Open access Journal International Journal of Emerging Trends in Science and Technology

Design of Ejection System in Transfer Mould Tool and Justifying Material Selection of Rubber Bumper Spring Component

Authors

Akash N[1], Hemanth R[2]

[1]Student, Dept. of PG studies, Govt. Tool Room & Training centre, Mysore, Karnataka, India
[2] Lectures, Dept. of PG studies, Govt. Tool Room & Training centre, Mysore, Karnataka, India

Abstract

There are more advanced quality and productivity requirements on rubber products. Transfer moulding remains the most popular method for producing the associated rubber parts. The main phases in a transfer moulding process involve filling, cooling and ejection. The properly determined gate location leads to better resin flow and shorter delay time, for that multi gating system is induced to bring down the defects in the component. The design of ejection system is one of the major considerations and adopting the air blow ejection by manual pneumatic switch (MPS) to achieve proper ejection of the component from the transfer mould. The material for rubber bumper spring is NR/BR (Natural/Polybutadiene) Rubber blend. Designing of mould is carried out by using computer aided designing software solid works 13.

Keywords: *Transfer mould, Gating location, Ejection system, NR/BR (Natural/Polybutadiene) Rubber blend*

1. INTRODUCTION

The rubber products manufacturing industry has been growing very rapidly in recent years. This growth will be accelerated by the tendency to substitute rubber for plastics, which is appearing throughout the world. The transfer moulding process is the most popular moulding process for making elastomer parts. The conceptual design of transfer moulding part is a highly iterative process. It involves a practical knowledge about areas of customer needs, part design requirements, material selection, and mold design features, mold making processes, moulding equipment and production economics. The transfer moulding process requires the use of press, raw elastomer material, and a mould [1].

2. TRANSFER MOULDING

Moulding is the process of manufacturing by shaping raw material using a rigid frame or model called a pattern [1]. A mold or mould is a hollowed-out block that is filled with a liquid like plastic, glass, metal, or ceramic raw materials. The liquid hardens or sets inside the mold, adopting its shape [1]. Transfer injection moulding is a process where the amount of molding material is measured and inserted before the molding takes place. The molding material is preheated and loaded into a chamber known as the pot. A plunger is then used to force the material from the pot through channels known as a sprue and runner system into the mold cavities. The mold remains closed as the material is inserted and is opened to release the part from the sprue and runner. The mold walls are heated to a temperature above the melting point of the mold material. This allows a faster flow of material through the cavities [1]. Cost of transfer mould is low, high dimensional tolerance can be obtained and little scrap/ waste [1].

- Transfer chamber opened, elastomer inserted
- Transfer chamber closed
- Mould is closed under high pressure
- Removal of the moulded articles, cleaning of the transfer chamber

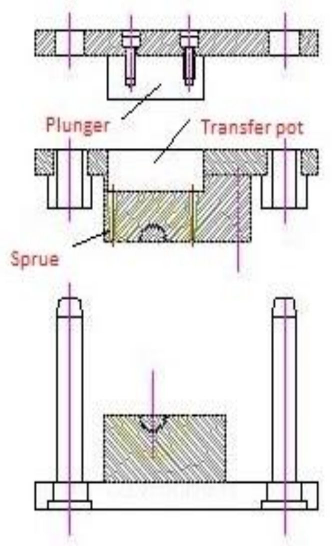

Fig-1: Transfer molding

3. NR/BR BLEND MATERIAL

Polybutadiene rubber (BR) is characterized by its superior abrasion resistance, so that blends of NR and BR that combine the excellent processing and physical properties of the former with the superior abrasion resistance of the latter are largely used in the industry in the production of tyre treads and conveyor belts. Natural rubber has a good tensile and tear strength and Polybutadiene rubber has a superior abrasion resistance. By changing the vulcanization temperature from 140-160 degree Celsius, which decreases all the mechanical property like tensile strength and elongation at break by increasing the hardness of the component [2]. Blending of elastomers is widely 2766hysic2766ed to improve the processing characteristics and 2766hysic-mechanical properties and to reduce the cost of individual rubbers [3]. Polybutadiene Rubber (BR) has better abrasion resistance than natural rubber (NR), and hence blends of BR and NR are extensively used in the manufacturing process [4]. Under mechanical stress, temperature, moisture, radiations, and aggressive environments, material performances decrease over the time. The alteration of use properties is named “aging” [5]. To reduce the cost and to improve the mechanical properties, thermal aging at ambient temperature has been observed in natural rubber elastomers [6]. Bristow et al. analyzed the changes in properties on NR/BR blends after thermal aging [7], and Mallik et al. studied the thermal aging effect on the physical properties of NR/BR blends at different blending ratios [8]. Saeed Taghvaei et al. studied the Increasing in aging time can affect on rheological, mechanical and thermal properties of cured rubber compounds by thermo gravimetric analysis and rheological measurement [9]. Karak et al. analyzed the hardness of the blends is not much affected by weight fraction of individual component. The results shows the hardness variation of 64-66 shore and BR has lower cure efficiency than NR, since NR contains some basic proteinous substances and also the methyl group in NR enhances the curing process, thus the cure rate steadily decreases with increasing BR content in the blends [10]. The cure characteristics, network structure and vulcanizate properties of 50/50 NR/BR blend. Having conventional curing systems produce a large proportion of polysulphidic crosslink's. This produces a reverting cure in most cases. NR/BR blend of ratio 50/50 have a good curing rate, excellent impermeability, good weather ability [11]. The blend of NR/BR increases the Rheological property, i.e. the study flow of matters in liquid and soft solid state [12].

