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A Review on Optimization of Extrusion Process Parameters to Reduce Uneven Wall Thickness in HDPE Pipes

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Abstract: All over the world HDPE Pipes are manufactured by extrusion technique. HDPE pipes are essentially non corrosive which makes them appropriately suitable for the purpose of water transportation. Uneven Wall thickness is one of the defects occur in HDPE pipes. One method of reducing thickness variation problem is by applying and using Taguchi method. Taguchi method is a used to improve quality of manufacturing product and it is also used to optimize a process parameters. Taguchi approach has been utilized widely in engineering analysis to optimize the performance characteristics within the combination of design parameters.

Keywords: Extrusion, Taguchi Method, Process Parameter, HDPE Pipes, Optimize.

I. INTRODUCTION

Extrusion process is continuous operation in which powdered polymer or monomer is fed by a screw along a cylindrical chamber. As the powder moves toward the die, it is heated and melts. The molten plastic is a forced through a die opening of desired shape. The material in granular form together with necessary additives is placed into a feed hopper which feeds the cylinder of the extruding machine. The hopper portion is kept cool by circulating water in order to avoid premature softening of the feed and blockage in the supply system The cylinder is so heated by electricity, oil or steam, that closely controlled temperature zones are set up along its length. A rotating screw is used for carrying and mixing of material through cylinder and forcing it through a die of a required shape. The screw are designed to suit each application. These vary size and form. [1]

Wall dimensions that are much larger than anticipated can be caused by the wrong die lip opening, improper processing conditions, or slippage in the puller. Corrective actions for these problems are listed below.[2]

Profile dies do not normally have adjustable die lips to allow the die gap to be adjusted for the particular process being run. (Pipe and tubing dies may or may not have adjustable die lip openings, depending on the pipe or tubing diameter and the application.) Once the die is cut, the only way to thin the walls are to lower the screw speed and/or increase the puller speed. Speed changes are associated with a fixed molecular orientation, depending on the draw ratio required to obtain the desired product wall thickness. If the draw down ratio and molecular orientation are too high, inferior properties can result in the transverse direction; the only alternative is to cut another die with a smaller die gap. Each die gap opening is coupled with a fixed puller speed and throughput rate to produce an acceptable product with a specific draw ratio and cross sectional area. The draw ratio is defined as the die cross section divided by the final product cross section. If the die opening is twice as large as the final product, the draw ratio is 2:1. Higher draw ratios produce higher molecular orientation, resulting in greater differences between machine and transverse direction properties. If a pipe or tubing has high wall thickness on one side and low on the other side, the die bushing has to be properly centered on the mandrel to produce uniform dimensions around the pipe or tubing circumference. Nonuniform wall thickness in pipe or tubing induces warpage in the pipe, with the pipe curling or bending toward the thinner wall due to higher molecular orientation and shrinkage on the thin side. Proper die adjustments are required to produce both correct and uniform wall thickness.[2]

Improper processing conditions occur when the wrong draw ratio is used with the correct die gap opening. If the puller is running too slow for the extruder throughput rate, the wall thickness will be greater than anticipated. For each die gap opening, there is only one extruder throughput-to puller speed ratio that gives the correct dimensions in the final product. This means the extruder screw speed in a flood-fed single screw extruder is nominally coupled with a given puller speed. The throughput rate in a flood-fed single screw extruder can be changed slightly at a given screw speed by changing the temperature profile and the melt viscosity. Any change in throughput rate must be accompanied by a change in puller speed to maintain thickness control. In general, higher melt temperatures lead to lower viscosity with higher resin flow, possibly generating higher throughput rates. Extruders are complex systems: as the barrel temperatures are changed, the feed characteristics may change (higher set temperatures in extruder zones 1 and 2); the conveying characteristics in the feed or conveying section might change; die pressure can be lower, reducing the backflow in the extruder; mixing characteristics change; and extruder pumping characteristics are different. Obviously the extruder is a fine balance of throughput rate, screw speed, and melt pressure and temperature. In absolute terms each fixed die gap opening has a fixed draw ratio based on the puller speed and extruder throughput. As the throughput rate goes up, the puller speed must be increased, and vice versa. At a given screw speed and operating conditions in a flood-fed extruder, the output rate is constant at a given melt temperature and pressure.[2]

Slippage in the puller allows the product dimensions to increase because the product is not being pulled away from the extruder at the proper rate. The caterpillar or puller pressure has to be adjusted to prevent the product from slipping without causing any distortion or damage to the final product. If the pipe, tubing, or profile is still wet from the cooling bath when it reaches the puller, slippage can be caused by moisture on the belts.[2]

