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"Design and Analysis of Plastic Ice-cream Spoon for Elimination of Defects"

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ABSTRACT

In Past, Mold Design process was time-consuming as well as hectic. At first, Manual Drawing and then 2D software were used; after which patterns were made. But the results were not convincing most of the times. Thus the design to market time increased immensely and also project cost required was on a higher side. Due to the technological advancements, the process of Mold Design has fastened and also the results are convincing. With the help of 3D software, Parametric Designs can be created, which are editable. Also we can look at number of possibilities for designing a mold. In a 3D software, Visualization of our creation is easy possible. Thus the design to market time get shrink immensely also the project cost required is on lower side.

Using CAD/CAM/CAE Software, companies can be very much assured that their product will be of a good aesthetics, it will be more durable, more accurate, and will launched in time. They can actually view and modify the product on computer before actually manufacturing it. 3D CAD Technology in Mold Design helps in Heavy Reduction in Design Time and Design Cost in Long term, also Optimization in Designing. We can work out multiple options and choose the efficient one. Better Visualization of objects before actual production is achieved. Mold flow Analysis makes it easy to judge the flow of material in the mold. CAD data can be used for creating manufacturing program using CAM i.e. Computer Aided Manufacturing.

Keywords— **CAD, Design and Analysis, Design to market time, Mold design, Optimization.**

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I. INTRODUCTION

With today's shrinking time-to-market window, development speed is essential. Computer today is a very versatile sand powerful tool in the hands of design engineer. The scientific research in the field of structural optimization has increased very substantially during the last decades, and considerable progress has been made. This development is due to the progress in reliable general analysis tools like the finite element method, methods of design sensitivity analysis, and methods of mathematical programming, and has been strongly boosted by the exponentially increasing speed and capacity of digital computers. This is practically made possible by using Computer Aided Design and Analysis, which accounts for completeness and accuracy.

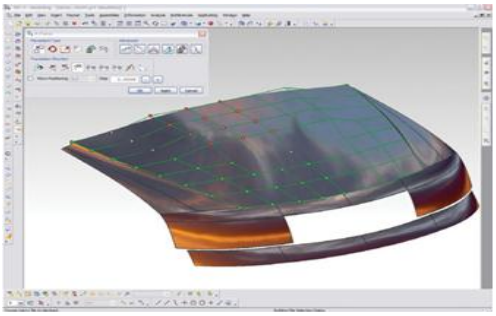

Fig.1 Application of CAD-CAM-CAE

Over the past decade, CAD-CAM-CAE has provided hope, excitement and solid foundation for manufacturing industries that have been in sharp contrast with recent reports of slow growth in productivity. This technology has responded to industry needs for sophisticated interactive graphics, computer controlled machine tools, intelligent robots, improved design quality, inspection techniques and a host of other

Innovations to do manufacturing better. It is contingent upon management to make the most of this new technology so that its full promise can be realized in the future. This technology reduces laborious work, gives accurate and best results. It is time saving and economical technology. This technology is useful for various industries especially mechanical that enables us to deliver superior customer services today and in the future. It helps to improve design quality as well in the future.

An Injection molding machine, also known as an injection press, is a machine for manufacturing plastic products by the injection molding process. It consists of two main parts, an injection unit and a clamping unit.

The majority of machines are horizontally oriented, but vertical machines are used in some niche applications such as insert molding, allowing the machine to take advantage of gravity. There are many ways to fasten the tools to the platens, the most common being manual clamps (both halves are bolted to the platens); however hydraulic clamps (chocks are used to hold the tool in place) and magnetic clamps are also used. The magnetic and hydraulic clamps are used where fast tool changes are required.

II. HISTORY

The first man-made plastic was invented in Britain in 1861 by Alexander Parkes. He publicly demonstrated it at the 1862 International Exhibition in London; calling the material he produced "Parkesine." Derived from cellulose, Parkesine could be heated, molded, and retain its shape when cooled. It was, however, expensive to produce, prone to cracking, and highly flammable.

In 1868, American inventor John Wesley Hyatt developed a plastic material he named Celluloid, improving on Parkes' invention so that it could be processed into finished form. Together with his brother Isaiah, Hyatt patented the first injection molding machine in 1872. This machine was relatively simple compared to machines in use today. It worked like a large hypodermic needle, using a plunger to inject plastic through a heated cylinder into a mold. The industry progressed slowly over the years, producing products such as collar stays, buttons, and hair combs.

