Investigation of the Emergence of Quality Defects during Plastic Injection Moulding

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Introduction

There are many different types of plastic products in everyday life. Plastics are widely used as packaging and construction materials in architecture, fibres and textiles, a wide range of household products, the transport sector, and in the electrical, electronics and other industries.

Plastic injection moulding is one of the world's most popular plastic processing methods, where a melt of plastic beads with additives is transformed into parts with a desired appearance, which is an inversion of the mould used in the injection process. Official sources mention that this type of plastic processing is used for 32% of all polymers.

This method is used to produce parts with complex geometric shape that require high dimensional accuracy. Plastic injection moulding is also used for parts with high surface requirements and visual uniformity. By machining the mould void using special techniques, it is possible to obtain different types of surfaces: finely, coarsely textured, matt, ultra-smooth and glossy.

However, while this approach offers great potential, achieving excellent part quality throughout a multi-thousand-piece production run requires resolving a few key issues at the part design stage and effectively dealing with problems that arise after the design has been validated i.e. during production.

The types of defects in these parts can vary widely: flashes, sink marks, flow lines, weld lines, burn marks, warpage, air bubbles, dots, scratches, glosses, other colour irregularities, etc.

All these different types of defects are caused by different factors which are being investigated in this research.

Experimental details

All main quality defect types that are occurring in plastic injection moulding were divided into 4 major groups that correlate with the origin of the defect cause and objectives of the paper were formulated:

1. Identify a mould defects and their impact on product quality;
2. Examine the properties of different types of plastic;
3. Evaluate the influence of injection moulding parameters on the geometric stability and appearance of the product;
4. Assess the impact of the human factor on product quality.

For the first objective, the injection moulding machine was selected with an actual part running on it (presented in Fig. 1). The bulk production of 8000 pieces were observed piece by piece looking for mould-caused defects on the every part (the selected part is presented in Fig. 2). Continued presentation of this method is explained next to the fourth objective.

Fig. 1 A horizontal Engel Victory 200 moulding machine

Fig. 2 Selected part for investigation

For the second objective to evaluate different types of plastic, material datasheet data was analyzed. The two selected materials ABS Isopak 547 and ABS Isopak 508-621K were selected, focusing mainly on the water absorption rate (24 hours in 23 °C, ASTM D570), which had water units of 0.3% and 0.5%, respectively. For molding shrinkage, Isopak 525GF20 with 0.20 to 0.30% molding shrinkage and Isopak 625 with 0.50 to 0.760 % molding shrinkage were compared.

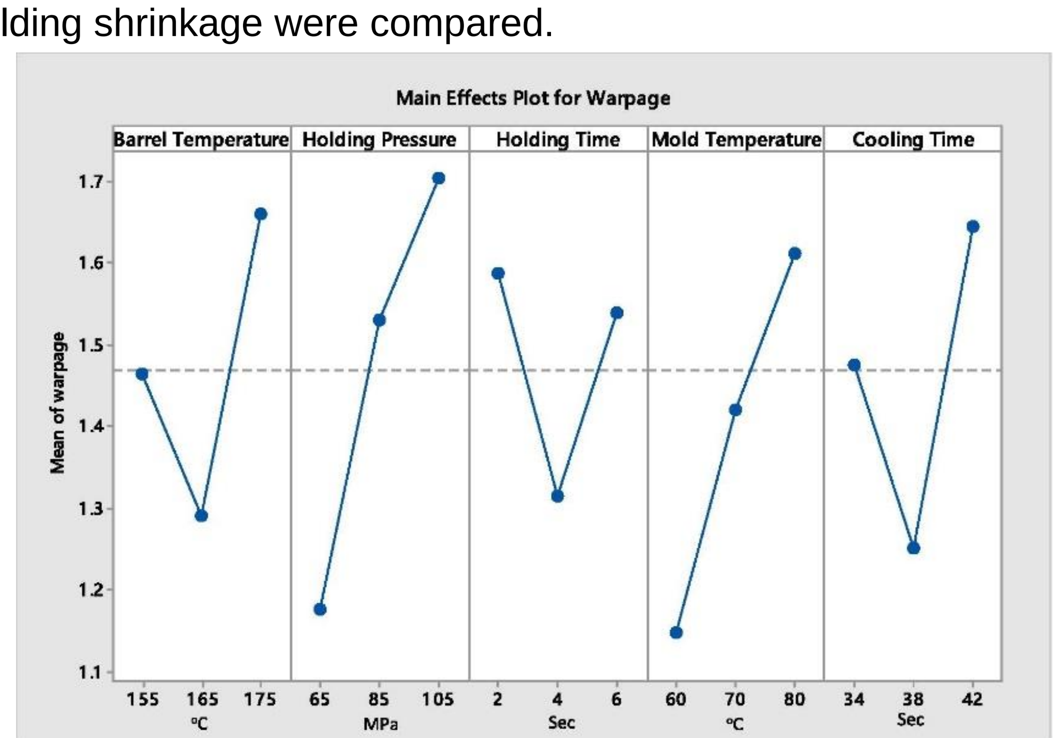

Fig. 3 Influence of various moulding parameters to the effect of warpage of moulded part

For the third objective evaluation of injection moulding parameters were selected. T. Ahmed with the research team from Jashore University of Science and Technology in 2022 carried out the process parameter effect research. Results are presented in Fig. 3.

