the time it takes to open a bag and put it in the hopper. The material must be dry out properly, preferably in a hopper dryer designed for this

purpose. Other problems include contamination with foreign materials such as metal chips, screws, bolts, nuts and rodent droppings. Even medical grade plastics are often contaminated. Of course, the contaminate will end up in the melt, so every precaution must be taken to avoid contamination by closing bags, covering hoppers, keeping a clean area around the extruders, and similar measures.

Remedies

- Addition of (mixing percentage) resin material should be exact
- Foreign material should be checked
- RPM back pressure should be increased for better mixing.

SURGING

Surging is a cyclical product thickness variation in the direction of extrusion. The surge cycle time is typically between 30 seconds and 3 minutes, and the cause can be inside or outside the extruder. Outside causes are easier to see and correct. For example, the take-off pull may be irregular; in this case the screw rpm and ammeter readings remain steady. Sometimes screw motor speed varies because its regulation is not working properly. This is rare and will show up as unsteady rpm. Sometimes the feed is uneven because of particle size, light weight, or bridging in the hopper and throat. With very small extruders, the feed channel depth is not much bigger. Than the feed particles, and they may feed erratically for this reason alone.

If none of these outside causes are observed, it is probable that the surging originates inside, typically at the beginning of the compression zone, where the solid bed the mass of pellets may be locking and breaking up irregularly. Screw rpm is steady but the ammeter shows variations of ± 5% or more. Sometimes this can be cured by increasing the temperature of the feed to promote earlier melting. Raising the rear barrel temperature may help, too. Make big changes, 25-50 °F (14-28 °C), and see what happens. Sometimes raising the barrel Temperature at the beginning of the compression zone will help by getting better sticking of the pellets to the wall there.

Remedies

- Try to running the extruder slower or faster by at least 10%.
- Altering or replacing the screw.
- Installing a gear pump between the extruder and the die.

POOR MIXING

This often sets the upper limit for output. The screw cannot be run any faster because the material is coming out with an “applesauce” surface, with streaks, parabolic ridges, and perhaps Particles of undispersed additive. Screw modifications, such as pins or separate mixing heads will help, but may raise melt temperature. Running more slowly will always help, as it provides more residence time. A screw with internal cooling mixes better because it has the effect of a shallower channel in the metering zone. The output per rpm drops 30, but may be regained by increasing the screw speed, unless melt temperature gets too high or the drive system cannot safely run faster. High pressure is good for mixing. A valve will do this, or a gear pump pressure control that can serve as a valve. Cooler dies increase the resistance and thus raise the pressure in the system. Finer screens will raise the pressure, but as they keep clogging, pressure is inconsistent.

Remedies

- Exact addition of (Percentage of mixing) resin material.
- Check for foreign material.
- Increase rpm back pressure for better mixing.

MELT TOUGHNESS OR MELT FRACTURE

This refers to fine ridges or rough surface seen when the melt comes too fast out of a narrow die. It is most common with polyethylene, and can be eliminated by running the melt or the die lips hotter, using a longer or more streamlined die, or trying a different grade or source of material. Additives may help greatly in this regard.

Remedies

- Use the Correct additives.
- Maintain the speed of extruder.
- Trying a different grade or source of material.

OVERHEATING

Overheating may limit the rate if the take-off cooling is limited, or it may produce degradation or make dimensional control and sizing difficult. In such a case, stop all barrel heat except in the rear zone as needed for bite (input) control and cool the barrel if necessary. (In a few cases, more barrel heat will yield a cooler melt.) There is a temperature below which the melt will not go at a given screw speed, even if all the barrel heaters are turned off.

See if the controller around 70% down the barrel is overriding. This means over packing of the metering zone—overbite—with much heat generated at the entry to that zone. In that case, reduce the bite by changing the feed temperature, rear barrel temperature, or particle size.

Remedies

- Stop all barrel heat except in the rear zone as needed for bite (input) control and cool the barrel if necessary.

MOISTURE RELEASE

Moisture is absorbed by some plastics. It passes through the extruder and boils when the pressure is relieved at the die lips. The result is a pattern of dotted lines, long bubbles, and pits. To remove moisture, the material must be pre-dry, or a vent must be used in the extruder, or both. A moisture level of 0.1% is usually low enough to avoid such visual problems.