The industry expanded rapidly in the 1940s because World War II created a huge demand for inexpensive, mass-produced products. In 1946, American inventor James Watson Hendry built the first screw injection machine, which allowed much more precise control over the speed of injection and the quality of articles produced. This machine also allowed material to be mixed before injection, so that colored or recycled plastic could be added to virgin material and mixed thoroughly before being injected. Today screw injection machines account for the vast majority of all injection machines. In the 1970s, Hendry went on to develop the first gas-assisted injection molding process, which permitted the production of complex, hollow articles that cooled quickly. This greatly improved design flexibility as well as the strength and finish of manufactured parts while reducing production time, cost, weight and waste.

The plastic injection molding industry has evolved over the years from producing combs and buttons to producing a vast array of products for many industries including automotive, medical, aerospace, consumer products, toys, plumbing, packaging, and construction.

III .PROBLEM DEFINITION

To increase the productivity, there are several factors like best method of doing job, time taken to do it, labour efforts,eliminating all unnecessarymovements, improvements in design, product development, etc.

Many companies produce ice-cream spoons but the production to their potential is less. Sample of ice-cream is as shown in fig. 2, 3 and 4

Fig. 2 Internal Features of Ice-Cream Spoon

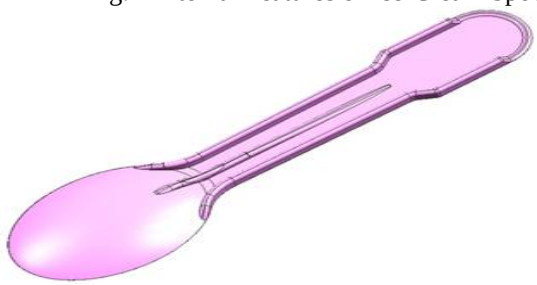

Fig. 3 External Features of Ice-Cream Spoon

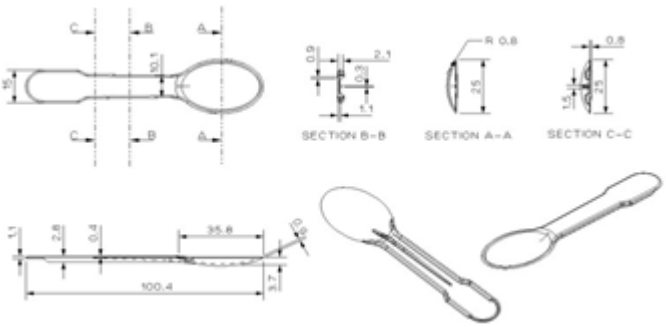

Fig. 4 Detail Drawing of Ice-Cream Spoon

In old design (Refer fig. 5 and 6) of spoon manufacturing die, productivity was less as only 4no. of spoons were manufactured in 1 cycle. Thus labour time was wasted in pouring and ejection again and again.

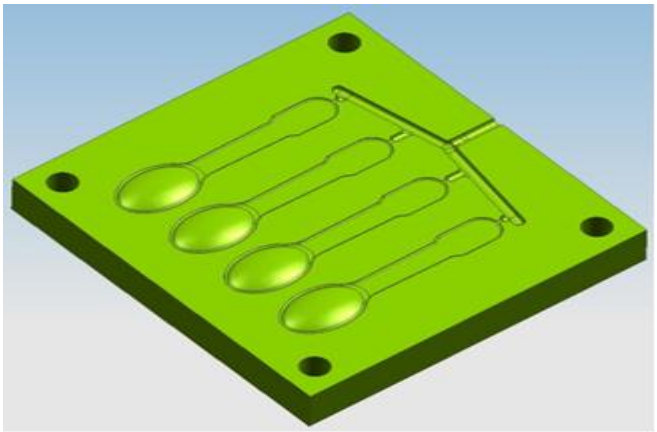

Fig. 5Design of Old Dies for Manufacturing Spoons

Fig. 6 Photograph of Old Dies Showing Core and Cavity

IV .METHODOLOGY

A) 3D Modeling & Drafting of the Plastic Product:

In 3D CAD i.e. Unigraphics NX (Siemens product) software we can design the product concept, we can create drawing and drafting views automatically then easy apply a dimensions using the 3D model, can create assembly and can check for interferences and also can check motion simulation.

