

STUDYING AND OVERCOMING THE PROBLEMS IN PRODUCTION, IN A SMALL SCALE INJECTION MOULDING COMPANY

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Abstract : Increasing the productivity of an industry requires detailed study of the industrial processes and focusing on the key factors where prevention or improvement can be implemented with a verified study. This project was carried out to detect the failure of highest frequency, find its cause, provide a solution, implement it and finally test it. Every step, study and implementation has been made by prioritizing reduction of production cost, increasing customer fulfillment and hence, no considerations were made to the quality factors.

Keywords : Injection moulding, key performance indicators, production, core pin, Stavax ESR.

1 INTRODUCTION

Nowadays, competitive market requires producers to produce high quality parts, with lower price in the least possible time. Injection molding is known as an effective process for mass production of plastic parts with complicated forms and high dimensional precision. It is a cyclic process for producing identical articles from a mold, and is the most widely used for polymer processing. The main advantage of this process is the capacity of repetitively fabricating parts having complex geometries at high production rates. Complexity is virtually unlimited and sizes may range from very small to very large. Most polymers may be injection molded, including thermo plastics, fiber reinforced thermo plastics, thermosetting plastics, and elastomers. Critical to the adoption of this high volume, low cost process technology is the ability to consistently produce quality parts. The productivity depends on the nature of the mold i.e its material, dimensions and design.

In this paper I am reviewing the methods to update my current understandings for further study. I began with studying the process at Triparna Engineering and made several attempts to increase its productivity by detecting and preventing the failure which occurs with the highest frequency in the process.

The paper is organized as follows :

- Study of Key Performance Factors (KPI) of the company
- Selection of KPI to be focused on.
- Identifying the major failures.
- Providing a solution , which in this case is modifying the material of core-pin from EN-24 low alloy steel to 1.2083 Stavax ESR mould steel.
- Testing the productivity of the process after the modification.
- Drawing a conclusion

2 OVERVIEW OF TRIPARNA ENGINEERING

Triparna Engineering, Dunlop, Kolkata, is a manufacturer of polymeric items like pens, bottle caps, etc. The mold design type they use is Korean type which is manufactured and maintained by Joy Engineering Company. Both the companies together constitute Anubhab Enterprises. The company has been having problems in loss of production time due to various problems occurring in the company. This had greatly affected the flexibility in production operations, full utilization of men, machine and other resources and also the coordination between men and machines.

So, to manage and provide solution for the above mentioned problems, I made a detailed study of their Key Performance Indicators (KPI) which are stated hierarchically :

- 1) Production time
- 2) Inventory

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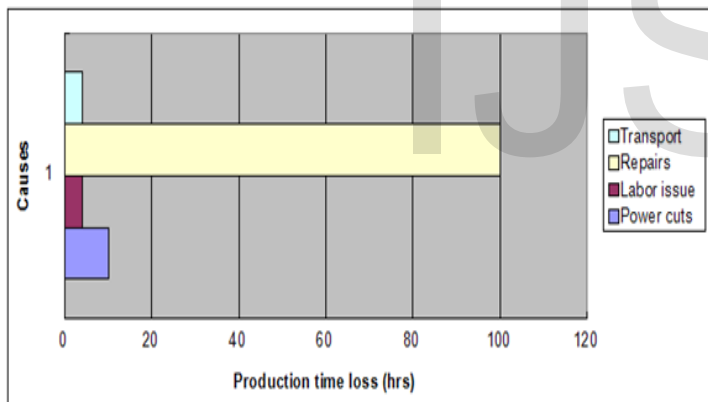
- 3) Equipment Effectiveness
- 4) Raw Materials
- 5) Lead Time
- 6) Downtime

I have selected the production time as the KPI as it affects the Return Of Investment (ROI),inventory,equipment effectiveness,lead and downtime.

Table 1 : Current Key Performance Indicators (month of August)

Key Performance Indicators	Target	Actual
Production time(hours)	600	430
Inventory(Tons)	30	22
Lead Time	0	3
Downtime %	10	15.13
Customer Satisfaction %	100	72
Rejection Ratio %	12	19.8

Factors causing loss of production time Fig .1



It is evident from the above chart that repairs are the maximum contributor to the loss of production time.

3 DETECTION OF FAILURE OF HIGHEST FREQUENCY

Table 2 : Factors contributing to the loss of production time due to repairs only.

Factors	Prevention	Occurrence (weekly)	Cause	Time Loss (Weekly)
Core Loss	Re-installation	6-7	Failure of core pin	90-92
Hoppe	Manual	1-2	Fresh to	4

r Jam	Cleaning		recycled material ratio is low	
Nozzle Jam	Heating and cleaning	1-2	Fresh to recycled material ratio is low	4
Machin e Hang	Re-start	1	System Problem	1

Core loss : It occurs due to failure of core pin. Core pins are traditionally made of low alloy steel and the most used material is EN-24. The failed core pins contribute to the loss of core or cavity and hence loss of production and eventually productivity. The pin fails due to high injection pressure, adhesion of the material and sudden cooling of the material. Remedial measures taken for the repair comprises of re-installation of pins along with the mold tool which approximately takes around 4 hours. The inner bore of the pin also gets filled with slag due to corrosion.

4 SOLUTION PROVIDED

So, in order to overcome this problem, which is a major factor for production loss, I modified the material of the core pins from EN-24 to 1.2083 Stavax ESR (Electro-Slag Refined) material . This material is primarily used for the cavity section to ensure quality of the products and faster EDM machining of male and female section of the moulds.