II. PROCESS PARAMETERS

The most important process parameters are melt pressure and temperature. They are the best indicators of how well or how poorly an extruder functions. Process problems, in most cases, first become obvious from melt pressure and/or temperature readings. Just think about what a doctor does when a patient comes into the office with a problem. Usually, the first check of the patient's condition is made by taking blood pressure and body temperature. These are two good indicators of the functioning of the human body. In the same fashion, melt pressure and temperature are good indicators of how the extruder is functioning. Other important process parameters are: screw speed, motor load, barrel temperature, die temperatures, power draw of various heaters, cooling rates of various cooling unit, vacuum level in vented extrusion, and these parameters relate just to the extruder. However, there are many more process parameters for the entire extrusion line and this, of course, depends on its specific components. Important parameters for any extrusion line are: line speed, dimensions of extruded product, cooling rate, line tension. Many other factors can influence the extrusion process, such as ambient temperature, relative humidity, air currents around the extruder, and plant voltage variations, among others.[3]

III.PROCESS OPTIMIZATION

Process optimization is the discipline of adjusting a process to optimize some specified set of a parameters without violating some constraint. The most common goals are minimizing cost, maximizing throughout, and or efficiency, This is one of major tool in industrial decision making. When optimizing a process specifications, while keeping all others within their constraints.[4]

IV.NEED OF AN OPTIMIZATION OF PROCESS PARAMETERS

Plastic pipe extrusion process is most widely pipe manufacturing process in the industry. [5] The complexity of extrusion process and the enormous amount of process parameters involved make difficult keep the process under control. One of the main goal of extrusion is the improvement of quality of extruded parts besides the reduction of cycle time and lower the production cost.[6] The common failure or defects which are normally occurring in plastic extrusion process are due to the three main causes part and mold design, material selection and processing . In many cases, the failures occur during the processing and these failures causes some defects that can be found in extruded parts such as: warpage, sink mark, residual stress, air trap, weld line, sink marks, low gloss, uneven surface gloss, spotted surface, rough surface, extruder surging, uneven wall thickness, diameter variation, centering problem.[7] In the extrusion process as discuss above the various defects are frequently occurs and hampers the productivity. If we need to enhance the production rate, it is very essential to optimize the process parameters and improve the productivity.[5]

V. TAGUCHI METHOD

Taguchi method is invented by Dr.taguchi and Konishi.[8] Traditional method of experimental design is very complicated and not easy to use. The number of process parameters increases. When large numbers of experiments carried out. To solve this problem, the Taguchi method uses a special design of orthogonal arrays to study the entire parameter space with only a small number of experiments. The taguchi method is well known technique because of that provides a systematic and efficient methodology for process optimization. Taguchi method is widely used for process optimization and product design in worldwide.[9] This is due to the advantages of the design of experiment using Taguchi's technique, which includes simplification of experimental plan and feasibility of study of interaction between different parameters. In taguchi method lesser number of experiments is required. As a consequence, time as well as cost is reduced considerably. Taguchi proposes experimental plan in terms of orthogonal array that gives different combinations of parameters and their levels for each experiment. According to the taguchi technique entire parameter space is studied with minimum number of experiment is necessary.[18,19] The Taguchi method involves reducing the variation in a process through robust design of experiments. The overall objective of the method is to produce high quality product at low cost to the manufacturer. The effect of many different parameters on the performance characteristic in a condensed set of experiments can be examined by using the orthogonal array experimental design proposed by Taguchi [11]. Taguchi realized that the best opportunity to eliminate variation of the final product quality is during the design of a product and its manufacturing process. Consequently, he developed a strategy for quality engineering that can be used in both contexts.[21] The process has three stages[21]-

A. System design: System design involves the application of engineering knowledge and analysis to develop a prototype design that will meet customer needs. In the product design stage, system design refers to the final product configuration and features, including starting materials, components and subassemblies. Actually, product and process design stages overlap, because product determines the manufacturing process to a great degree. Also, the quality of the product is impacted significantly by decisions made during the product design.[10]

B. Parameter design: Once the concept is established, the nominal values of the various dimensions and design parameters need to be set, the detail design phase of conventional engineering. Taguchi's radical insight was that the exact choice of values required is under-specified by the performance requirements of the system. In many circumstances, this allows the parameters to be chosen so as to minimize the effects on performance arising from variation in manufacture, environment and cumulative damage.[21]As per G. Taguchi, a robust design is one in which the parameter values have to be selected so that the product or process performs consistently, even in the face of influencing factors that are difficult to control.[10]