B) Mold Design using Mould Wizard for optimum solution:

Using Mold Wizard module of Unigraphics NX (Siemens product) the process of Mold Design can be done with ease as well as in least time. This wizard helps us in creating Core & Cavity. Standard library helps us in selecting Mold Base, Ejector pins, Sprue Bush, Locating Ring, Sliders, Runner gating, Cooling Lines etc. Also the Drawing Views of all the parts are created automatically which we can draft as per our requirement.

C) CAE for regulating the material flow in Mold:

Computer-aided engineering (CAE) simulation programs for plastics molding processes. It is used widely by the plastics injection molding industry. The MOLDFLOW injection molding Simulation of polymers can provide information on the thermo-mechanical properties and residual stresses of the Part resulting from the manufacturing process. MOLDFLOW writes this information to an interface file for subsequent finite element stress analysis.

D) Mold drawing:

In Mold Wizard, there are options by selecting which we can create standard drawing views, Hole Table (Ordinate Dimensions) as well as part list as per one's requirement can be created. Alsodimensioning the parts is easy. Section views as per requirement can be obtained.

E)Manufacturing (CAM):

In CAM we can generate the CNC Codes, specify the tool path, and specify tools, check for collision, and check simulation on the part which has been designed using CAD. We can avoid the accidents that may be caused while manual programming on CNC or VMC Machines.

The methodology used is illustrated in fig

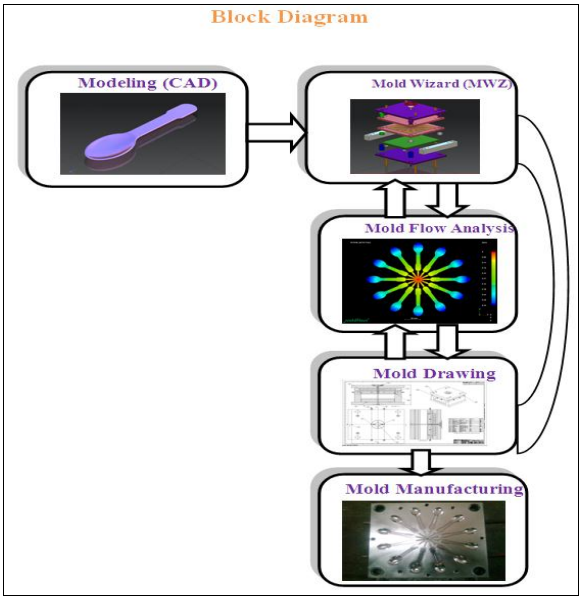

Fig.7Block Diagram of Overall Methodology

V.WORK DONE

To initiate for designing, study of all the components is necessary. Principal components should chiefly design to get noticeable improvement. Rest of parts may get designed depending on it.

At first, the 3D model is created in Unigraphics Nx. It takes around 5 to 6 hours. After this the drawing of the model is created for cross checking purpose. Then by using Mold Wizard of Unigraphics Nx 4, the mold of spoon is created. At first, the company was having a 4 cavity mold for the component. Thus for increasing productivity design of a 12 cavity mold is done.

