

## Original Research Article

# Understanding the Cause and Effect of Bent Side Rail in Molding Process

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## ABSTRACT

During processing of Quad Flat No-lead (QFN) on the production line, it has been observed that strips were found with bent rails after the molding process. Mold is a process in the semiconductor industry where package encapsulation happens by filling the cavities with molding compound, depending on the required package thickness. Succeeding processes of post-mold cure, strip etching, and laser marking were not affected by the encountered bent rails at mold but singulation process feedback that the affected strips prompted jig alignment errors which prevents the strip to be successfully auto processed at jig saw singulation. The problem on hand have encouraged the authors to understand the cause of bent rails thru process mapping and validation of its effect on the downstream processes.

*Keywords: Jig Alignment Error, Mold Process, Bent Side Rail, QFN, Transfer Mold*

## 1. INTRODUCTION

Transfer molding is a process where the units build with die and wires are being unified thru encapsulation. After the strips were molded, they will undergo another downstream process such as post-mold curing, strip etching, and laser marking before it reaches the singulation process where the strips will be cut into single units. Relevant topics are discussed and briefly elaborated on [1-4] with various ideas and learnings that can be related to this topic.

For the strips to proceed with singulation, alignment should satisfy the limit settings at the machine. If the alignment settings were not met, the machine will prompt errors for assistance. One of the errors that was frequently encountered was the jig alignment error, that was mentioned on [5-8]. Strips that have been encountered with jig alignment errors were inspected and found to have a bent side rail. Other strips without bent rails were successfully processed at jig saw singulation without any errors.

The occurrence of bent side rails was traced back to be induced after the mold process. Strips that were loaded on the molding machine have been validated to have flat side rails, but upon unloading bent rails were evident.

Data on hand have pushed the authors to come up with a technical study on how these bent rails were induced and how it can affect the jig saw singulation process. The authors aim to come up with recommendations that would address the occurrences of bent rail.

## 2. METHODOLOGY

The authors have taken the study of the mold process and validated how the process can produce strips with bent rails. Although bent side rail will not reject products, it has been observed that it will take a longer time and assistance for the strips to be processed at singulation. The authors have also studied why the bent side rails affect the downstream process of singulation. Once data were collected, the next activity is to analyze how to address the occurrence of bent rails. Lastly, the authors conclude and recommend the alternatives that can be considered with the encountered issues considering the results and validations that were brought about by the methodology.

## 2.1. Studying the Mold Process

The Mold Process is where to perform package encapsulation by filling the cavities with molding compound. Molding compound used in the production line is coded to avoid issuance of expired and wrong molding compound for the product. The process starts on a loading module where the strip magazines are loaded to a platform, followed by input indexing or strip pick-and-place module to transfer strips from the magazine to the preheater. The pre-heat module was then used to heat up the strip in preparation for the higher temperature of molding. Shown in Figure 1 is the pre-mold transfer module that transfer of strips and molding compound pellets into a molding module. Molding module shown in Figure 2 is where package encapsulation occurs by filling the cavities with molding compound. After molding, strips will be picked and place on the de-culling module show in Figure 3 where mold culls were removed from molded strips. Culls were the cured mold compound that remains after transfer molding. Strips will be unloaded after the de-culling processes.