C. Tolerance design: In tolerance design the objective is to specify appropriate tolerances about the nominal values established in parameter design. A reality that must be addressed in manufacturing is the nominal value of the product or process parameter that cannot be achieved without some inherent variation. A tolerance is the allowable variation that is permitted about the nominal value. The tolerance design phase attempts to achieve a balance between setting wide tolerances to manufacture and minimizing tolerances to optimize product performance. Tolerance design is strongly influenced by the Taguchi’s loss function.[10]

The objective of problem statement is to obtain maximum value or minimum value of desired response. Taguchi method chooses to calculate the signal-to-noise ratio for finding effective parameter for desire response value. To calculate the S/N ratio, experiments are conducted in a systematic manner. Taguchi’s idea is to recognize controllable and noise factors and to treat them separately as a design parameter matrix and a noise factor matrix, respectively. Experiments are organized according to orthogonal arrays (OAs). Noise factors are changed in a balanced fashion during experiments. The characteristics of S/N ratio can be divided into three categories smaller is better, Higher is better and nominal is best when the characteristic is continuous.[12] The effect of many different parameters on the performance characteristic in a condensed set of experiments can be examined by using the orthogonal array experimental design proposed by Taguchi. Once the parameters affecting a process that can be controlled have been determined, the levels at which these parameters should be varied must be determined. Determining what levels of a variable to test requires an in-depth understanding of the process, including the minimum, maximum, and current value of the parameter. If the difference between the minimum and maximum value of a parameter is large, the values being tested can be further apart or more values can be tested. If the range of a parameter is small, then less values can be tested or the values tested can be closer together. [11]

VI. LITERATURE REVIEW

1) *Mr. Sandip S. Gadekar et al.[5]* studied the defects in the plastic pipe, to optimize the plastic pipe manufacturing process. The optimization taguchi techniques used in this paper. For the research work Shivraj HY-Tech Drip Irrigation pipe manufacturing, Company was selected. The experiment was analyzed using commercial Minitab16 software, interpretation has made, and optimized factor settings were chosen. After prediction of result the quality loss was calculated and it compared with before implementation of DOE. The research works has improves the production, quality and optimizes the process.
2) *Narasimha and Rejikumar [7]* presented a systematic approach to find the root causes for the occurrence of defects and wastes in plastic extrusion process. The cause-andeffect diagram was implemented to identify the root causes of these defects. The extrusion process parameters such as vacuum pressure, temperature, take-off speed, screw speed of the extrusion process and raw material properties were identified as the major root causes of the defects from the cause-and-effect diagram. The quality loss for the current performance variation was calculated using Taguchi’s principle of loss function and requirement for improvement was verified. In this paper design of experiment (DOE) was applied to optimize the process parameters for the extrusion of high-density polyethylene (HDPE) pipe Ø 50mm and plain pipe ∅ 25mm. Four independent process parameters viz.

vacuum pressure, take-off speed, screw speed and temperature were investigated using Taguchi method. Minitab 15 software was used to analyze the result of the experiment. Based on the result of the analysis, optimum process parameters were selected.

