International journal of Inventive Research in Science and Technology ISSN: 2583-5637 (Online)
Volume 4 Issue 11 November 2025

DESIGN & OPTIMIZATION OF VERTICAL AXIS WIND TURBINE WITH AND WITHOUT BOOSTER

VISHAL KUMAR
M.Tech Schollar,,MIT,Bhopal
dineshvishwakarma004@gmail.com

Dr. Keerti Chaware
Professor MIT,Bhopal
kirtiudechaware@gmail.com

ABSTRACT :- Assessment of plastic Injection moulding process is important for the manufacturing of plastic products to achieve higher standards of quality and customized products. Designing an effective evaluation process for Injection moulding process itself is an intensive task and aims to intelligently combine process parameters that improve the competitiveness aspects of the Injection moulding process and may bring about improvement in the system. This thesis presents process parameters based multi-response optimization approach using hybridization Taguchi with Desirability function application as a tool to prioritize and ranking of Injection molding process parameters and to analyze an optimal process parameter settings evaluation of Injection molding process in plastic manufacturing industry perspectives. The aim is to encourage more efforts in this regard for more great benefits and applications.
Keywords: *Desirability Function, Minitab-16, Machine cycle time, Tensile Strength*

1.INTRODUCTION

Injection Molding is being used. John Wesley Hyatt and his brother Isaiah, both American inventors, came up with the idea for the machine in 1872 and patented it the following year. The machine was simple in comparison to the sophisticated equipment that is used nowadays. To inject plastic into a mould via a heated cylinder, it operated much like a big hypodermic needle, with a plunger being used to push the material forward. Plastic goods have not been used in the production of items needed in day-to-day life since 1978, despite the fact that the manufacturing technique of injection moulding is no longer in demand. Nevertheless, as time goes on, items made of plastic materials are gradually replacing those made of metals and non-metallic materials. The rise in industrialization and general societal progress over the last three decades is largely responsible for the meteoric rise in demand for
this particular piece of equipment. Toys, home goods, automobile components, and consumer electronics are all examples of things that are made using the injection moulding method since it is so prevalent in modern life. An injection moulding machine may also make containers buckets, plastic toys, plastic toys, goods for medical equipment, tiny plastic fasteners, and bottles, among other things.

When producing high-quality plastic goods, the producer will often take into consideration many components of the manufacturing process. The products have to be able to fulfil the requirements laid out by the customers, the amount of energy used and the cost of production have to be kept to a minimum, the mechanical properties of the plastic product, which are gained by the product during the processing and are dependent on the parameters, can be regulated to ensure that the product is free of flaws.

1.2 Historical context of the study

Injection moulding is the most adaptable method for the production of complicated plastic items. However, it is also the most labor-intensive method due to the fact that it can handle the intricate geometry of the products in an effective manner. Injection moulding operations, on the other hand, may occasionally provide the mould designer with a problem in terms of designing a mould that produces products with a low defect rate. This is due to the fact that plastics are readily useful even if they have faults of this kind. Warpage, shrinkage, weld lines, and air traps are all issues that may occur (Saman et al. [2009]) [1] Also, Molding materials having variable thermal characteristics that impact the mechanical qualities of plastic components during the injection moulding process. These attributes may be affected by mould materials. Molds may be made from a variety of materials, including steel, aluminium, and others; however, an aluminium mould offers several benefits in comparison to other mould types, including lower manufacturing costs, lower weight, and better heat transmission (Ozcelik et al. [2010]).[2] The design of plastic moulds is not only a vital step in the production process that is most usually utilised, but it is also necessary for controlling parameters in order to produce goods that are free of defects. The procedure of moulding the hot injection material involves letting it freeze within the mould before continuing. When the mould is opened, the finished product, which has now hardened into the form of a net, is ejected from it. Despite the fact that this procedure is straightforward, there are several factors involved in the manufacturing process, which makes it difficult to forecast the end product's level of quality (Mathivanan et al.) [2010]

[3]. As a consequence of this, the process of enhancing and testing in the research parameters to maximise the effectiveness of the injection moulding process that may be included into the process. In a general sense, there is an absolute need for an optimization process to be carried out. Inconsistencies might occur in the production process of plastic components because of erroneous information and a general lack of expertise.

The primary concern is ensuring that the potential hazards connected with the manufacture of plastic goods are identified and mitigated before the processing stage ever begins. Injection moulding is best solved using a predictive model method based on empirical data when the process variation is small enough to fit the proper location of the response within the diagnostic window. If this is not the case, then a different solution may be more appropriate. Experimenters often use a variety of methods, such as full factorial design, fractional factorial design, response surface technique, Taguchi approach, and others, when attempting to develop solutions for issues of this nature. The Taguchi method design is the one that is used since it requires a lower total number of tests, which in turn helps cut down on the amount of time and money spent on it.

