International Journal of Mechanical Engineering (IJME)
ISSN 2319-2240
Vol. 2, Issue 3, July 2013, 63-68

International Academy of Science, Engineering and Technology
Connecting Researchers; Nurturing Innovations

DESIGN AND FABRICATION OF SILICON RUBBER MOULD (SRM)

ZULZAMRI SALLEH & M. YUZRI M. YUSOP

University Kuala Lumpur, Applied Science & Advanced Technology Section, Malaysian Institute of Marine Engineering Technology, Dataran Industry Teknologi Kejuruteraan Marin, Bandar Technology Maritim, Jalan Pantai Remis, Kuala Lumpur, Malaysia

ABSTRACT

This paper presents the experimental work that has been done in developing a silicon rubber mould (SRM) for producing dumbbell shaped samples. All work starting from the design and selection of material to be used for the mould right up to its actual production and the characteristic of samples produced by SRM are presented. The dumbbell samples produced by the SRM are in accordance to ASTM D638-91a with dimensions as specified under Type MII for mechanical testing.

KEYWORDS: Dumbbell-Shape, Silicon Rubber Mould, Mechanical Testing

INTRODUCTION

Rapid prototyping (RP) is one of the modern manufacturing techniques, which uses computer aided design (CAD) based automated additive manufacturing process to construct parts; that are used directly as finished products or components [1-2]. Currently RP is in a stage, where manufacturing facilities are being used for specialized, low-volume and customized products [3-4]. SRM (Silicon Rubber Mould) is one of the RP techniques, which is used widely in industry since the 80's to produce functional plastic parts[2, 5]. It is a unique technique, because it combines low cost production with reliable, high quality parts [6]. Silicon rubber moulds are capable of reproducing extremely complex geometries with very fine details [7]. Due to low cycle time, cost per piece, and high tool life, silicon rubber moulding is best suited for batch production applications.

For development of silicon mould, master patterns can be prepared using any cost-effective method. Fine geometrical details of the master pattern can be faithfully reproduced with SRM [8-9]. In the present work, the process of SRM has been used for replication of plastic components. In this paper, female mould was prepared using silicon rubber with condition two types of composition. After the mould is completed, dumbbell-shape with type MII male plastic sample will stick on the surface of the SRM until it was cured at room temperature. Figure 1 shows the dimensions of Type MII sample.

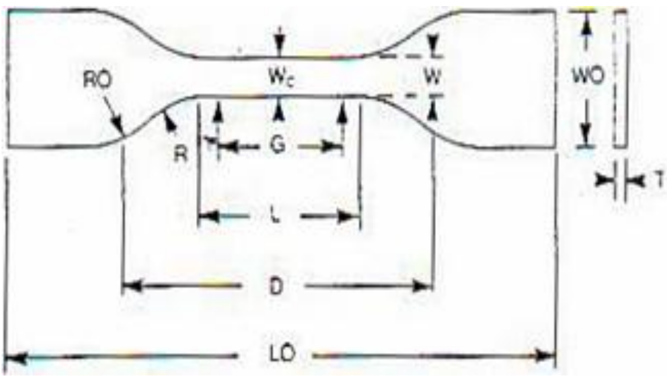

Figure 1: Dimensions of Type MII Sample

Table 1 shows the dimension of Type MII which is used for this study. Dimensions are in millimeters.

Table 1: Details Dimension of Type MII

Dimension	Parameter (mm)
W- width of narrow section	6
L- length of narrow section	33
W0- width of overall	25
L0- length of overall	115
G- gauge length	25
D- distance between grips	80
R- radius of fillet	14
R0- outer radius	25
T- thickness	4

Forming by moulding processes varies depending on the nature of the part, the number of parts, and the cost. The mould material can be made either from metal, polymer, wood, or plaster. In this study silicon and rubber has been used as the material for the mould. The moulding process flow is shown in Figure 2.