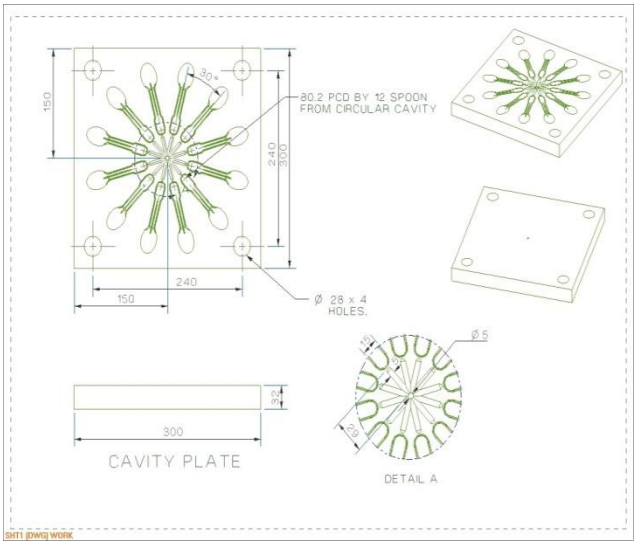

Fig. 8 Drawing of Cavity

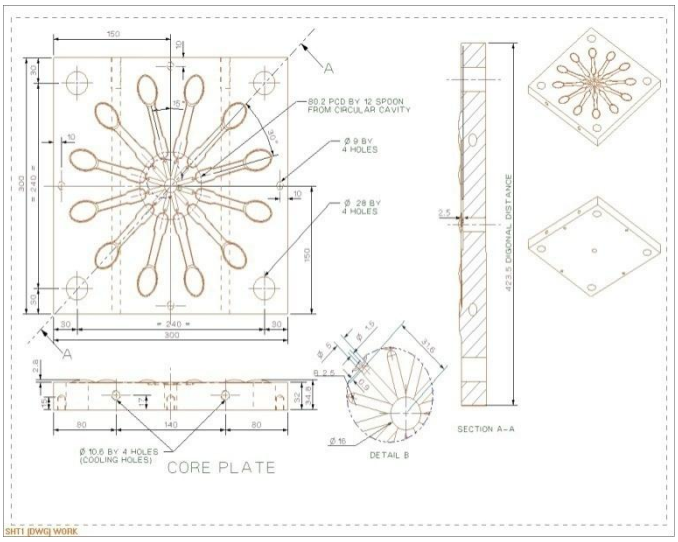

Fig. 9 Drawing of Core

The core and cavity is first created and depending upon it selection of appropriate mold base, runner gating, sprue bush, ejector pin etc. is done. In Mold Wizard all the standard part library is available which makes it easy to create the above mentioned parts. Also mold base of various standards viz. DME, Husco, Futaba etc are available in the software. This activity takes around 48 hours.

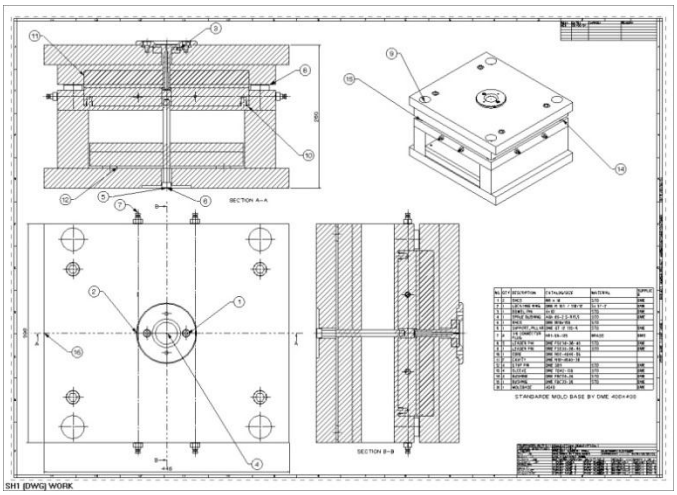

Fig. 10 Drawing of Mold with BOM

Assembly of this design is as shown in fig. 11.

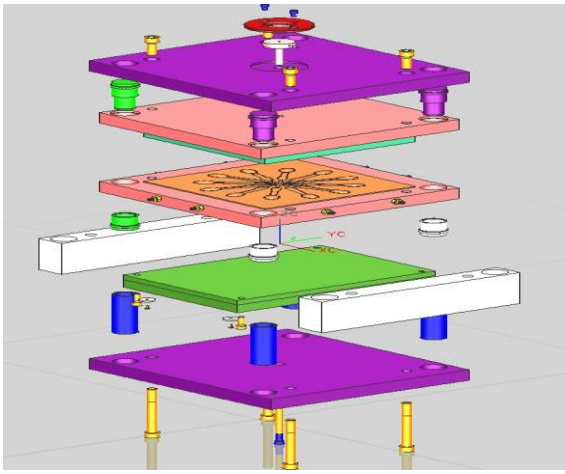

Fig. 11 Assemblage of New Design of Die or Mold

After the creation of Mold, creation of the Mold Drawings is done, considering the standards. Stripper plate type of ejection is used. It is important to create the drawing in such a way that shop floor peoples should understand them easily. At the end of drawing creation, mould flow analysis using Mould Flow Software is done. After this finalization of model drawing, it is sent for manufacturing.