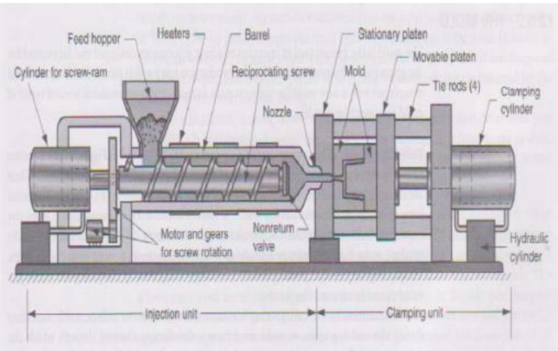


Fig. 1.1: Single screw injection molding machine

1.3 Variables pertaining to the operation of an injection moulding machine

The fundamental procedure may be broken down into many categories, including speed, pressure, duration, temperature, and stroke. As a result of a number of elements influencing the process, the connection between them is dynamic and interactive in character. As an illustration of this connection, one may show that the recovery time, melting temperature, and/or symmetry are all affected by the linear shrinkage speed (during recovery) of the screw when the hydraulic back pressure is increased.

Increasing the melt's temperature impacts not only the filling of the mould, but also the injection pressure, mould and product temperatures, and the product's final temperature. The machine was simple in comparison to the sophisticated equipment that is used nowadays. To inject plastic into a mould via a heated cylinder, it operated much like a big hypodermic needle, with a plunger being used to push the material forward. Plastic goods have not been used in the production of items needed in day-to-day life since 1978, despite the fact that the manufacturing technique of injection moulding is no longer in demand. Nevertheless, as time goes on, items made of plastic materials are gradually replacing those made of metals and non-metallic materials. The rise in industrialization and general societal progress over the last three decades is largely responsible for the meteoric rise in demand for this particular piece of equipment. Toys, home goods, automobile components, and consumer electronics are all examples of things that are made using the injection moulding method since it is so prevalent in modern life. It follows that as the pressure is raised, changes in one variable have a domino effect on three other significant variables (e.g. hydraulic backpressure). Specifically, the process and any components that may be moulded later on are affected. It is crucial to control the correct process variable in order to fix a process disturbance when making changes to a particular process variable or machine setting (which substantially impact the stability of the moulding process and result in the manufacture of rejected components). For instance, short moulding may occur if the hopper's throat temperature is set too low, leading to false conclusions about the need to adjust other variables (for eg. holding pressure and/or firing volume and/or speed filling the mould, etc.) to eliminate the problem. The right hopper throat temperature may prevent this issue from occurring. Although the process remained unsteady due to the incorrect initial selection, the moulder suggests the problem may be resolved by adjusting a different kind of variable. In this way, the issue would be solved. Despite this, the manufacture of components that are unsatisfactory and/or inconsistent will continue while the product is being made.

2. LITERATURE REVIEW

Both the injection moulding process's settings and its environment may have an impact on the final product's quality (discussed in section 2.1). Several factors, including processing temperature, processing length, pressure, and environmental conditions, might alter conditions during the injection processing phase. All of these parameters have the potential to influence the injection moulding process in some way, including the dimensional errors, mechanical quality, and manufacturing cycle times.

There has been a major transition away from the traditional injection moulding technique and toward the gas injection moulding process due to advancements in the moulding of larger, more complex parts. This shift has occurred throughout the last several decades (Guo et.al.[2014] [4]). Because frequent testing and inspections ensure that the machinery is in good working order. There still has to be a floor under the product's quality, however. When there are numerous unseen factors, such as variation in physical properties (for example, when regrind resins are used), changes in the ambient environment (for example, humidity or temperature in the shop), and characteristics of the machine, the procedure conditions are re-read to lower the quality of the part within the tolerance limit (especially when using hydraulic power). Many experts have spent the better part of the past two decades studying effective process control systems. These researchers have used automated and adaptive quality control in addition to specialised control methods to address the aforementioned challenges. The machine was simple in comparison to the sophisticated equipment that is used nowadays. To inject plastic into a mould via a heated cylinder, it operated much like a big hypodermic needle, with a plunger being used to push the material forward. Plastic goods have not been used in the production of items needed in day-to-day life since 1978, despite the fact that the manufacturing technique of injection moulding is no longer in demand. Nevertheless, as time goes on, items made of plastic materials are gradually replacing those made of metals and non-metallic materials. The rise in industrialization and general societal progress over the last three decades is largely responsible for the meteoric rise in demand for this particular piece of equipment. Toys, home goods, automobile components, and consumer electronics are all examples of things that are made using the injection moulding method since it is so prevalent in modern life. It is difficult to develop a practical method of control without first gaining a thorough understanding of the relationships between all of these factors (Chen and Tung [2005]) [5]. nThe specific effort required to locate the optimal solution is proportional to the impact that the parameters have on the answer. The injection pressure must be raised to account for the greater temperature of the molten material if it is too hot. The composition contains a biodegradable component, yet the melting point of that chemical is rather high. There may be a fast shot and a lot of flash within the material if the injection pressure can be maintained exceedingly low (Mok et. al.[1999]) [6]. Thus, to reduce defects as much as possible, it is preferable for the interaction between melting temperature and injection pressure to be larger than that between holding pressure and injection pressure (Kamaruddin et. al.[2010]) [7] .