Some plastics, such as PET, the nylons, and polycarbonate, can degrade and weaken if even a tiny amount of moisture is present when they are melted. For these, dehumidifying dryers are used to get moisture down to 0.01% or less.

Remedies

- To remove moisture, the material must be pre-dry.
- Vent must be used in the extruder.
- Keep the moisture level of 0.1% is usually.

TRAPPED AIR

This is not common in pelletized material used with long extruder barrels. However, some old machines have short barrels, and even a long machine can be pushed so fast that the air is carried forward into the product. A trapped-air surface shows bubbles and pits, but little, if any, dotted lines. Such a surface will improve if run more slowly if moisture is not the problem. A cooler head and die may help. Vents and vacuum hoppers will eliminate trapped air and are essential for powders, where passages between the particles are much smaller; the air cannot escape back through these passages and is carried forward instead.

Remedies

- Avoid the over-speed of extrusion.
- Pre-Dry the material.
- Vents and vacuum hoppers will eliminate trapped air.

LITERATURE REVIEW

S.No	Author	Process Review	Output parameter	Benefits/Conclusion
1	J G Khan, R S Dalu and S S Gadekar	Defects In Extrusion Process And Their Impact On Product Quality	Different defects in the plastic extrusion process, to recognise its impact on the product quality and to suggest for improvement of extrusion process for better quality.	From analysis of the different papers related to defect and observing their views of many researchers on plastic extrusion process there should be need of reduce the causes for the best possible extrusion product output. These quality Causes are become inappropriate setting of operational parameters as per observation. By the application of above remedies the percentage of loss would be improve, as predicted, for the products.
2	Geo Raju1, Mohan Lal Sharma2, Makkhan Lal Meena3	Recent Methods For ptimization Of Plastic ExtrusionProcess: A Literature Review	Process parameters and die design for plastic extrusion. Analysis based on various approaches: • Taguchi technique • artificial neural networks (ANN), fuzzy logic • genetic algorithms (GA) • non-linear modelling • response surface methodology	Different research works on the basis of different approaches : a. mathematical model, b. Taguchi technique, c. artificial neural networks (ANN), d. fuzzy logic, genetic algorithms (GA), e. non-linear modelling Taguchi method is a robust design technique used in industries for making the product/process may insensitive to any uncontrollable factors such as environmental variables. Taguchi approach has helped in reducing the experimental time and cost of product and quality improvement for better quality. In similar way ANN and GA are used to examine as the new approaches to analyse of different process parameters to get best product quality.
3	WA Akinfiresoye *, OJ Olukunle and AA Akintade	Development Of A Wood Plastic Composite Extruder	comparison of extrusion and injection moulding for producing WPC are as: • melting • shaping • and cooling Extrusion and injection moulding both are use screws to convey, pump, and blend the mixed component but pressure and shearing in injection moulding are higher than extrusion regardless the process parameters mentioned.	small scale wood-plastic composite extruder machine was designed, fabricated and tested at the Agricultural and Environmental Engineering department of The Federal University of Technology,Akure. The extruder is powered by 10Hp three phase electric motor.
4	Dharmendra Kumar (M. Tech Scholar), Sunil Kumar (Asst. Professor)	Process Parameters Optimization For HDPE Material In Extrusion Blown Film Machinery Using Taguchi Method	The optimum level of the process parameters is greatest S/N ratio.(I)melting (ii) temperature (iii)extrusion speed(iv) extrusion pressure (v) winding speed considered. Orthogonal array experiments were conducted. After conducting the experiments, the tensile strength is measured and Signal to Noise ratio is calculated. graph and table helps to find out optimum parameter values	Combination parameter is find out by selecting level with highest value for each factor. The optimal process parameter is the combination for HDPE is A3, B3, C3, D2.The value difference given table shows which one factor is the most important Tensile strength for HDPE, Melting Temperature (B) is determined by most effective factor for HDPE which is follow by Extrusion speed (D) Extrusion pressure (A) and Winding speed (C).
5	Mitul J. Barot, Tejas B. Mehta, C.E.Vijay Parekh	Review Finite Element Analysis And Optimization Of PVC Window Profile	Change the design of the sheet that have more strength by using FEA method and optimize the window sheet by using taghchi method, therefore to understand the plastic extrusion process, to understand its process parameter researcher study various research paper related to extrusion process. And present the brief review of thus paper.	A finite element analysis of extrude product is very useful to study the effects of various parameters like Melting temperature, Screw speed, Extrusion pressure, Extrusion ratio, Die angle which are difficult to measure during process and all these parameters have significant effects on microstructure, extrude quality, material flow behaviour and strength of the extrude. So these parameters need to be analysed and according to this modelled the extrude product.