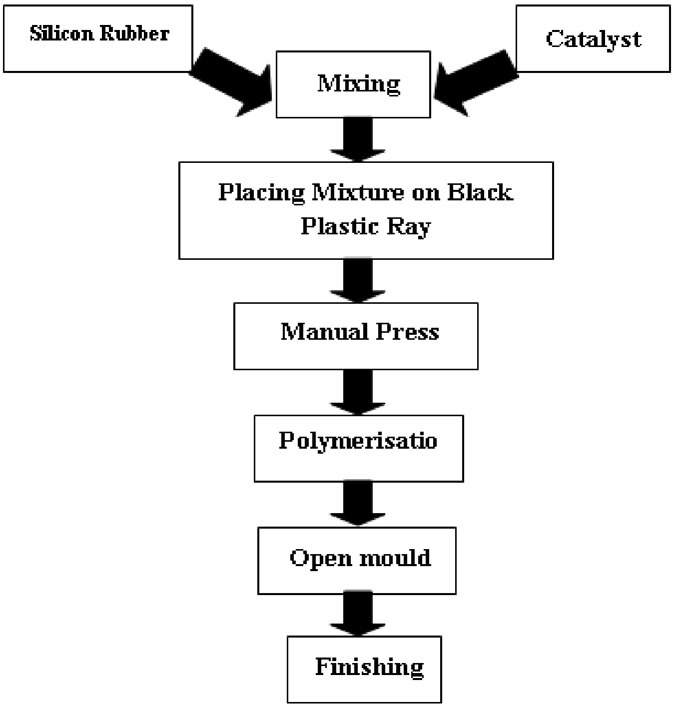

Figure 2: Show the Moulding Process Flow

Currently there are four types of moulding processes in manufacturing such as contact moulding, compression moulding, vacuum moulding and injection moulding. Contact moulding is a type of open moulding (there is only one mould, either male or female). The duration for resin setting varies, depending on the amount of accelerator, from a few minutes to a few hours. One can also obtain parts of large dimensions at the rate of about 2 to 4 parts per day per mould[10]. For compression moulding, the counter mould will close the mould after the impregnated reinforcements have been placed on the mould. The whole assembly is placed in a press that can apply a pressure of 1 to 2 bars.

The polymerisation takes place either at ambient temperature or higher. The process is good for average volume production because it can produce many products especially automotive and aerospace parts. Vacuum moulding is called depression moulding or bag moulding. As in the case of contact moulding described previously, one uses an open mould on top of which the impregnated reinforcements are placed. One sheet of soft plastic is used for sealing (this is adhesively bonded to the perimeter of the mould). Vacuum is applied under the piece of plastic. The piece is then compacted due to the action of atmospheric pressure, and the air bubbles are eliminated. Porous fabrics are used to absorb excess resin. The whole material is polymerized by an oven or by an autoclave under pressure (7 bars in the case of carbon/epoxy to obtain better mechanical properties), or with heat, or withelectron beam, or x-rays. This process has applications for aircraft structures, with the rate of a few parts per day. With resin injection moulding, the reinforcements (mats, fabrics) are put in place between the moulds and counter mould. The resin (polyester or phenolic)is injected. This type of moulding employs low pressure for polymerisation as oppose to vacuum moulding. This process can produce up to 30 pieces per day.

The investment is less costly and has application in automobile bodies. In this study,silicon rubber have been selected because it is the best material for producing moulds of life castings and other objects used in sculpture, special effects and taxidermy.

As with liquid latex, it yields a light, flexible, detailed mould, but has the added advantages of longer life, resistance to chemicals and decomposition. It is the recommended material for making long-lasting moulds. A silicon mould also can be made in less time than a latex mould, if “fast” catalysts are used. Among silicon's few disadvantages is that it is more expensive than latex, and not quite as elastic or tear resistant. The most common silicon compounds used for mould making are RTV or "Room Temperature Vulcanizing" silicon that are mixed in two parts (a base and a catalyst) to induce curing.

The silicon mixture is poured or spread over a prepared model or specimen, then reinforced with gauze or other reinforcing material between layers for increased strength and improved tear resistance. In this research, the fabrication of SRM using open mould process will be developed and discussed. The results from fabrication of SRM also will be discussed especially the effects of catalyst and methods of preparation of SRM moulds.

METHODOLOGY

In this study, the materials for silicon rubber were supplied by the fibreglass workshop of Universiti Kuala Lumpur MIMET silicon rubber type RTV586 with catalyst type#11 were supplied by Hightech Polymer Sdn Bhd. First of all the surface of the dumbbell–shape blueprint must be clean and free from imperfections.

This is a critical step because the silicon rubber mould and its polyurethane parts will replicate exactly the surface of the original copy. The sample model was then fixed to the base plate (plastic tray) using a double cellophanes tape. Next, apply a coat of wax release agent to all related surfaces which is base and model sample surfaces.

This will facilitate separation of the surfaces from the completed silicon rubber mould. Mix the RTV - 586 materials with catalyst #11 and poured into the mould. The ratio of silicon rubber with catalyst was 35:1 respectively from RTV - 586 and catalyst #11. The mixer machine was used to ensure that the mixing well is done gently so that no air is trapped inside the material. Minimising bubbles are important, because we will skip the degassing process which requires commercial equipment.

The working life of the silicon rubber material is between 5-10 minutes, which means than once the components are mixed together, user have at least 10 minutes to mix and pour them. Usually the mixture of the RTV - 586 and catalyst #11are achieved after the colour changes from white to pink.