Using the rotatable central composite design response surface approach, Hazwan et al. [2017] [25] investigate the Warpage as the response by taking into account melt temperature, packing pressure cooling time, and coolant temperature as process factors. According to the findings of their investigation, the temperature at which the material is cooled is the factor that has the greatest impact on the dimensional defect warpage. Researchers Villarreal Marroquin et al. [2011] [26] investigated the effects of melt temperature, packing pressure, Center composite design, and Latin Hypercube design of response surface approach on shrinkage and cycle time as responses. According to the findings of their investigation, melt temperature is a major factor in both cycle duration and shrinkage.

The combined reaction of warpage and clamp force is investigated by Yin et al. [2011] [27] . The melt temperature, mould temperature, packing pressure, packing duration, and cooling time are all process characteristics that are taken into consideration. The outcomes are then examined with the use of Backpropagation and a genetic algorithm. Their research showed that when packing pressure was raised, warpage decreased and a higher clamping force was needed to keep the material in the mould. Melt temperature, packing pressure, packing duration, and cooling time are all used by Mehat et al. [2012] [28] to calculate an approximation of the shrinkage defect. Taguchi's technique, in conjunction with GRA, is used to achieve this. It was determined that the melt temperature was the most useful processing parameter. Using injection velocity, injection time, and packing pressure as process parameters, Chen et al. [2008] [29] polled the same question in terms of product weight. Their investigation led them to conclude that increased pressure during packaging has a significant role in driving product weight up. Xu et al. [2015] [30] use particle swarm optimization and artificial neural networks to study the effects of warpage on polycarbonate plastic. They take into account the temperatures of the mould and the melt, as well as the injection velocity. According to the findings of the research, a significant amount of the Warpage may be attributed to the melting temperature. Gao and Wang [2009] [31] use the Kriging surrogate model to investigate study Warpage as a response. They use variables such as melt temperature, mould temperature, injection time, packing time, and packing pressure. According to the findings of the research, one of the contributing factors to the warping of plastic goods is the temperature at which the melt occurs.

3. DESIGN OF EXPERIMENTS AND ITS ASSOCIATED OPTIMIZATION METHODS

A test is considered to be planned if some relevant adjustments are made to an input variable of a process or system in order for changes in the response to be observed and recognised according to the output. This allows for a designed experiment to be carried out. Methods of experimental design are an extremely important component in the process of developing and enhancing procedures. "Designing for value" may be greatly aided by the careful planning and execution of experiments. When preparing experiments, researchers usually take into account the design of the experiment to answer certain questions. This serves as a viewpoint. These aspects of the design of experiments may be enumerated as follows

1. Does the usage of a product fulfil the purpose for which it was designed in a way that is both safe and effective?
2. Which aspects of the production process are responsible for the variations in the product's quality and accuracy?
3. Modifications made to the parameters of the process will have an effect on the manufacturing process.
4. Determine whether an immediate solution may be implemented to facilitate an improvement in the production process.
5. Is there a possibility that the interplay of the process parameters will have an effect on the final product's quality?
6. Under what conditions is it possible to carry out an effective experiment that, when accounting for both costs and the amount of time required, results in the best possible solution?

Experiments that may increase product quality while reducing costs and time spent making it should be performed in order to build a manufacturing process that is helpful. Methods that are referred to as process processing are those that are used to enhance both the quality of the design and the quality of the product itself. These methods are regulated by the parameters of the manufacturing process that are referred to as the processing of an item. Treatments and experimental units, which are given for treatment of the responses, may be used to describe a short experiment. The solution and treatment approach are going to be different depending on the units that are imposed and the responses that are assessed.

3.1 Definitions of Terms Employed in an Experiment

There are several different phases involved in the scientific study. It begins with the preliminary experiments, followed by the collecting of data, the conduct of experiments, the analysis of the data using various techniques as shown in Fig.3.1, and the discussion of the various words that had been used in experimental data. These terms are as follows:
Treatments: A treatment is any of a number of possible treatments that are evaluated for its effect on the patient. The terms "experimental units" and "units of experiment" refer to the same thing. Experimental units are the objects that are applied to the therapy. Responses are the findings measured after applying treatment in a pilot experiment. Responses are also known as responses. The answer provides an accurate account of what took place throughout the experiment.