6	S. Ravi, M. Sudha, and P. A. Balakrishnan	Design Of Intelligent Self-Tuning GA ANFIS Temperature Controller For Plastic Extrusion System	GA ANFIS contro-paperller design method for temperature control in plastic extrusion system. Temperature control of plastic extrusion system suffers problems related to longer settling time, couple effects, large time constants, and undesirable overshoot. The system is generally nonlinear and the temperature forth plastic extrusion system may vary over a wide range of disturbances.	GA ANFIS Controller have capability to eliminate sudden input disturbance and maintain the set point temperature in the plastic extrusion system. The simulation results clearly show that the GA ANFIS controller reduces the timing specifications of fuzzy and PID controllers. This paper demonstrates the effectiveness of intelligent controller on nonlinear system, particularly for temperature control in plastic extrusion system.
7	M. hirumarimurugan, S. SivaSubramanian and M.Ramasubramanian	Performance Evaluation Of Extrusion Process	Alternative technique is used to control the temperature in the extrusion process. It is used for better performance than the conventional controllers	This work provide extrusion process temperature controllers which is used to understand the actual thermal behaviour for the melt flow for evaluating controller performance. Many techniques have been used in extrusion process. Experimental study shows various controllers have some performance drawback which can be overcome by the addition of anti-windup compensators which reduces the overshoots caused by the integral part of the controller section. An anti-windup compensator is made of nominal controller appended with anti-windup compensation. The reason behind using anti-windup compensation is that it leaves the loop unaffected as long as saturation does not occur. To prevent the integrator state is prevented from growing large and cause over shoots and limit cycles we have opted for anti-windup compensation. Hence the usage of anti-windup compensator will improve the performance of the controller system
8	Prabhat Kumar Mahto , Rajendra Murmu	Temperature Control For Plastic Extrusion Process	Four control techniques PI, PID FUZZY and ANFIS. The tuning synchronizes monitor the controlled variable and process to work at its desired operating condition. All method is simulated using MATLAB/Simulink.	It concluded the design, analysis and suitability for extrusion temperature response control model for plastic extrusion by ANFIS control, FLC, PID and PI control. A comparative study of performance of PI, PID, fuzzy logic controller and ANFIS controller is studied. It uses MATLAB/Simulink for simulation. Due to sudden input disturbances and different set points temperature changes for plastic extrusion system.
9	A. Hosseini, E.Azarsa, B.Davoodi, Y.Ardahani	Effect Of Process Parameters On The Physical Properties Of Wires Produced By Friction Extrusion Method	Hot and cold crack defects generated on wires made due to too high and low die rotational speed, respectively. Defects, voids in the wires will increases with increase in die transverse speed.	1) By friction stir extrusion processing method defect free aluminium wires can be fabricated from aluminium chips that had been produced through other manufacturing processes. 2) Limits on the process appear to be related to the extrusion temperature which, if too low, results in cold tearing and, if too high, causes what appears to be a form of hot cracking. 3) From macroscopic and microscopic evaluations it can be inferred that the optimum condition for
10	Ismail Yusuf, Nur Iksan , Nanna Suryana Herman	A Temperature Control For Plastic Extruder Used Fuzzy Genetic Algorithms	In fuzzy logic, it represents the degree of as an extension of valuation. Conventional FLC used membership function generated by human operators, who have been manually designing the membership function of FLC. To satisfy such requirements include one common weakness where the membership function selection process is done with trial and error; it runs step by step, which is too long in completing the problem. A new approach for optimum coding of fuzzy controllers using GA. GA is used to determine membership function especially designed in situations.	GA has been successfully applied to solve many optimization problems. In this research, genetic algorithms are implemented to a system (programming language) for determining the membership function of FLC. By designing compact data structures for genes and chromosomes and an accurate fitness evaluation function, GA have been implemented which is very effective in finding more accurate membership functions for the fuzzy system. The data structures adopted are compact, and thus very convenient to manipulate by genetic operators. The performance of GA can be further improved by using different combinations of selection strategies, crossover and mutation methods, and other genetic parameters such as population size, probability of crossover and mutation rate.