4. METHODOLOGY

Components are modeled using the CAD software Solid Works 2013. Component has a Hallow cylindrical structure with dimensions: Outer diameter 77.3 mm, Inner diameter 27.54 and length 200 mm as a molded part was used. Component has continuous ribs as shown in the figure and other details of model are given below

Component Name: Main body part
Material: NR/BR blend
Shrinkage: 1.7-2%
Moulding type: Single Cavity transfer mould tool
Tonnage required: 100 tonnage capacity
Density: 0.98 g/cm3
Projected Area of component: 4208.35 mm2 (From CAD Model)

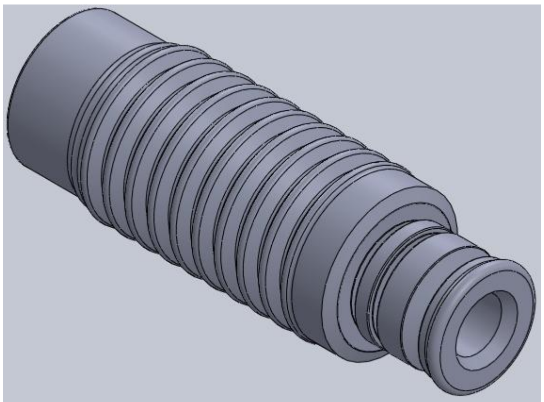

Fig-2: Component 3D model

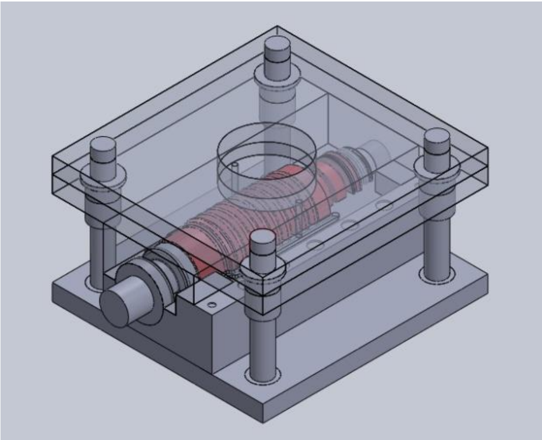

Fig-3: Component in the tool

Hydraulic presses are accepted in many industries because of their wide range of use. They are able to produce significant force, ranging from 10 through 200 tons. Hydraulic presses provide force through the use of fluid pressure on a piston by means of manual or powered pumping element. The power source provides the ability for infinite adjustment of stroke, speed, length and pressure while staying within the limits of press capacity. To carry out the process we are opting for 100 ton hydraulic press of swept volume 482cc and injection pressure of 1575kg/cm².

5. Gate

A small opening which connects the runner and cavity is called as gate. When designing transfer mold the size and location of the gate is one of the most important considerations for correct moulding of the part. Incorrect gate positioning can result in uneven filling, over packing, and dimensional instability of the part. Incorrect selection of the gate size can result in an inability to fill the part, inability to thermally shut off the gate, dimensional instability or internal stresses in the part. It is important in selecting the optimal gate size and location is the choice of the type of gate. Gate types can be divided between manually and automatically trimmed gates [13].

Manually trimmed gates are those that require an operator to separate parts from runners during a secondary operation. The reasons for using manually trimmed gates are: The gate is too bulky to be sheared from the part as the tool is opened. Some shear-sensitive materials should not be exposed to the high shear rates inherent to the design of automatically trimmed gates [13].