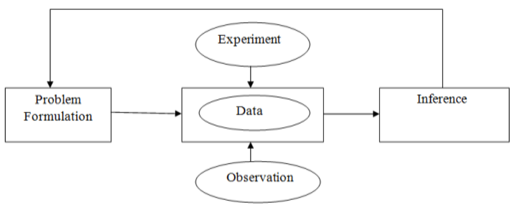


Fig. 3.1 Critical stages of Statistical input in scientific investigations

3.3 Taguchi's Method

The all-encompassing quality control system that Taguchi developed is one of the most significanttechnical accomplishments of the 20th century. This approach places more of an emphasis on the practical implementation of engineering concepts as opposed to more complex statistical methods. It encompasses quality engineering at both the upstream and shop floor levels. Upstream approaches include conducting trials on a smaller scale in order to minimise variability in an effective manner while still preserving designs that are both cost-effective and resilient for mass production and the market. The technology used on the shop floor offers ways for quality control and maintenance that are both cost-effective and real-time. When a quality approach is adopted up front, it not only has numerous benefits over improvements, but it also decreases both the cost and the amount of time required.

Taguchi does not agree with the conventional interpretation of the term "quality." He uses the divergence from the on-target display as an example of what he means by "quality." He has articulated an unique conception of what constitutes product quality. According to him, "the quality of a manufactured product is the total loss that is generated by society by that product, which is sent from that time, apart from any damage caused by internal work." In other words, the quality of a manufactured product is the total loss that is generated by society by that product. The term "Taguchi from loss" refers to the loss that occurs as a result of the variable nature of the function and the damage that is brought on by adverse side effects. Even if the product is untrue or does not fall within the parameters of the specification, if the goal value of the product is exceeded, that product will be held responsible for the loss. Dr. Taguchi suggests using a three-part approach in order to accomplish the product quality goals that were set forth in the design phase.

4. EXPERIMENTAL PERFORMANCE

4.1 Method based on experimentation and feedback

In order to have a better knowledge of the phenomena, a number of experiments are carried out. It is possible to accomplish this by attentively observing the measurements taken after each experiment. Then, through an analysis of the data gathered, one can determine "which parameters should be regulated and how many" in order to get the result that is desired. This is how one can accomplish the goal. If this strategy is chosen, the experiment's parameters that need to be altered will not be available for selection. Given these circumstances, the data that are currently available are insufficient to draw any significant conclusions. For the reasons stated above, it is clear that this strategy cannot be used. A planned experiment is a methodical strategy that uses controllable variables as input components in a process. These experiments are incredibly beneficial in determining which factor in the process is the most important in determining how the quality features of interest are affected. The experimental design is analysed concurrently for two or more parameters to determine the extent to which each of those elements may impact the ensuing average or the variability of a certain set of product or process characteristics. A planned experiment is a methodical investigation that includes a variety of input parameters that are subject to controlled variation. One of the most common forms of designs is known as a factorial design. In this style of design, the levels of the various factors are varied in such a manner that every conceivable combination of factor levels is investigated. The outcomes of various test combinations have been noticed, and the whole set of findings is being examined to discover effective variables and preferable level combinations.

Taguchi, on the other hand, divides optimization issues into two distinct categories: static problems and dynamic problems. In most cases, there are numerous control elements in a process that may be adjusted, each of which directly affects either the goal value of the output or the actual value of the output. The process of optimising a system entails selecting the optimal value for each control component so that the desired amount of output may be realised. A issue of this kind is referred to be a static problem. If the product that has to be adapted is a signal input that directly chooses the output, then optimization entails establishing the optimal control factor in such a way that the ratio of the input signal to the output is closed in accordance with the intended relationship. A issue of this kind is referred to as a dynamic problem.

4.1.1 Development of the experimental design and setup

The Taguchi technique is intended to enhance the quality of the product as well as the process, both of which are areas in which performance is dependent on a variety of elements. Selecting the fewest feasible elements to use in the experimental design was the starting point. However, there is a great number of conceivable combinations including many other aspects when it comes to engineering tasks. Aside from this, high-order interactions could be required to impact certain parameters for certain projects. Using a time-honored approach to cut down on the amount of possible test combinations of tests, which is also referred to as partial factorial experiments. Taguchi was the one who developed a specific set of generic designs for use in factorial trials. When these arrays are used, it is easier to identify the minimum number of tests that are necessary for a certain set of factors. When all elements involve a certain number of levels and dialogues are negligible, then ordinary orthogonal arrays will be able to fulfil the demands of the procedures that entail the most experimentation. In the event that there is a mixed level, it will be essential to make adjustments to the orthogonal array, and there will be instruments.