11	S. RAVI, P.A. BALAKRISHNAN	Stable Self-Tuning Genetic Fuzzy Logic Temperature Controller For Plastic Extrusion System	In order to produce a good quality of plastic extrudates the temperature in each zone must be set appropriately and precisely controlled. In this paper GA based FLC control technology in temperature response control for the plastic extrusion system at different set point changes and sudden disturbances compared with fuzzy logic control. Details of plant model, control methods, design and simulation results are Presented in the subsequent sections.	This paper demonstrated the design, analysis and suitability of temperature response control model for plastic extrusion by Genetic Algorithm tuned FLC control. Due to sudden input disturbances and different set points temperature changes for plastic extrusion system, the simulation results show the FLC control is with little overshoot and take a delay to settle with reference value. Genetic Algorithm controller FLC tuning is without overshoot and settle very quickly compared with FLC controller. This paper demonstrates the effectiveness of intelligent controller on non-linear system particularly for temperature control in plastic extrusion system. The proposed controller identifies the process variations quickly and provides good control for the set point changes and for sudden disturbances. The Genetic Algorithm based FLC controller will prove especially efficacious in plastic extrusion system.
12	Ismail Yusuf, Nur Ihsan , Nanna Suryana Herman	A Temperature Control For Plastic Extruder Used Fuzzy Genetic Algorithms	Determine the membership function of FLC using the GA optimization for the fastest processing in completing the problems. The data collection is based on the simulation results and the results refer to the maximum overshoot. From the results presented, we will get a better and exact result; the value of overshot is decreasing from 1.2800 for FLC without GA, to 1.0011 for FGA.	GA has been successfully applied to solve many optimization problems. In this research, genetic algorithms are implemented to a system (programming language) for determining the membership function of FLC. By designing compact data structures for genes and chromosomes and an accurate fitness evaluation function, GA have been implemented which is very effective in finding more accurate membership functions for the fuzzy system. The data structures adopted are compact, and thus very convenient to manipulate by genetic operators.
13	Dharmendra Kumar (M. Tech Scholar), Sunil Kumar (Asst. Professor)	Process Parameters Optimization For HDPE Material In Extrusion Blown Film Machinery Using Taguchi Method	Four factors namely- • melting temperature • extrusion speed • extrusion pressure • and winding speed	The best group of combination parameter in the tabular form can be examined by choosing the level with highest value for given factor. The difference value from said analysis represent which one factor is the most important for Tensile strength of Melting and HDPE. Temperature is found most effective factor for HDPE followed by Extrusion speed (S) Extrusion pressure (P) and Winding speed (V_w).
14	S.Siva Subramanian1, S.Durga, K.R.Loshni, V. Dinesh Kumar	A Review On Control Of Plastic Extrusion Process	Investigate about the application of genetic algorithm in the design and implementation of Fuzzy logic controller. FL Controller use membership function generated by human operators.	Genetic Algorithm has been used to solve many optimization problems. In this paper genetic-algorithms are applied to a system for defining the membership functions. This method developed a system that helps users to defining the membership function of Fuzzy Logic Controller using the Genetic Algorithm optimization method for the fastest processing in completing the problems. The data collection is based on the simulation results and the results refer to the maximum overshoot. Plastic extrusion verified to be a robust method and it is valuable in all type of industries expanding the scope to include a range of polymers that can be processed with or without plasticizers.

CONCLUSION

From the different studies and analysis of the various papers related to defect and observation of different researchers by papers related to extrusion process need to minimize its defects for the best extrusion product quality. Such quality problems are become inappropriate setting of operational parameters as per observation taken by the researchers. By the use of above methods to minimize the percentage of loss would be improve, as predicted, for the products.

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