3) *Dharmendra Kumar and Sunil Kumar [13]* used the taguchi method to optimize the process parameters and improve the quality of components that manufactured. The objective of this study was to illustrate the procedure adopted in using taguchi method to a extrusion blown film machinery. The orthogonal array, signal-to-noise ratio employed to study the performance characteristics on tensile strength; a greater S/N ratio corresponds to better quality characteristics. Therefore, the optimum level of the process parameters was the level with the greatest S/N ratio. In this analysis; four factors namely melting temperature, extrusion speed, extrusion pressure and winding speed were considered. Accordingly, a suitable orthogonal array was selected and experiments were conducted. After conducting the experiments the tensile strength was measured and Signal to Noise ratio was calculated. With the help of graph and table, optimum parameter values were obtained.
4) *Mukesh kumar verma and Mukesh dubey [14]* study present a systematic approach to find the root causes for the occurrence of defects and wastage in plastic extrusion process in the pipe manufacturing industries. It is very essential to learn the process parameter and the defect in the plastic pipe manufacturing process to optimize it. For the optimization Taguchi technique is used in this paper. Taguchi Method is a statistical approach to optimize the process and improve the quality of components that are manufactured. The experiment was analyzed using Minitab 17 software, interpretation has made, and optimized factor settings were chosen. In this analysis three factors namely take-off speed, melting temperature, extruder speed, were considered. Accordingly, a suitable orthogonal array was selected and experiments were conducted. After conducting the experiments the diameters were measured and Signal to Noise ratio was calculated. With the help of graph and table, optimum parameter values were obtained.
5) *G.V.S.S.Sharma et.al.[15]*explains High-density polyethylene (HDPE) pipes find versatile applicability for transportation of water, sewage and slurry from one place to another. Hence, these pipes undergo tremendous pressure by the fluid carried. The present work entails the optimization of the withstanding pressure of the HDPE pipes using Taguchi technique In the proposed optimization strategy, the design of experiments (DOE) are conducted wherein different control parameter combinations are analyzed by considering multiple setting levels of each control parameter. The concept of signal-to-noise ratio (*S*/*N* ratio) is applied and ultimately optimum values of process control parameters are obtained as: pushing zone temperature of 166 °C, Dimmer speed at 08 rpm, and Die head temperature to be 192 °C. Confirmation experimental run is also conducted to verify the analysis and research result and values proved to be in synchronization with the main experimental findings and the withstanding pressure showed a significant improvement from 0.60 to 1.004 Mpa.
6) *Vikash agarwal et.al.[16]*studied and investigated the optimization parameters of extrusion blow molding process for making plastic container of high density polyethylene grade B6401(HDPE) produced by mitsui CX processed at HALDIA PETROCHEMICAL LTD.A plastic container made by the using L9 orthogonal array. The process parameters are used screw temperature, blowing time, exhaust/cooling time and the responses were the compressive strength and volume accuracy were selected as quality target. An optimal parameter combination of the Extrusion blow molding process was obtained by grey relational analysis. By analyzing the Grey relational grade , the degree of influence foe each controllable process factor onto individual quality targets can be found. Additionally, the analysis of variance has been also applied to identify the most significant factor.
7) *Asrat mekonnen [10]* explained Ethiopia Plastic Share Company (EPSC) was used as a case to show the application of Taguchi's methods (design of experiment (DOE)) together with loss function. Specifically, the paper is designed to develop Taguchi's method of DOE to alleviate process design problems of some of EPSC products. The quality loss for the current performance variation was estimated using Taguchi's loss function and requirement for improvement was proven. For the improvement purpose DOE was applied to optimize the process parameters of the products. Temperature zones were considered as process parameters for the products. Orthogonal arrays used in this optimization process were L8, L16, and L27 for the products. The experiment was analyzed using commercial Minitab 15 software and interpretation was made and optimized factor settings were chosen. Using the factors being chosen the performance value was predicted; based on the predicted values of the performances of the products loss function is calculated and compared with the quality loss before implementation of DOE. From this it was understood that, using Taguchi's method of DOE improves the quality loss because of performance deviation (scrap inclusive) by about 89.95% for the selected products of the company.
8) *Sisay G. Woldearegay et.al[17]* studied and find the root causes for nonconformity occurrences in plastic extrusion process. Data has been taken on the main causes for products defect and studied the relative contribution of plastic e (HDPE1 Ø 50mm, Plain pipe Ø 25mm), conduit (F/C Ø 16mm) and poly products (F/B 8cm/220µm). Four independent process parameters were

investigated, namely vacuum pressure, take-off speed, screw speed and temperature were considered for DOE. The defects identified are such as surface roughness and scratches, bulging, sink marks, uneven wall thickness, uneven film Width, dimensional variation, centering problem, tears and marks .On this particular case study, by using the principle of Taguchi's loss function, loss function was calculated and compared with the quality loss before applying of DOE. From this it was understood that, using Taguchi's method of design of experiment the quality loss because performance deviation improves by about 85.31% for the selected products.

9) *Krupal Pawar et.al[20]* studied and optimize extrusion process parameters for maximizing the PVC pipe wall thickness using Taguchi's method are investigated. The material of pipe manufacturing was PVC plastic. The experimental investigation was done in Jain Irrigation Systems Ltd., pipe manufacturing, company. The experiments are analyzed using commercial Minitab17 software, interpretation has made, and optimized factor settings were chosen. The present study concludes that the feed drum temperature: 1300, the die temperature: 1700, the extrusion pressure 100 Mpa, and extrusion speed: 50 rpm gives the maximum optimize the thickness of the PVC pipe for minimizing the pipe defects.