4.2 Carry out an Experiment Making Use of an Orthogonal Array

In order to ensure that tests are carried out in the most effective manner, it is necessary to design them using a scientific methodology. The statistical design of experiments is used to arrange the procedure of the experiment so that relevant data may be gathered and evaluated using statistical techniques, which will ultimately lead to results that are legitimate and objective. A statistical technique is the only kind of study that should be performed when the issue at hand contains data that might be affected by experimental error. In light of this, an experimental challenge may be broken down into two categories the first is the design of the trials, and the second is the statistical analysis of the results.

Fig. 4.1: Injection molding machine uses for Experiment (CIPET)

4.3 Workpiece material

The polymerization of propane results in the production of polypropylene, which is the most versatile thermoplastic polymer that is currently available on the market. It is a homopolymer of polypropylene with the number M110 that was created using the Spheripol Technology. India's Haldia Petrochemical India Pvt. Ltd. is the company that supplies it. Table 4.3 contains the following descriptions of the characteristics of M110 polypropylene:

Table 4.3 – Material Properties

S. No.	Specification	Unit	Value
1.	Melt Flow Index	g/10 min	11
2.	Density	g/cm3	0.90
3.	Tensile Strength at Yield	MPa	34
4.	Tensile Elongation at Yield	%	9
5.	Flexural Modulus	MPa	1450
6.	Izod Impact Strength	J/m	30
7.	Vicat Softening Point (10N)	0C	154
8.	Heat Deflection Temperature (0.46 N/m2)	0C	99

4.4 Selection of process parameters and their level selection for the study

Some pilot experiments were carried out based on the findings of an extensive literature review, specifically referring to some papers such as Gu, F. et. al. [2014], Nian, S. C. et. al. [2015], etc., as well as based on the discussion with specialists in the field and on the basis of personal experience. These findings were gleaned from the personal experience. A range of process parameters, along with the process parameters themselves, as well as their levels, have been decided upon for the purpose of conducting an experiment. This was done with additional consideration given to the directives included in the operator's manual that was supplied by the manufacturer of the injection moulding machine. To investigate the effect that the primary process parameters, including melt temperature, injection pressure, packing pressure, and packing time, have on the mechanical properties of the PP plastic product, a first pilot experiment is going to be conducted using the 4 Parameters and L-9 Orthogonal array. One more parameter, cooling time, was included based on the suggestion of a group of experts and the L-27 experiment, and another literature survey was done to include more main parameters and study main causes like warpage dimensional defect.

5. EXPERIMENT DATA ANALYSIS

5.1 Polypropylene that has never been used is comprised

Melt temperature, packing pressure, injection pressure, and packing duration were all chosen as process factors, and three levels each were tested using a Taguchi orthogonal array to organise the trials. Results from nine separate trials using 100% virgin polypropylene are summarised in Table 4.8.

Table 5.1 -Process Parameters and levels for Virgin polypropylene 100 %

Process Parameters	Abbreviation	Level 1	Level 2	Level 3
Packing pressure MPa	PP	40	50	60
Injection pressure MPa	IP	20	25	30
Melt temperature ^{0}C	MT	220	230	240
Packing time in Sec	PT	4	8	12

5.2 Multi-response optimization of 100% Virgin Polypropylene composition with hybridization of Taguchi with Desirability Function

For each unique combination of quality attributes, a unique Desirability index is computed in order to describe the level of desirability. According to this research, a higher tensile strength indicates a better kind of material, but a lower cycle time indicates a better type of material.

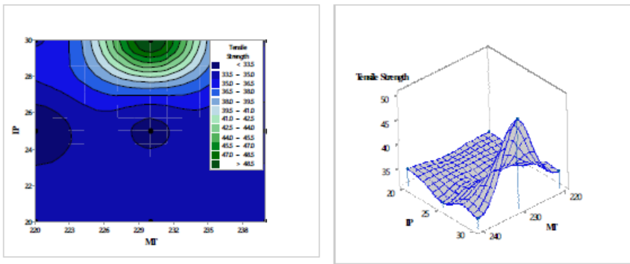
5.2.1 Value of desirability analysis and determination

Each characteristic is then translated into a preference scale that ranges between 0 and 1 with the assistance of Equations no. 3.25 and 3.26. The desired value for the tensile strength may be derived using Eq.3.25 as a starting point. The equation 3.25 is used to determine the length of the cycle. Because the Tensile Strength has a stronger correlation with the better type qualities, and the Cycle time has a lower correlation with the better type features. As an example, a target value is agreed upon for sample 1 based on the cycle time experimental value data. The tensile strength of sample 1 was measured at the intended value of T=49.83, and the lower value was measured at L=32.33. Then, by using the formula Eq.3.25 d1= ((y-L)/(T-L))r, you may get the following results: The formula for calculating it is: (Y-32.333)/(49.83-32.333)=.928571, where Y is the value of the tensile strength that was experimentally determined to be 34.307. Using the same method, the value of the cycle time may be determined with the assistance of Eq.3.26. After that, the value of desirability is computed, and the results are given in Table 5.18. Consequently, desirability levels d1.

