Concept Generation and Selection

Generation Process
Reviewing the PDS was the first step in concept generation in order to fully understand each specification contained in this document. Please refer to Table 2 for the details of the product design specification. Since our project consists of several systems, we decided to split the concept generation into manageable chunks. These pieces will be combined during the concept selection phase. The pieces were divided by function, so no limitations were placed on the generation process.

The next step was to gather the necessary information in order to generate concepts with all the available background information. We were able to research several adhesion books on what people have done in the past to tackle the same issue we are addressing with this project. Information about what worked and what didn't was obtained through this research. The group also did some patent searches to try to get some more ideas on what people have done. We looked at the current ASTM D3359-02 standard and identified possible solutions to the problems that this method has as well. In order to gain the information necessary to perform concept generation, interviews were conducted with Research and Development engineers at Andersen in order to fully understand the solution space. Once we felt we gathered enough information, individual brainstorming sessions were completed by all group members. Idea generation was completed with the collaboration of all group members. This brainstorming process was repeated in order to ensure the solution space was fully explored. These sessions were moderated to ensure all members voiced their opinions and no discouraging words were used.

Several promising concepts will be described below:

1. Drag cutting mechanism: This design is supposed to emulate the motion of a human performing the test. The scoring blades would be actuated by a handle pulled by the operator. Human error would be eliminated by ensuring consistent angle and cutting force, every test. This concept would try to stay as close to ASTM D3359-02 as possible.

![Pulling Scorer (Pen)](image)

Figure 3 – Drag cutting mechanism
2. Pull test: This concept would use adhesive to attach a dolly to the paint. When the adhesive cured, the dolly would be pulled using a meter to measure the force needed to remove it. This force value would quantify adhesion.

![Pull test diagram](image)

Figure 4 – Pull testing concept

3. Press cutting mechanism – This concept would use a cookie cutter type idea that would actually press and cut the paint. The user would pull a lever to actuate the cutting mechanism. This straight cut would eliminate dragging of the blade across the painted substrate.

![Press cutter diagram](image)

Figure 5 – Press cutter

Please see Concept Generation appendix for detailed sketches of all ideas generated.
Selection Process

To narrow down the nearly 100 design concepts, a multi-voting method was used. The cards were spread around our workspace, and each group member was able to make several choices on what they saw as promising concepts. Based on the results of the first multi-voting procedure, we were able to narrow down our options to three promising ideas. These ideas were used in the final concept selection. Shown below in Table 3 is the weighted concept selection matrix that was used as our decision making tool in the selection process.

<table>
<thead>
<tr>
<th>Metrics</th>
<th>Weight</th>
<th>Current Test</th>
<th>Pull Test</th>
<th>Press Cutter</th>
<th>Drag Cutter</th>
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<tbody>
<tr>
<td>Reproducibility</td>
<td>25</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Repeatability</td>
<td>25</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Time/Test</td>
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<td>4</td>
<td>1</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Cost/Test</td>
<td>15</td>
<td>4</td>
<td>2</td>
<td>4</td>
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<tr>
<td>Manufacturing Cost</td>
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<td>5</td>
<td>5</td>
<td>2</td>
<td>4</td>
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<tr>
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<td>5</td>
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<td>3</td>
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<tr>
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<tr>
<td>Ranking</td>
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<td>4</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 3– Concept selection matrix

Based on our customer requirements, an appropriate weight was given to each of the metrics found in the matrix above. These metrics were directly derived from our product design specifications to ensure our concept that is selected will be the best design possible for our customers. Please notice that the current test will be used in our concept selection chart as a baseline for rating of our concepts.

Repeatability and reproducibility data was used to assign values for each of the concepts. We know that this data is poor for the current test, which is reflected in the scores. Pull test data was provided by Andersen and is very poor. The poor Gage R&R of the current testing method can be attributed to human error. The press cutter and drag cutter would reduce or eliminate human error from the ASTM D3359-02 processes. This error reduction would greatly improve Gage R&R.

Time per test is another important specification that was derived from the PDS. The current test is just uses a hand tool, so the time is quick. Pull testing takes hours for the adhesive to cure properly, so the time to set up for this test is the highest by far. The press and drag cutters both would allow similar setup and run times as the current testing method.

Cost per test for the current test is very low because the only disposable parts are razor blades. The pull test does not fare well here either, because each test would require a new or reworked dolly. The press and drag cutters both only require razor blades to be
changes once in a while. Therefore these concepts were rated the same as the current test for this specification.

Manufacturing cost for the current test is very low because it is a simple hand tool. The pull test would not take much to manufacture, because it would integrate tensile testing systems that are already in place at Andersen Corporation. The press cutter would require many parts to ensure proper mechanism function as well as a carriage that would be able to handle excessive forces that are involved in a press style cutter. Please refer to Supporting Calculations appendix for details on how forces were calculated for the press cutter. The drag cutter could potentially be injection molded parts because of the low forces involved in this system. The cost would be kept low due to the materials and limited necessary parts.

Safety of the current system is about in the middle because it is a hand tool, but contains sharp razor blades that are exposed during the test. The pull test is the safest concept because no blades are used as all. The press cutting system, according to our calculations, is the least safe concept we’ve come up with. Due to the high forces involved in this system, the slenderness ratio becomes very important. Please see the Supporting Calculations appendix for calculations that suggest failure of the blades due to the slenderness ration of the blades. The drag cutting system is about as safe as the current test system due to the exposed blades.

Based on the above concept selection matrix, we decided that pursuing the drag cutter into the detailed design phase would best suite our customer’s needs.

**Design Description**

**Modeling and Analysis**

Several modeling and analysis have been completed during the detailed design stage of this project. Slenderness ratio was used to calculate a safe amount of force to apply to the razor blades during testing. This helped us size the spring and design the carriage of the blades. Spring fatigue life was also calculated in order determine the life of this component which sees fairly high stresses. A linear bearing is being used in our carriage mechanism. Hertzian contact stress was calculated for this joint because of the high point stress that could be seen in this type of situation. Proper initial torque values were calculated for all bolts used in this system. This ensures proper force distribution on the bolt and that the bolts do not come loose after the mechanism is used. ANSYS analysis was completed on two critical components of the cutting system to confirm our hand calculations.

**Slenderness Ratio Calculation:**

In order to determine how much force could safely be applied to the blades that will be used, a slenderness ratio was calculated on each of these blades. This calculation was