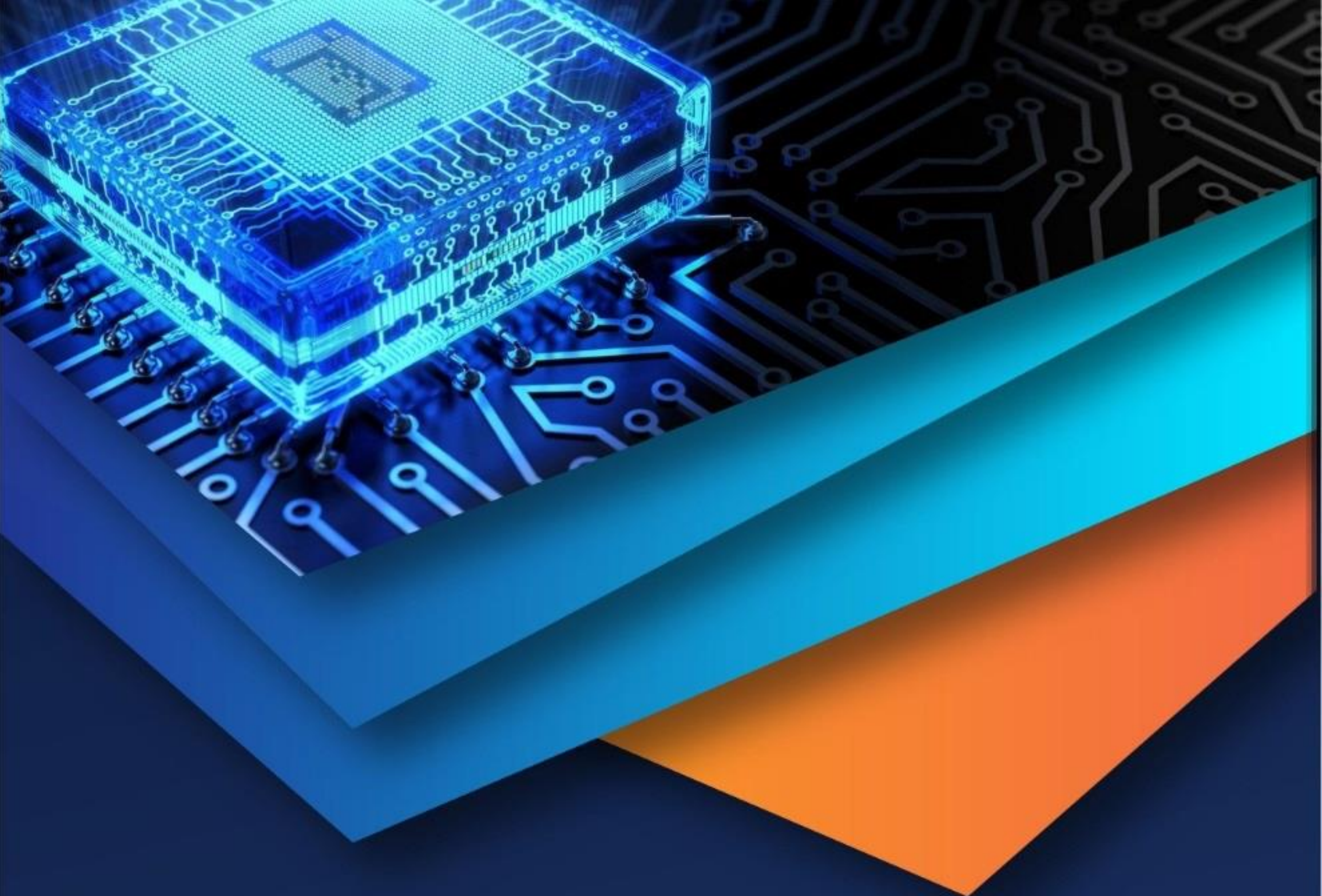
VII. CONCLUSION

Process parameters play prominent role for successful manufacturing of any product. But there lots of process parameters involved in any process. Taguchi method involves identification of proper control factors to obtain the optimum results of the process.

This paper gives all the process parameters involved in the extrusion process and it also gives need of an optimization of process parameters. The literature mention in this paper considered various process parameters such as are takeoff speed, screw speed, temperature, vaccum pressure, die temperature, pushing zone temperature, melting temperature, feed drum temperature, extrusion speed, screw temperature ,blowing time, exhaust/cooling time. After that accordingly they have selected suitable orthogonal array and experiment conducted .