6. RESULT AND DISCUSSION

6.1 Polypropylene is 100%

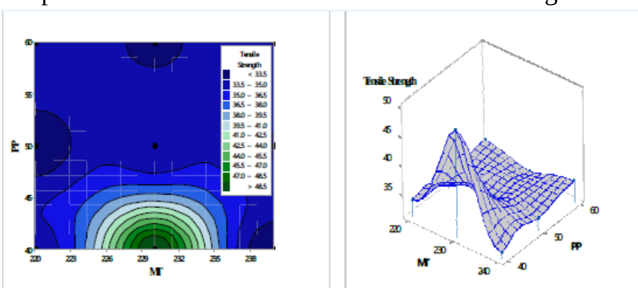
Both the contour plot and the surface plot of the tensile strength in respect to the processing parameters IP and MT are shown in figure 6.1. Figure 6.1.a shows the contour plot, while figure 6.1.b shows the surface plot. It is clear from looking at this figure that in order for thin shell semi-crystalline plastic materials to attain their optimum tensile strength, the injection pressure must be raised to a high level and the melt temperature must be raised to a moderate level.



(a) (b)

Fig.6.1: (a) Contour Plot and (b) Surface Plot for Injection Pressure (IP) Vs. Melt Temperature (MT) for Tensile Strength of Virgin Polypropylene

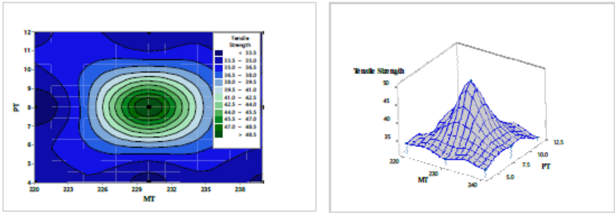
Both the contour plot and the surface plot of the tensile strength in response to the processing parameters PP and MT are shown in Fig.6.2 (a) and Fig.6.2 (b), respectively. It is clear from looking at this figure that the optimal conditions for achieving optimum tensile strength in thin shell semicrystalline plastic materials are to have the packing pressure be relatively low and the melting temperature be somewhere in the middle of the range.



(a) (b)

Fig.6.2: (a) Contour Plot and (b) Surface Plot for Packing Pressure (PP) Vs. Melt Temperature (MT) for Tensile strength of Virgin Polypropylene

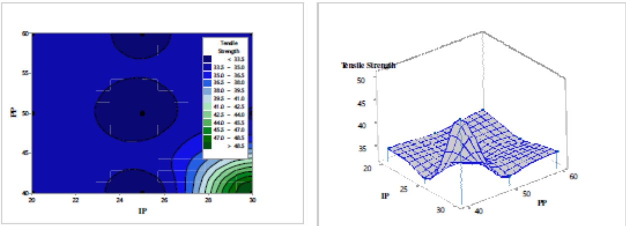
The contour plot of tensile strength in relation to the processing parameters PT and MT is shown in figure 6.3 (a), and the surface plot of tensile strength is depicted in figure 6.3 (b). It is clear from looking at this figure that the optimal conditions for achieving optimum tensile strength in thin shell semi-crystalline plastic materials are to have the packing temperature set at a medium level and the melting temperature set at an identical medium level.



(a) (b)

Fig.6.3: (a) Contour Plot and (b) Surface Plot for Packing Temperature (PT) Vs. Melt Temperature (MT) for Tensile strength of Virgin Polypropylene

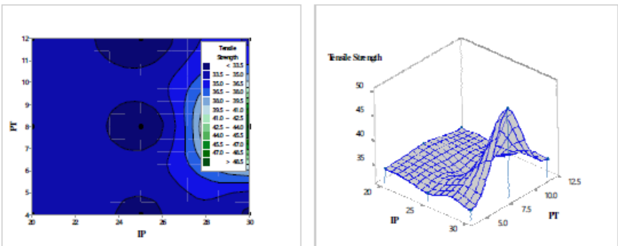
Both the contour plot and the surface plot of the tensile strength in response to the processing parameters PP and IP are shown in Fig.6.4 (a) and Fig.6.4 (b), respectively. In thin shell semicrystalline plastic materials, the greatest tensile strength may be attained at Injection Pressure, at a high level, and Packing Pressure, at a low level, as shown in the figure. This can be seen by comparing the Injection Pressure to the Packing Pressure.