A) Mold flow analysis results

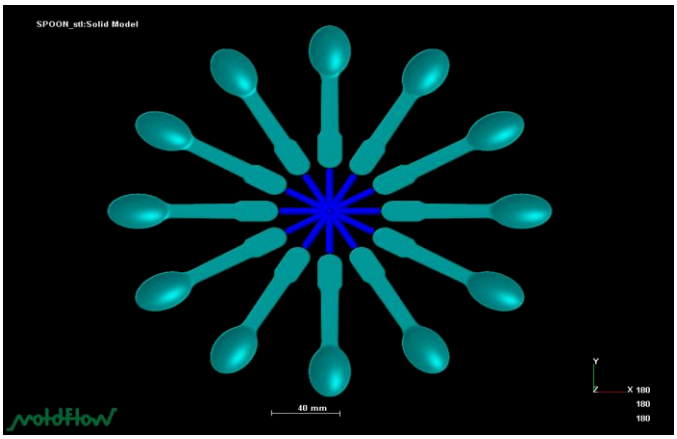

Fig. 12 Solid Model

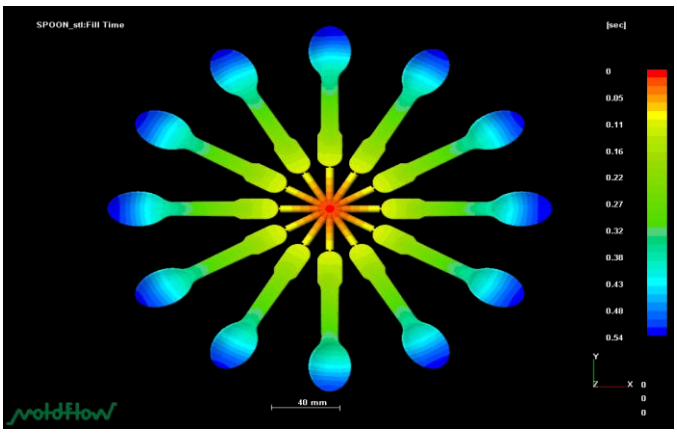

Fig. 13 Fill time= 0.54 sec

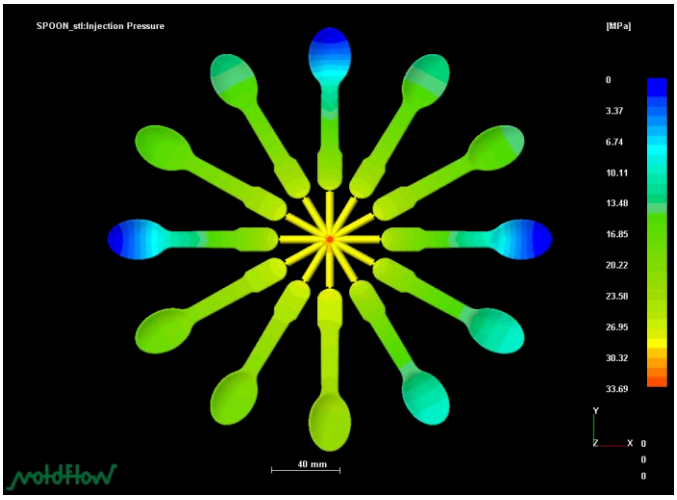

Fig. 14 Injection pressure = 33.69 MPa

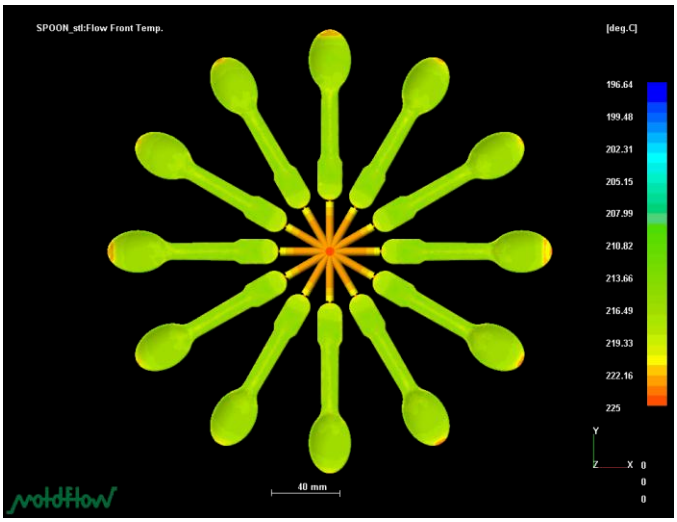

Fig. 15 Flow Front Temperature

The Mold seems to be feeling well. The results primarily relate to fill pattern, injection pressure and part.