REFRENCES

[1] R.K.Jain, " Production Technology", Khanna Publishers ,Page No.266, 2001
[2] Harnold F.Giles,Jr John R. Wagner, Jr .Eldridge M.MountIII. " Extrusion definitive processing guide and handbook", Willam Andrew Publishing , Page No.307-308,2005
[3] Chris Rauwendaal, "Understanding the extrusion", Hanser Publishers ,Page No.19-20,2010
[4] Shyam Kumar Karna, Dr. Rajeshwar Sahai, "An Overview on Taguchi Method", International Journal of Engineering and Mathematical Sciences" ,Jan-June 2012 Volume 1, pp.11-18.
[5] Mr. Sandip S. Gadekar , Prof.Javed G. Khan , Dr. R. S. Dalu, "Analysis of Process Parameters for Optimization of Plastic Extrusion in Pipe Manufacturing" ,International Journal of Engineering Research and applications, Vol. 5, Issue 5, (Part -1) May 2015, pp.71-74
[6] Geo raju, Mohan lal sharma, Makkhan lal meena, "Recent methods for optimization of plastic extrusion process: a literature review", International journal of advanced mechanical engineering, International Journal of Advanced Mechanical Engineering, volume 4, number 6 (2014), pp. 583-588
[7] M.Narasimha and R.Rejikumar, "Plastic Pipe Defects Minimization" , International Journal of Innovative Research And Development Volume 2 Issue 5 Page No.1337-1351, May 2013
[8] Taguchi G, Konishi S. Taguchi methods, orthogonal arrays and linear graphs, tools for quality American supplier institute. American Supplier Institute; 1987
[9] Wang, W.H., and Tarng, Y.S., "Design Optimization of cutting parameters for turning operations based on the Taguchi method". Journal of Materials Processing Technology, 84, 1998, pp. 122- 129.
[10] AsratMekonnen, "Uses and Applications of Quality Engineering For Plastic Production Process", International Journal of Science, Engineering and Technology Research, Volume 2, Issue 1, January 201
[11] Stephanie Fraley, Mike Oom, Ben Terrien, John Zalewski, " Design of experiments via taguchi methods: Orthogonal Array" From ControlsWiki.
[12] Patel Rajendra Kumar Jitendrabhai, "Multiobjective Optimization of hot machining process parameters for EN24 material using grey relational analysis", Dissertation.
[13] Dharmendra Kumar, Sunil Kumar, "Process parameters optimization for HDPE material in Extrusion Blown Film Machinery using Taguchi method" International Organization of Scientific Research Journal of Mechanical and Civil Engineering (IOSR-JMCE), Volume -12, Issue - 4, Pages:1- 3, Jul-Aug 2015.
[14] Mukesh Kumar Verma and Mukesh Dubey, " Optimization of Process Parameters of Plastic Extrusion in Pipe Manufacturing", International Journal of Engineering and Management Research ,Vol.5, Issue.6, Page No. 276-280 ,December 2015.
[15] G.V.S.S. Sharma, R.Umamaheswara Rao, P.Srinivasa Rao, " A Taguchi approach on optimal process control parameters for HDPE pipe extrusion process", Journal of Industrial Engineering International, Volume 13,Issue 2,Page No.215-228, June 2017
[16] Vikash Agarwal, Jyoti Vimal, Vedansh Chaturvedi, "Optimization of Extrusion Blow Molding Process Parameters By Grey relational analysis and Taguchi method" ,International Journal of Research in Engineering And Applied Sciences,Volume 2, Issue 2, Page No.407-417, February 2012.
[17] Sisay G.Woldearegay, Achamyeleh A.Kassie, M.Narasimha, R.Rejikumar, "Experimental Investigation About Influences OfProcessing Parameters In Plastic Extrusion Process", International Journal of Research In Computer Application and Management, Volume No.3, Issue No.6, June 2013.
[18] Phadke, M.S., "Quality Engineering Using Robust Design". Prentice Hall International Inc., New York, 1989.
[19] Roy, R.K., "A primer on the Taguchi method". Competitive Manufacturing Series, Van Nostrand Reinhold, New York 1990.
[20] Krupal Pawar, Sachin Jadhav, Ashwin Dumbre, Sunny.A.V, Girish H.S, Anil G.Yadav , "Experimental Investigation to Optimize the Extrusion Process for PVC Pipe: A Case of Industry", International Journal of Advance Research and Innovative Ideas In Education, Vol-3,Issue-2,2017
[21] https://en.wikipedia.org/wiki/Taguchi_methods.



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