(a) (b)

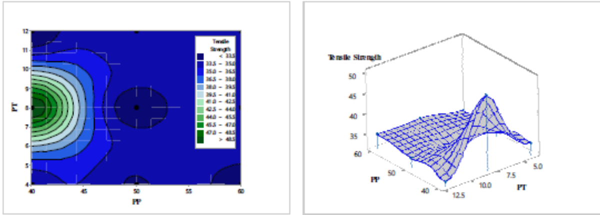
Fig.6.4: (a) Contour Plot and (b) Surface Plot for Packing Pressure (PP) Vs. Injection Pressure (IP) for Tensile Strength of Virgin Polypropylene

The contour plot of tensile strength in relation to the processing parameters PT and IP is shown in figure 6.5 (a), and the surface plot of tensile strength is depicted in figure 6.5 (b). It is clear from looking at this figure that the tensile strength of thin shell semi-crystalline plastic materials may be optimised by increasing the injection pressure to a high level and increasing the packing time to a medium level.



(a) (b)

Fig.6.5: (a) Contour Plot and (b) Surface Plot for Packing Time (PT) Vs. Injection Pressure (IP)for Tensile Strength of Virgin Polypropylene



(a) (b)

Fig.6.6 (a) represents the contour plot and Fig.6.6 (b) represents the surface plot of Tensile Strength in relation to the processing parameters PT and PP. From this figure, it can be observed that maximum Tensile Strength can be achieved at Packing Time, at medium level and Packing Pressure, at a low level for thin shell semi-crystalline plastic materials.

6.2 Optimal combination of process parameters with the help of Taguchi with Desirability Function

On the basis of the total desirability value calculation described in chapter 5, figure 6.8 is shown here. As a result of its Melt Temperature being at Level 2, Packing Pressure being at Level 3, and Injection Pressure also being at Level 3, Packing Time being at Level 1 has a greater attractiveness value.

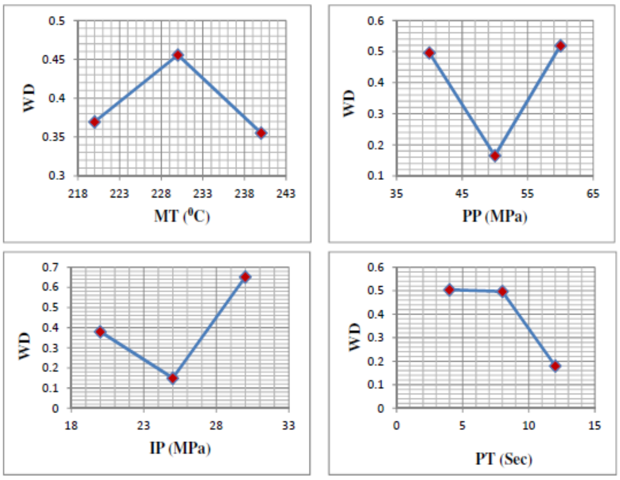


Fig. 6.7 Evaluation of optimal setting for overall desirability Value for Virgin Polypropylene

Table 6.1- Optimal setting for the 100% Virgin Polypropylene Composition by Desirability Function

Melt Temperature (^{0}C)	Injection Pressure (MPa)	Packing Pressure (MPa)	Packing Time (Sec)
230	30	60	4

6.3 Confirmation Test

For the purpose of carrying out the confirmation test based on a higher desirability value from Fig.

6.32, the melt temperature was set at 230 degrees Celsius, the injection pressure was set at 30 megapascals, the packing pressure was set at 60 megapascals, and the packing time was set at four seconds. This resulted in a tensile strength of 51.34 megapascals and a cycle time of 22 seconds (Table 6.2).

Table 6.2- Optimal setting for the Tensile Strength and Cycle Timefor Virgin Polypropylene

Melt Temperature (^{0}C)	Injection Pressure (MPa)	Packing Pressure (MPa)	Packing Time (Sec)	Tensile Strength (MPa)	Cycle time (Sec)
230	30	60	4	51.34	22

The error of experiment was found to be 3% after a confirmation test and an experimental run, which demonstrates that this method is appropriate for the maximisation of tensile strength and the minimization of cycle time of the plastic products. According to the findings of the investigation, both approaches are appropriate for the procedure.