For the fourth objective assessment of the impact of a human factor, the first research method was used, empirically checking 8000 moulded parts. This was made as an internal operation of a plastic injection moulding company, as this part was prepared for bulk production and during it's first masive order it needs to be 100% checked by human operator. So due to the sake of this research, the operator „A" checked for the nonconformities (and counting down the ones that are machine caused) and the „B" one checked if there are any defects caused by a human operator: the one that is operating the machine and the „A" one, that is handing pieces directly to him.

It was counted that out of 8000 pieces, 155 (or 1.9375%) were detected as defected pieces: 69, or 0.8625%, were named as 'human factor defect', 56 (0.7000%) of defected parts were process-related, various types of nonconformities like warpages, jet marks and sink marks that were quite insignificant as it hadn't fixed placement on the part and only 30 (0.3750%) were machine related (see the objective no. 1).

Discussion and Conclusions

Some important notices after the research stage on the formulated objectives emerged. All the quality defects have causes and those causes seem to be fixable, which all can be connected into one flowchart to see all the possible map of defects. (See Fig. 4).

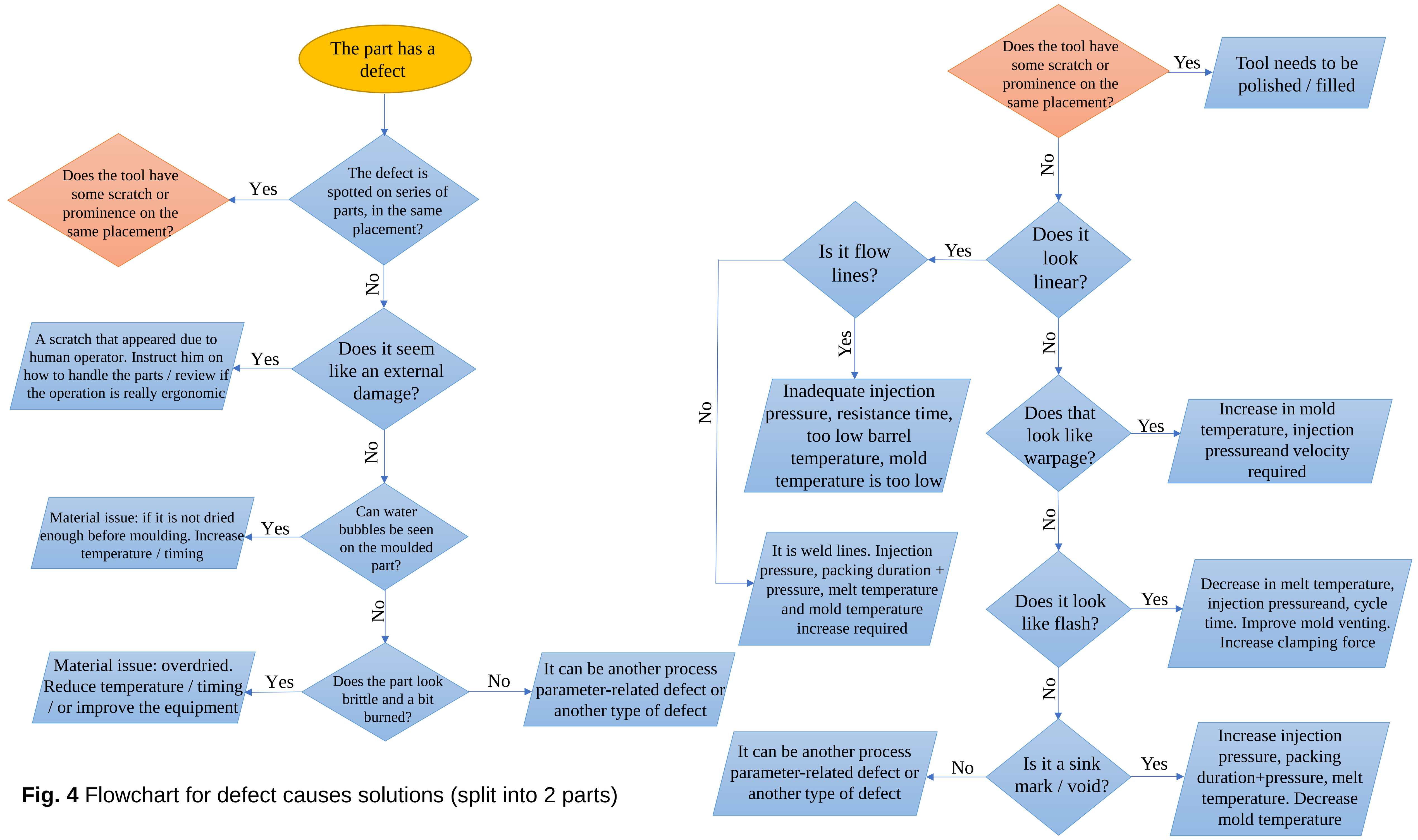

Fig. 4 Flowchart for defect causes solutions (split into 2 parts)

1. Various types of visual and dimensional quality defects are mainly related to these aspects: injection mould properties, plastic pellet material, parameters of injection moulding and a human factor.
2. Defects related with tool and process parameters are found in the same location on the high number of parts, while defects related with material quality or human factor have no specific location in the part.
3. Human factor and defect percentage in the accomplished experiment has shown the biggest correlation of all. Human-cause defects made up to 44.5161% of all the defected parts spotted. It shouldn't be generalized for all the parts and all the Plastic Injection Moulding industry as more experiments should be executed, but it all makes sense in the Industry 4.0 context, where human resources are being moved to another means in the working environment.