Gate types trimmed from the cavity manually include:

· Sprue gate
· Edge gate
· Tab gate
· Overlap gate
· Fan gate
· Film gate
· Diaphragm gate
· External ring
· Spoke or multipoint gate

Automatically trimmed gates incorporate features in the tool to break or shear the gate as the moulding tool is opened to eject the part. Automatically trimmed gates should be used to avoid gate removal as a secondary operation, maintain consistent cycle times for all shots and to minimize gate scars.

Gate types trimmed from the cavity automatically include:

· Pin gate
· Submarine (tunnel) gates
· Hot runner gates
· Valve gates [13].

The most common gate type is direct pin point gating, which offers the simplest construction and high reliability. The gate is of pin point, leaving a very negligible mark on the surface of the component.

Design of feed system

a) Runner Diameter

$$D = \frac{\sqrt{W_s} \times \sqrt[4]{l}}{3.7}$$

Where l= length of the component=200mm

$$D = \frac{\sqrt{196.4} \times \sqrt[4]{200}}{3.7}$$

D=14.24mm

(From MTN KALIP COMPANY, ISTANBUL, TURKYE)

Using the Chart provided by the company for weight of 320 gms and length of 200mm, the diameter of runner will be 7.48×1.29=9.28~9mm

b) Gate width

$$W = \frac{n \times \sqrt{A}}{30}$$

Where n= material constant=1.0

$A = \frac{\pi \times 62.1^2}{30}$ Where A= Area of the cavity

A= 3028.8 mm²

$$W = \frac{1.0 \times 55.035}{30}$$

W=1.835~2mm

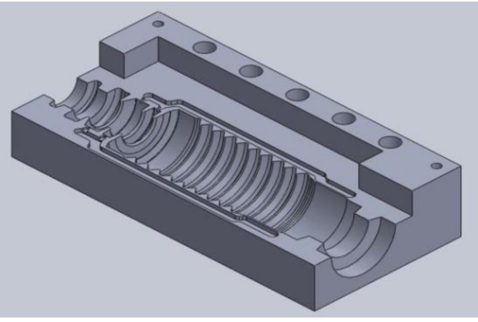

Fig-4: 4 gated bottom cavity

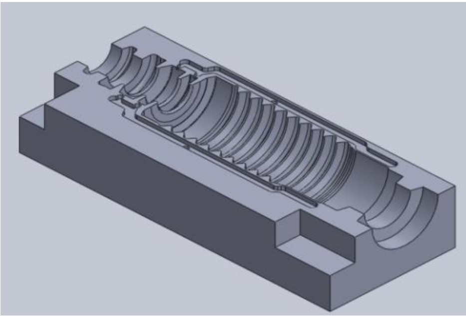

Fig-5: 4 gated top cavity

Fig 4 and fig 5 shows the 4 gated top and bottom cavity, primary design is carried out with 4 gates at the top end of the component. During the trail out of the manufacturing the filling time of the component in the transfer mould tool was 4 minute 20 sec. further optimization of gating system is done to cut off the filling time of the component.

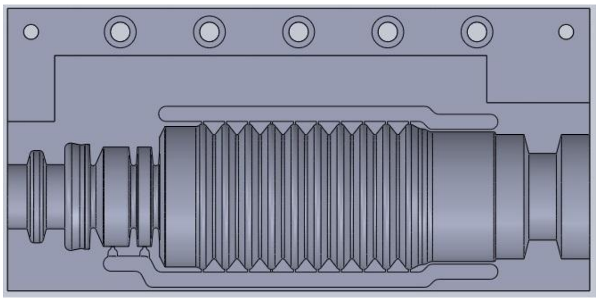

Fig-6: Multi gated bottom cavity

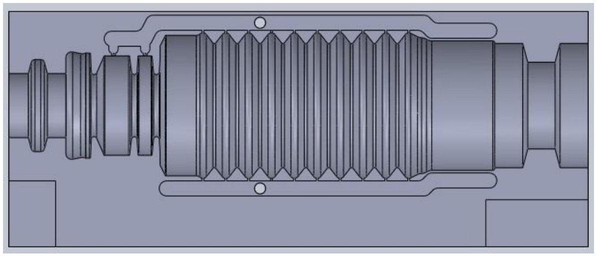

Fig-7: Multi gated top cavity

Optimization of the gating system is carried out by adopting more number of gates. Two gates are provided at the top end of the component and gating is done in the each ribs of the component. Due to the complex shape and the criticality of the component, gates are provided at each rib as shown in the fig 6 and fig 7. By optimizing the gating system the filling time of the component in the transfer tool is reduced to 1 minute.