Finally it is poured into the black plastic tray where the dumbbell sample is located at the bottom case and the top of silicon were pressed manually. After 24 hours, the whole assembly was flipped over and the paste was removed. Figure 3 shows the steps of procedure preparing SRM mould.

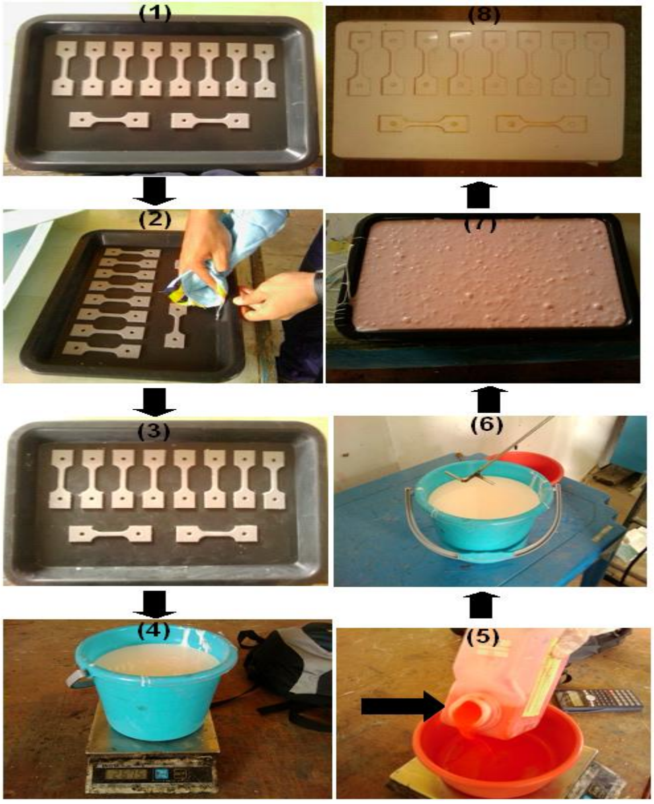

Figure 3: Procedure for Preparing SRM (Silicon Rubber Mould)

RESULTS AND DISCUSSIONS

In this study, there are five SRM moulds were produced. These SRM's produces 50 pieces of dumbbell-shape female. Table 2 shows measured dimensional value for one of the critical dimensionat 'w'width of narrow section 6mm (Refer Figure 1).

Table 2: Observation Result for SRM Moulds

SRM No.	Mixing Time (Minute)	Width of Narrow (mm)	Mixer Type	Observation Photo	Judgement
SRM 1	3	5.5	Conventional		NG(No Good)
SRM 2	4	5.7	Machine		NG(No Good)
SRM 3	6	6.0	Machine		OK
SRM 4	8	6.0	Machine		OK
SRM 5	10	6.0	Machine		OK

For the first mould SRM 1, the result was not good because there are a lot of bubbles and voids inside which mould. The surface of SRM1 was not fully covered with pink colour which means that it is not evenly distributed. This problem occurred because no mixer unit has been used during the mixing process. The colour of the SRM should pink if the mixture (catalyst + RTV) is properly mixed. It can be seen at cavity area, the width of the narrow section is dented and the measurement is about 5.5mm only where by the specification is 6.0mm. This dented might be due to an incomplete wax process or improper cleaning of the samples. While for SRM 2, the result is also not good because the time of mixing process is very fast (~ 3 minutes only) eventhough using the mixer machine was used.

Another factor might be due topouring the catalyst into RTV 586 too fast making catalyst not properly dried. Table 2, shows good results for sample SRM 3, SRM 4 and SRM 5 where if successful results were due to good mixing process (6-10minutes) and proper wax cleaning. For example one method must make sure no leftover wax remain on the dumbbell-shape sample by doing the 2-3 layer of waxing process especially at critical area for an example width of narrow (w).

The surface of SRM 3, SRM 4 and SRM 5 are also smooth because the mixing technique firstly pouring and stirring the RTV 586 with the mixer and then intermittence mixing was done after auditioning the catalyst. While stirring the RTV 586 and the catalyst, the angle of mixer must be approximately 45° from the container edge and rotated 360°. Figure 4, shows the diagram the angle of mixer approximately being 45°. The direction up-down and right-left also are required in order to get the good mixture of catalyst and RTV 586 as in Figure 5.