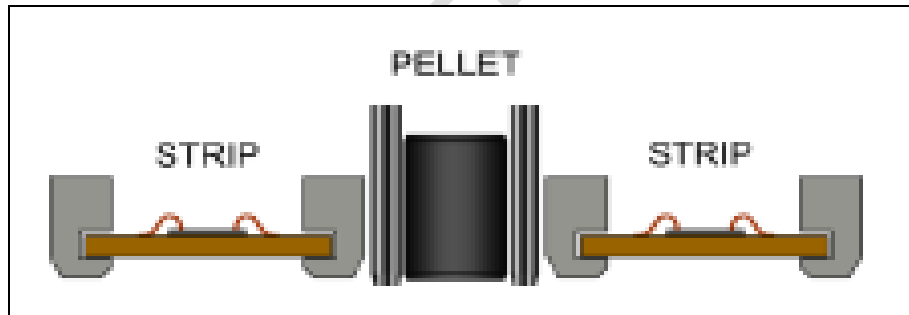
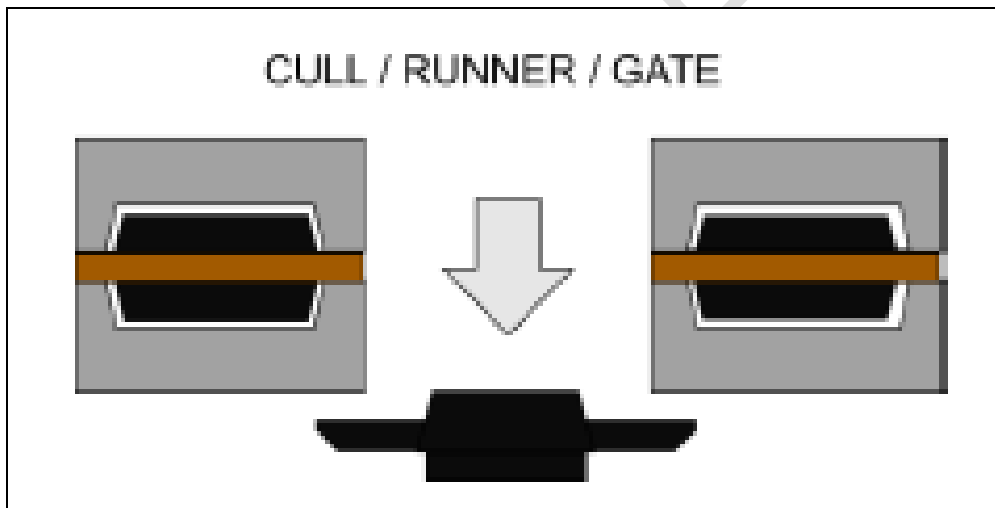


Fig. 1. Pre-mold transfer module



**Fig. 2. Molding Module**



**Fig. 3. De-culling Module**

The molding process was done to ensure that the components inside the units were secured and protected. Mold compound pellets were melted before transferring and occupying the mold chase. From Mold, several process steps such as Post Mold Cure (PMC), Strip Etching, and Laser Marking were done before the strips reaches singulation, this process flow is shown in Figure 4.



**Fig. 4. Assembly Process Steps**

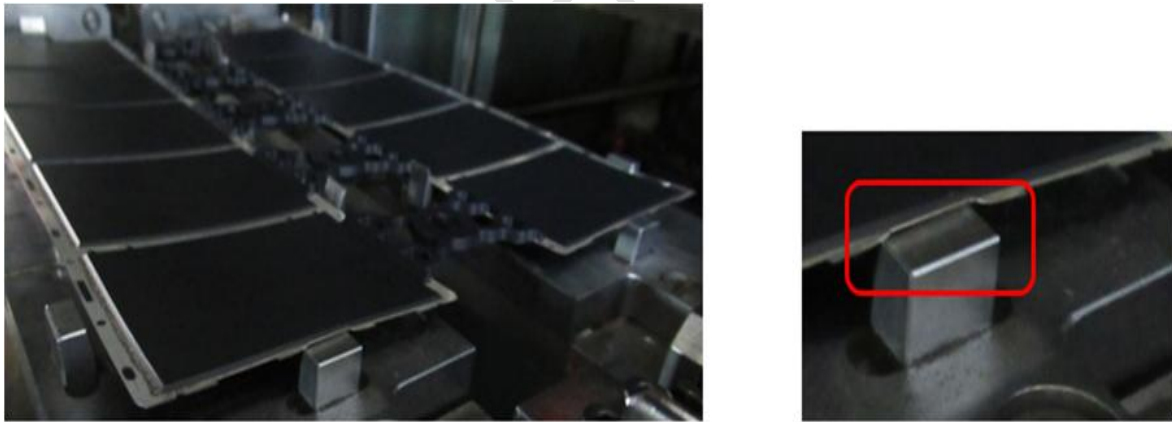
After Molding, strips were stacked on the magazines for PMC then it will be etched to remove the unnecessary areas of the strips. Marking comes after etching where the unit traceability will be marked on top of the strips. Bent rails were not an issue from mold to marking, but it induces issue on the singulation process.

At singulation, the strip configuration and unit alignment on the strip has been verified prior cutting. Alignment of the strip with bent rail to the jig detects the bent rail with failed alignment and thus prompts jig alignment errors that prevents the strip to be processed.

## 2.2. Analyzing How Bent Side Rail Occurs

The authors have validated if the bent rail signature can be found prior to strip molding, but the strips were not damaged or bent before loading the strips at the mold. However, an inspection of the strips upon unloading was observed to have bent rails. The authors have focused to find where can bent rail be induced inside of the molding machine and it was found to be on the unloader de-culling area.