6. EJECTION SYSTEM

An ejection is very much necessary in order to eject the moulded part from the tool. The design of ejection system is one of the major factors, how efficiently the tool will be in production. The cavity is divided in two mold halves in such a way that natural shrinkage of moulding causes the part to stick moving half when mold open. Step by step ejection of the component is illustrated with the help of figures as shown below [13].

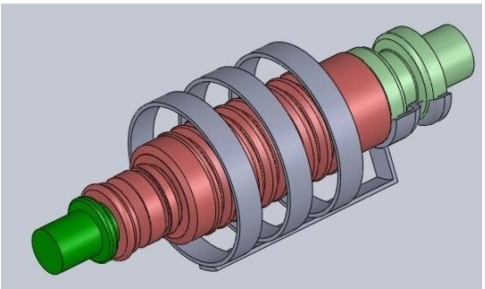

Fig-8: core, component with ejection holder

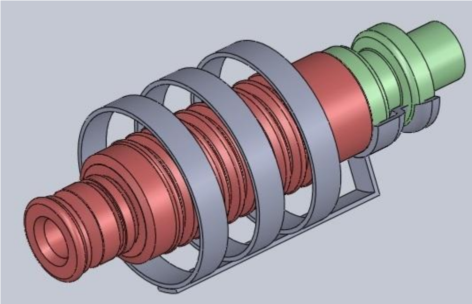

Fig-9: Dissembled core, component with ejection holder

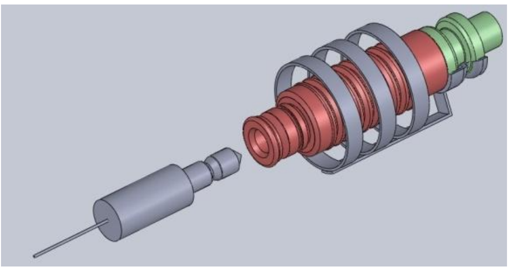

Fig-10: MPS placing into the component

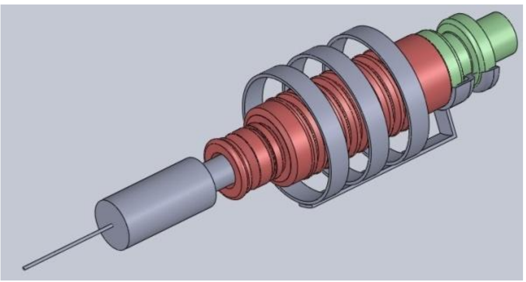

Fig-11: MPS placed into the component

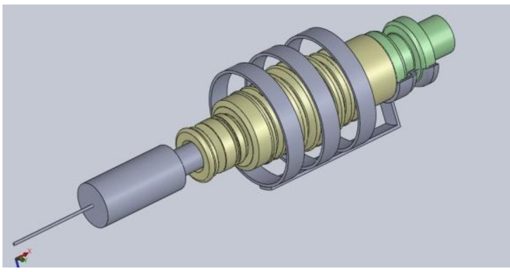

Fig-12: component expanded at the centre

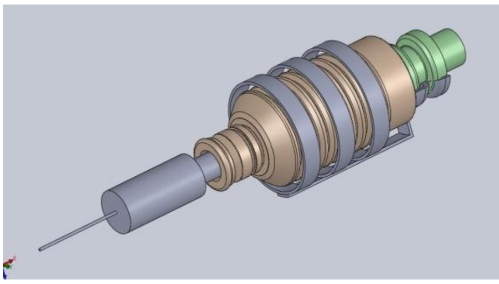

Fig-13: component expanded completely

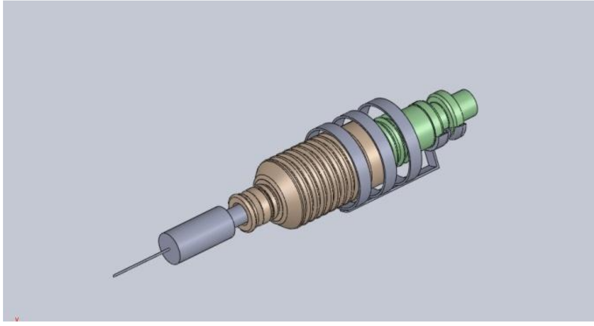

Fig-14: component ejecting out

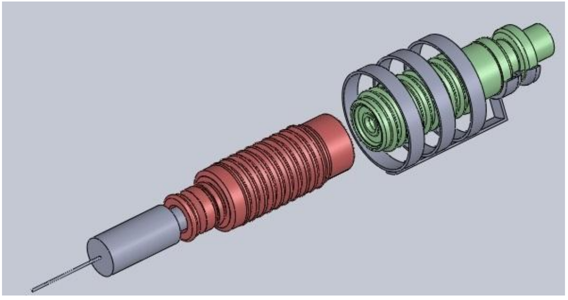

Fig-15: component ejected out

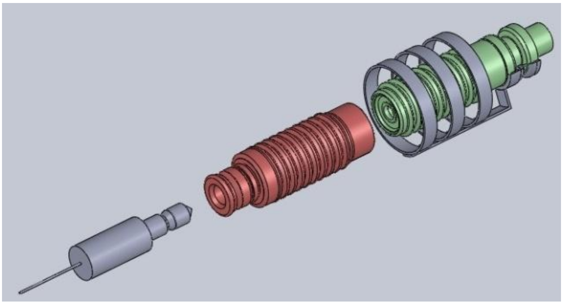

Fig-16: Complete ejection of component

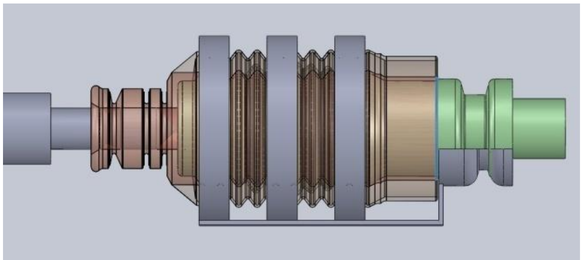

Fig-17: component expansion

Ejection process is illustrated with the help of fig 8 to fig 17, after the opening of the die, the core containing component is placed in the ejector handle then the core 1 is dissembled. Manual pneumatic switch having nozzle at the end is inserted into the component and air pressure of 2 bars is applied. Firstly stared using 1 bar pressure there faced problem ejecting component so the air pressure is increased to 1.5 but achieved at 2 bar pressure, by using more air pressure like opting for 5 bar lead to puncher of the component. Here ejection is done by placing nozzle of MPS into component then 2 bar air pressure is applied, there can observe expansion at the centre of the component and air pressure inside the component is exhausted at the rear end of the component making it to expand and the component is ejected easily out from the core

7. CONCLUSION