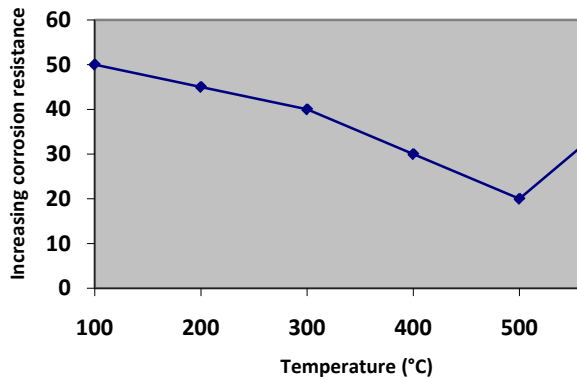
Benefits of Stavax ESR over EN-24 :

- 3.1 Better corrosion resistance..
- 3.2 Better polishability.
- 3.3 Resistance to wear is greater.
- 3.4 Better machinability.

3.1 Better corrosion resistance

Stavax ESR is more resistant to corrosion when compared to EN-24 under corrosive attack by water, water vapour, weak organic acids, dilute solutions of nitrates, carbonates and other salts. This occurs due to the fact that Stavax ESR is required to be tempered at 250°C which is very low compared to the recommended tempering temperature of EN-24 which is 540-680°C.

Fig.2 Relationship between Corrosion Resistance and temperature



The above figure shows the influence of tempering temperature on corrosion resistance and it can be concluded that lower the tempering temperature, higher is the resistance to corrosion.

3.2 Better polishability

Polishability is a very important factor affecting the production cost of pins as well as the quality of the manufactured product. Especially for thermosetting plastics the polishability is a key concern as they tend to adhere to the surface of the pin. At tempered and hardened condition, EN-24 required more time in being polished when compared to Stavax ESR. So, as Stavax ESR has better polishability it ensures better quality products, lower polishing costs and higher pin life.

3.3 Resistance to wear is greater

Table 3 : Modulus of Elasticity at different temperatures

Modulus of elasticity (10^3N/mm^2)	100° C	200° C	300° C	400° C	500° C
EN-24	205	195	185	175	165
Stavax ESR	215	200	190	180	175

The above table shows that Stavax ESR has higher modulus of elasticity at higher temperature. At injection pressure of 34.42 MPa and temperature of 230.65°C, a Stavax ESR pin gives comparatively lesser failures over a week (4 times) than an EN-24 pin (6 times). Further, heat treatment cost is lesser as tempering is cheaper which reduces the production cost of the pin.

Table 4 : Weekly Failure rate

Core-pin material	No. of failures of 1 pin in a week	Production time loss due to repair and re-installation (hrs)	Total production time loss in a week (hrs)
EN-24	6	4	24
Stavax ESR	4	4	16

3.4 Better Machinability

Core pins are manufactured turning, grinding, EDM boring and polishing. Stavax ESR has a higher Material Removal Rate (MRR) during EDM boring as the material is a electro-slag refined material unlike EN-24 which is a low alloy steel. At a gap voltage of 100V, with high frequency and a feed rate of $4 \mu\text{m.s}^{-1}$ Stavax ESR gives a MRR of $0.4653 \mu\text{g.s}^{-1}$ while EN-24 gives $0.32910 \mu\text{g.s}^{-1}$ [3][4].

4 TESTING

The gross standard production in an injection moulding system in Triparna Engineering relies on the following equation :

$$\text{Gross production} = \left[\frac{(60 \times 60 \times \text{no. of cavities}) \times 12}{\text{cycle time} \times 144} \right] \text{ kg}$$

Where,

No. Of cavities = No. Of core pins

144 = Standard Gross

12 = 1 shift (12 hrs)

Cycle time = Total time for the mold or tool for closing, injecting, solidifying and opening (in seconds)

For a mold with EN-24 core pins, whose failure frequency is around 6 times a week, then averagely a mold tool

operates with 2 -3 missing core. While, a mold with Stavax ESR pins runs averagely with 1 missing core at max.

So for optimum production (No core loss)

Suppose,
Cavity = 16
Cycle time = 12 sec
Material = HDPE

$$Gross(optimum) = \left[\frac{(60 \times 60 \times 12) \times 12}{12 \times 144} \right] = 400kg$$

For core pins of EN-24 material (average core loss = 3),

Cavity = 16-3 = 13
Other parameters being same, the gross production becomes,

$$Gross (EN24) = \left[\frac{(60 \times 60 \times 13) \times 12}{12 \times 144} \right] = 325kg$$

Similarly, For Stavax ESR pins (average coreloss = 1)

Cavity = 16-1 = 15

$$Gross (Stavax) = \left[\frac{(60 \times 60 \times 15) \times 12}{12 \times 144} \right] = 375kg$$

pins made of EN-24, when modified to Stavax ESR gives a variety of advantages and also improves the quality of the product.

The modification :

- Increases production.
- Reduces mould maintenance cost.
- Reduces mould cost.
- Increases the surface finish of the product

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Table 5 : Difference in loss

Material	Gross production (kg)	Loss (kg)
EN - 24	325	75
Stavax ESR	375	25

So, it is evident that Stavax ESR core pins give higher production than core pins made of EN-24.

Conclusion

In this paper, the manufacturing process is modified to give better production. The machine on which the process is studied is of 100 tonnage and is manufactured by Toshiba. The mold or tool design taken into account is Korean type.

The process is studied in order to overcome the problems in production, which I did by having a proper methodology while approaching the issue. After, reaching the root cause I studied the material engineering of the mold. The core