When the strips are done molding, the molded lead frames will be picked up by the unloader picker and then will be placed at the de-culling module to separate the strips and removes mold culls. Upon observation, it has been found that the position of the molded strips was misplaced with the de-culling module upon transfer from mold chase, thus making the molded strips placed beyond the position of the strip stopper guide of the de-culling module. Strip stopper guide hits with the strip side rail upon strip placement resulting in side rail bend. Shown in Figure 5 is the actual validated sample of strips that have resulted with bent side rail.



**Fig. 5. Molded strips at de-culling module**

Strip misplacement happens when the motor pulse rate parameter which is responsible for the unloader position of the strips from the mold chase and de-gating module was not aligned to the proper unloading strip placement. Thru optimization of motor pulse rate parameter, unloader position with respect to the de-culling module was corrected and resulted with the eliminated occurrence of strip bent rails.

## 2.3 Jig Alignment Error at Singulation Process

Singulation process was equipped with jig alignment validation to ensure that the strips were aligned with the chuck table rubber nest jig before it proceeded with strip cutting. Jig alignment errors occur when the machine measured that the strip alignment and strip placement with the rubber nest jig was high enough to be compensated. During validation, strips with bent side rail prompt jig alignment errors.

Strips that were affected with bent side rail at mold cause jig alignment errors as the protruded area of the strip induces movement upon loading of the strip, thus causing failure at jig alignment measurement of the machine. The strip can still be processed by using manual jig aligner to ensure that the protrusion of the strip will not induce strip movements upon loading. Yet, the manual process takes time and manpower assistance, unlike the normal automatic singulation process

### 3. RESULTS AND DISCUSSIONS

With the data collected and summarized at Table 1, it has been found that the bent side rail of the strip was caused by misalignment of the strip with the de-culling module upon loading placement at molding process. Optimization of the motor pulse parameter has solved the problem by eliminating bent rail occurrence.

**Table 1. Process Mapping for Cause and Effect of Bent Rail**

Process Mapping for Occurrence of Bent Rail				
Process		Bent Side Rail Occurrence		Remarks
		Input	Output	
Mold	Strip Loading	PASSED	PASSED	No Issue
	Pre-Heat	PASSED	PASSED	No Issue
	Molding	PASSED	PASSED	No Issue
	De-culling	PASSED	FAILED	No Issue
	Strip Unloading	PASSED	PASSED	No Issue
PMC	Strip Stacking	PASSED	PASSED	No Issue
	Magazine Loading	PASSED	PASSED	No Issue
	Mold Curing	PASSED	PASSED	No Issue
	Magazine Unloading	PASSED	PASSED	No Issue
Etching	Strip Loading	PASSED	PASSED	No Issue
	Etching	PASSED	PASSED	No Issue
	Strip Unloading	PASSED	PASSED	No Issue
Marking	Strip Loading	PASSED	PASSED	No Issue
	Marking	PASSED	PASSED	No Issue
	Strip Unloading	PASSED	PASSED	No Issue
Singulation	Strip Loading	PASSED	PASSED	No Issue
	Strip Alignment	FAILED	FAILED	Jig alignment Error
	Cutting	FAILED	FAILED	Need assistance at jig saw
	Unit Tray Loading	FAILED	FAILED	Need assistance at jig saw
	Tray Unloading	FAILED	FAILED	Need assistance at jig saw

Strips with bent rail have been processed thru post-mold cure and laser marking without error noted. However, jig alignment error was encountered at Singulation. Once jig alignment error occurs, the strip cannot be auto processed at jig saw singulation and will be assisted thru manual strip loading using the manual aligner jig.

### 4. CONCLUSION AND RECOMMENDATIONS

Thru the results gathered in this study, the authors would like to conclude that the cause of bent side rail in Mold process was due to the misalignment of the position of molded strip during de-culling process. Adjustment to align the strip on the de-culling module was performed to eliminate the occurrence of bent side rails.

The authors also conclude that bent rails induced at mold is validated to have negative effect at singulation where jig alignment errors occur as the strip misaligned on the singulation jig caused by the bent protrusion. Strips encountered with jig alignment error due to bent rail can be assisted thru manual loading of the strip using the aligner jig.

In reference to the conclusion, the authors recommend on including the validation of bent rail as early as set-up buy-off procedure to prevent issues on the downstream process. This activity would help in avoiding the jig alignment error at the singulation auto process. Noted also that cited references [9-14] will be useful for improvement and recommended to apply on similar process to introduce process robustness.

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