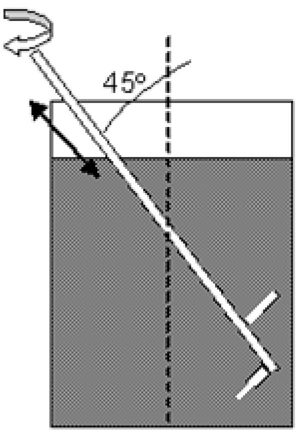

Figure 4: Direction of Mixer at 45°

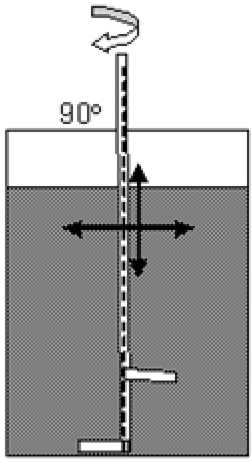

Figure 5: Direction of Mixer at 90°

A proper pouring process is to proper start at first row line on the tray with the direction from left to right shown at Figure 6. For this technique, the thickness of SRM mould is much constant because the flow of mixing material was evenly distributed at all places until the edge of the tray. While samples SRM1 and 2 were using the pouring method at the centre of the tray as shown in Figure 7. For this technique the flow of mixing material were not evenly distributed until edge of tray thus the internal void and bubbles occurred when observed through the cross-sectional area of the sample.

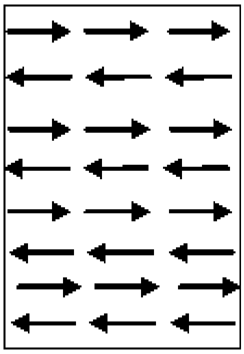

Figure 6: Pour from Left to Right

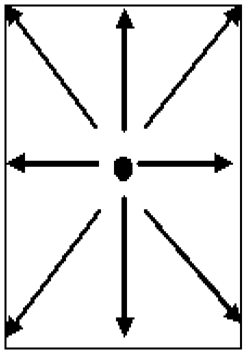

Figure 7: Pour from Centre to Edge of Tray

CONCLUSIONS

The author has successfully designed and fabricated five is due to Silicon Rubber Mould (SRM's) in this research. Out of five SRM's only 2 have defects which are due to the improper mixing method and pouring technique. The types of defect identified are such as internal bubbles and voids. These bubbles can be removed approximately 15 minutes if using degassing unit[11].It is suggested that the direction of stirring mixer is also main important in producing a good samples. The direction of pouring the mixing material needs to be considered as the affects the thickness of the SRM.

ACKNOWLEDGEMENTS

The authors acknowledge the financial support of FRGS grant no.: FRGS/2/10/TK/UNIKL/03/2 from Ministry of Higher Education (MOHE) of Malaysia and Universiti Kuala Lumpur MIMET.

REFERENCES

1. Singh, R. and Verma, M. (2008), "Investigations for reducing wall thickness of aluminum shell casting using three dimensional printing" Journal of Achievements in Materials and Manufacturing Engineering, Vol. 31,pp 65-69.
2. Singh, R. (2010) "Three-dimensional printing for casting applications: A state of art review and future perspectives" Advanced Materials Research, Vol. 42, pp 83-86.
3. Ainsworth I. Ristic M. and Brujic D. (2000), "CAD- based measurement path planning for free form shapes using contact probes" International Journal of Advanced Manufacturing Technology Vol. 16, pp 23-31.
4. Singh, J.P. and Singh, R. (2009) "Investigations for statistically controlled rapid casting solution of lead alloys using three dimensional printing" Journal of Mechanical Engineering Sciences (Proc. of IMechE Part C) Vol. 223, pp 2125-2134.
5. Singh, R. and Singh, B. (2010), "Process Capability of Rapid Manufacturing for Plastic Components," LAP Lambert Academic publication, Germany ISBN 978-3-8433-8735-4, pp76.
6. Chua C.K., Leong K.F. and Lim C.S. (2003), "Rapid Prototyping: Principles and Applications (2nd ed.)" World Scientific Publishing Co. Pvt Ltd.
7. Singh, V. (2010), "Experimental investigations for statistically controlled rapid moulding solution of plastics using Polyjet rapid prototyping" M.Tech. Thesis: Punjab Technical University, Jalandhar.
8. Chung S., Im Y., Kim H., Jeong H. and Dornfeld D.A. (2003), "Evaluation of micro replication technology using silicon rubber moulds and its applications" International Journal of Machine Tools Manufacturing,43, pp 1337–45.
9. Chung S., Park S., Lee I., Jeong H. and Cho D. (2005), "Replication techniques for a metal micro component having real 3D shape by micro casting process" Microsystems. Technol,11, pp 424–428.
10. Daniel Gay, Suong V. Hoa, Stephen W. Tsai. (2003), Composite Material, Design and Application "CRC Press LLC
11. Vipul.S., Rupinder.S.(2011), "Investigations for modeling the silicon moulding process for plastic components" International Journal of Materials Science and Engineering, Vol. 2, No. 1-2.