The analysis results herein are believed to be reliable but users should undertake sufficient verification and testing to determine the suitability for their own particular purpose of any information presented herein. Nothing herein is to be taken as permission, inducement, or recommendation by Mold flow Corporation to practice any patented invention without a license or in any way infringe upon the intellectual property rights of any other party.

Table I

Mold flow analysis results

Part Name:	SPOON
Material Supplier	Reliance Industries Limited
Max Injection Pressure:	140.00 MPa
Mold Temperature:	50.00 deg.C
Melt Temperature:	225.00 deg.C
Model Suitability:	Part model was highly suitable for analysis.
Mold ability:	Your part can be easily filled but part quality may be unacceptable. View the Quality plot and use the Dynamic Adviser to get help on how to improve the quality of the part.
Confidence:	Medium
Injection Time:	0.54 sec
Injection Pressure:	33.69 MPa
Weld Lines:	Yes
Air Traps:	Yes
Shot Volume (cavity, runner):	27.33 cu.cm (19.61, 7.72)
Filling Clamp Force:	31.33 tonne
Packing Clamp Force Estimate @20%:	(6.74)MPa 12.17 tonne
Packing Clamp Force Estimate @80%:	(26.95)MPa 48.67 tonne
Packing Clamp Force Estimate @120%:	(40.43)MPa 73.01 tonne
Clamp Force Area:	177.08 sq.cm
Cycle Time:	8.34 sec

VI. RESULT

A) Comparison

Table II

Comparison between Old and New Mold

Parameters	Old Mold	New Mold
Mold opening and closing time (2 M)	3sec	4sec
Injection Time (T)	3sec	5sec
Cooling Time (C)	10sec	14sec
Ejection (E)	4sec	3sec

Cycle time (2M+T+C+E)	20sec	26sec
Time required for one part	5sec	2.16sec
Production per day (Max 10 Hrs./Day)	1800x 4slots=7200 no's	1380x12slots=16,560 no's
Weight of Mold	110kg	350kg

B) Graphical comparison

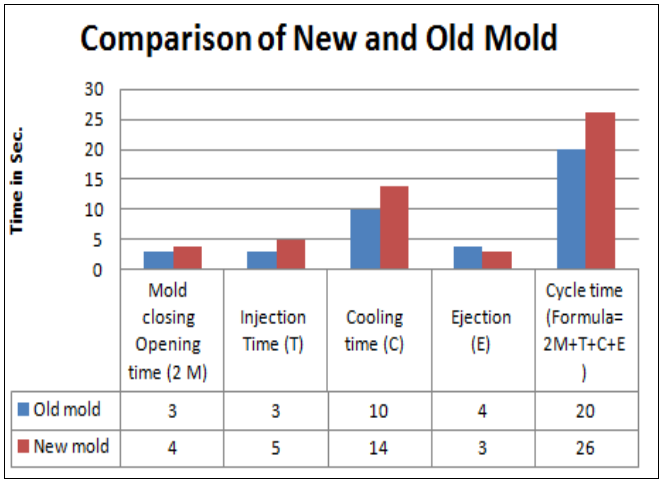

Fig. 16 Graphical comparisons of New and Old Mold

1. Increase in daily production = 16560-7200 = 9360.
2. Reduction in time required for 1 product
   = (5-2.16) sec = 2.84sec.
3. No. of product by new mold
   = 2.3 times no. of product by old mold.
4. Increase in productivity
   = (9360 X 100) / 16560 = 56.52%.
5. Decrease in production time
   = (2.84 X 100) / 5 = 56.8%.
6. Increase in weight = (350 - 110) kg = 240 kg.

VII .CONCLUSIONS

The productivity is increased up to 56.62% and production time is decreased up to 56.8%.The Mold can be filled completely and gives reliable results. Users should undertake sufficient verification and testing to determine the suitability for their own particular purpose.

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