6. CONCLUSIONS & FUTURE WORK

6.1 CONCLUSION

From the optimizational study the concluding remarks drawn are as follows:

1. Tensile Strength can be maximum.
2.Melt temperature at 2300C and 30 MPa injection pressure
3. Melt temperature at 2300C and packing Pressure at 40 MPa
4. Melt temperature at 2300C and 7.5 sec .packing time
5. Injection pressure 30 MPa and 40 MPa packing pressure
6. Injection pressure 30 MPa and 7.5 sec. packing time

REFERENCES

[1] Saman, A. M., Abdullah, A. H., & Nor, M. A. M. (2009, November). Computer simulation opportunity in plastic injection mold development for automotive part. In Computer Technology and Development, 2009. ICCTD'09. International Conference on (Vol. 1, pp. 495- 498). IEEE.

[2] Ozcelik, B. (2011). Optimization of injection parameters for mechanical properties of specimens with weld line of polypropylene using Taguchi method. International Communications in Heat and Mass Transfer, 38(8), 1067-1072.

[3] Mathivanan, D., Nouby, M., & Vidhya, R. (2010). Minimization of sink mark defects in injection molding process–Taguchi approach. International Journal of Engineering, Science and Technology, 2(2), 13-22.

[4] Guo, W., Mao, H., Li, B., & Guo, X. (2014). Influence of processing parameters on molding process in microcellular injection molding. Procedia Engineering, 81, 670-675.

[5] Chen, Z., & Turng, L. S. (2005). A review of current developments in process and quality control for injection molding. Advances in Polymer Technology, 24(3), 165-182.

[6] Mok, S. L., Kwong, C. K., & Lau, W. S. (1999). Review of research in the determination of process parameters for plastic injection molding. Advances in Polymer Technology: Journal of the Polymer Processing Institute, 18(3), 225-236.

[7] Kamaruddin, S., Khan, Z. A., & Foong, S. H. (2010). Application of Taguchi method in the optimization of injection moulding parameters for manufacturing products from plastic blend. International Journal of Engineering and technology, 2(6), 574.

[8] Parey, A., & Tandon, N. (2007). Impact velocity modelling and signal processing of spur gear vibration for the estimation of defect size. Mechanical systems and signal processing, 21(1), 234-243.

[9] Pandey, R. K., & Panda, S. S. (2014). Optimization of bone drilling parameters using greybased fuzzy algorithm. Measurement, 47, 386-392.

[10] Singh, S., Singh, I., & Dvivedi, A. (2013). Multi objective optimization in drilling of Al6063/10% SiC metal matrix composite based on grey relational analysis. Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture, 227(12), 1767-1776.

[11] Saurabh Kumar Gupta, K. N. Pandey, Rajneesh Kumar "Effect of Process Parameters on Temperature distribution of Friction Stir Welding of Dissimilar AA5083 and AA6063 Aluminum Alloys" International Conference on Friction based Processes (ICFP-2014), Indian Institute of Science (IISc) Bangalore, 04-06 September 2014.

[12] Srinivas Rao, U. and Vijayaraghavan, L. (2013). Determination of minimum uncut chip thickness in mechanical micro-machining using johnson-cook fracture model. International Journal of Mechatronics

[13] Dang, X. P. (2014). General frameworks for optimization of plastic injection molding process parameters. Simulation Modelling Practice and Theory, 41, 15-27.

[14] Ramesh, G., & Reddy, M. Y (2015). Minimization of Sink Mark Defects in Injection Moulding Process. International Journal of Advanced Engineering and Global Technology, 3, 988-996.

[15] Mathivanan, D., Nouby, M., & Vidhya, R. (2010). Minimization of sink mark defects in injection molding process–Taguchi approach. International Journal of Engineering, Science and Technology, 2(2), 13-22.

[16] Erzurumlu, T., & Ozcelik, B. (2006). Minimization of warpage and sink index in injectionmolded thermoplastic parts using Taguchi optimization method. Materials & design, 27(10), 853-861.

[17] Ozcelik, B., Ozbay, A., & Demirbas, E. (2010). Influence of injection parameters and mold materials on

mechanical properties of ABS in plastic injection molding. International Communications in Heat and Mass Transfer, 37(9), 1359-1365.

[18] Tsai, K. M., Hsieh, C. Y., & Lo, W. C. (2009). A study of the effects of process parameters for injection molding on surface quality of optical lenses. Journal of materials processing technology, 209(7), 3469-3477.

[19] Galantucci, L. M., & Spina, R. (2003). Evaluation of filling conditions of injection moulding by integrating numerical simulations and experimental tests. Journal of materials processing technology, 141(2), 266-275.

[20] Karasu, M. K., Cakmakci, M., Cakiroglu, M. B., Ayva, E., & Demirel-Ortabas, N. (2014). Improvement of changeover times via Taguchi empowered SMED/case study on injection molding production. Measurement, 47, 741-748.