The work deals with the design of gating location and ejection system of transfer mould tool. By adopting multi gating system, filling time is reduced from 4 minute 30 sec to 1 minute. Easy ejection is achieved by using Manual pneumatic switch and maintaining the air pressure at 2 bars. Quality product at considerable cost can be achieved by transfer mould tool. 50/50 ratio NR/BR blend gives reasonable mechanical properties.

REFERENCES

1. **Krell.** Production of rubber moulding by injection transfer moulding, volume 195, page 1-19.
2. **D Zaimova, E Bayraktar, D Katundi**, Effect of processing condition on the physical, mechanical and viscoelastic properties, volume 50 issue 2, page 81-91, February 2012.
3. **L. M. Robeson**, Polymer Engineering and Science, 24 (1984) 587.
4. **R.J.Crawford,** Plastics and Rubber Engineering Design and Applications (Mechanical-Engineering Publications Ltd, London, 1985) p. 69.
5. **M. Dos Santos, PAZ. Suarez and J. C. Rubim**, Polym Degrad Stab 90 (2005) 34.
6. **R. L. Warley and J. Halladay**, Polym Test 24 (2005) 678.
7. **G. M. Bristow and C. Metherell,** Rubber Ind 7 (1973) 252.
8. **A. K. Mallik and R. D. Shah**, Indian Rubber Manufactures' Research Association, Thana (1983) 31-43.
9. **Saeed Taghvaei Ganjalia, FereshtehMotieea**, A Study of Aging Properties of Uncured NR/BR Blends: Using TG-DTG Technique, Vol. 2, No. 4, 2011.
10. **N. Karak and B.R. Gupta,** Effects of Different Ingredients and Cure Parameters on Physical Properties of a Tyre Tread Compound, vol-2 ,1-2/2000.
11. **Rani Joseph, George Joseph, Thomas**, Studies on the Cure Characteristics and Vulcanizate Properties of 50/50 NR/BR Blend, Vol. 12,1987, pp. 53-64
12. **FereshtehMotiee, SaeedTaghvaei-Ganjali-** Investigation of correlation between rheological properties of rubber compounds based on NR/BR rubber with their thermal behaviors, 22 February 2013, doi: 10.1186/2228-5547-4-16.
13. **R.G.W. Pye,** Injection mould design text book, ISBN 81-7671-0105

Author Profile

I am **Akash N**, Doing M.Tech (Tool Engineering) in Government Tool Room and Training Centre, Mysore. Currently doing our final semester project work on Transfer mould Tool Design