Journal of Undergraduate Research

Volume 5, Issue 8 - May 2004

Hot Tack Seal Test on Golden Flake VFFS Machines Report and Activities

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ABSTRACT

Hot Tack and Peel strength performance tests were performed on samples of sealed and unsealed thermoplastic potato chip pouches from the Golden Flake Potato Chip factory located in Ocala Florida. Comparisons were made against competitive salty snack packages (Frito-lay) purchased at a local supermarket. Results suggest that virtually all samples exhibited heat-seal problems that could be mitigated by modifying sealing temperatures and dwell times.

Key Words: Heat seal, hot tack, impulse, seal strength

INTRODUCTION

Hot Tack is defined as the ability of a heat seal to withstand stress while the seal is still hot (Soroka, 1999). Hot Tack performance is important in today's fast-paced snack food packaging world. The higher a heat seal's hot tack strength the faster products can be packaged.

Hot Tack is one of the most important characteristics of thermoplastic films used in bag-making applications, particularly in vertical-form-fill-seal (VFFS) machines. Vertical-form-fill-seal machines utilize hot tack strength when products fall on newly formed seals within fractions of a second after the seal is formed. Soroka, (1999) describes a good hot-tack seal as one that will be able to resist peeling apart, even though it is still hot.

"The Hot Tack performance of the seal will directly influence the speed at which the VFFS packaging machine can be operated and/or the maximum weight of product that can be packed per packing unit" (Anonymous, 2003).

Several companies make Hot Tack testing devices. Solvay Polyolefins Europe, H. W. Theller LLC,

and Brugger are just a few of the companies that have developed machines to test the Hot Tack of seals using the ASTM F1921-98 guidelines.

The strength of heat seals is often determined by measuring the force required to pull apart the pieces of film which have been sealed together, either in a dynamic load test or a static load test (Robertson, 1993). Different laboratory tests have been developed to evaluate hot tack performance of thermoplastic resins in the form of films:

- *The spring test method, according to ASTM D 3706*
- *The instrumented hot tack testing method, according to ASTM F1921-98*
- *The falling weight method, according to industry common practice*
- *The practical test on a VFFS packaging machine*

All these methods consist of submitting the hot seal to a tensile force shortly after it has been formed (Internet, 2003). Work performed in this study involved the use of a dynamic load-testing instrument.

INTRO TO THIS STUDY

- *Realization of defects in Golden Flake bag seals*
- *Research Hypotheses: Defects in Golden Flake heat seals are attributable to improperly defined heat seal settings on Golden flakes VFFS machines.*
- *It is expected that analysis of hot tack parameters of Golden flake seals will help to define more appropriate heat sealing parameters that will significantly reduce heat seal defects*

TEST OBJECTIVES

The objective of this study was to determine appropriate seal characteristics for the Golden Flake chip bags. The manufacturer noted several complaints about the strength and completeness of these seals and, in particular, the rear seam seal. Golden Flake uses two types of VFFS machines. Lines A, B, and E are Woodman Co. 1992 models, while lines C and D are 1985 Write models. Observation of operating lines revealed the following operational parameters (May 27, 2003):

Table 1

Typical operating parameters observed on Golden Flake VFFS machines

Machine Line	Upper Jaw Temp. (F)	Lower Jaw Temp. (F)	Seam Temp. (F)	Dwell Time (s)	Sealing Pressure (PSI)
A	295	294	320	0.45	42
B	265	270	314	0.45	42
C	No Data	No Data	No Data	No Data	No Data
D	No Data	No Data	No Data	No Data	No Data
E	280	278	317	0.45	42
Mrs. B's	285	285	310	0.34	46

METHODS AND MATERIALS

Test Instruments

- ***Dynisco/Theller Hot Tack Heatsealer with Computer***
- ***Ruler and scalpel***
- ***14 sample unsealed strips (Hot Tack Test)***
- ***12 Sample bags of chips (3 from each running line samples at 15 min. intervals)***
- ***3 seals per bag with 4 test strips per seal (144 test strips)***
- ***3 Mrs. B's Sample Bags with 12 samples each (36 Samples)***
- ***10 Mrs. B's Sample shot Tack Strips***
- ***9 Sample seals from competitor Frito Lay***

Test Methods (Theory)

The Theller Hot Tack Heatsealer was used to perform Hot Tack tests on twelve unsealed strips of source film to identify appropriate sealing parameters. Temperature, dwell time, seal pressure, and cooling time were evaluated. Ideally, a heat seal should provide uniform strength throughout the seal, resulting in a profile similar to Figure 1.

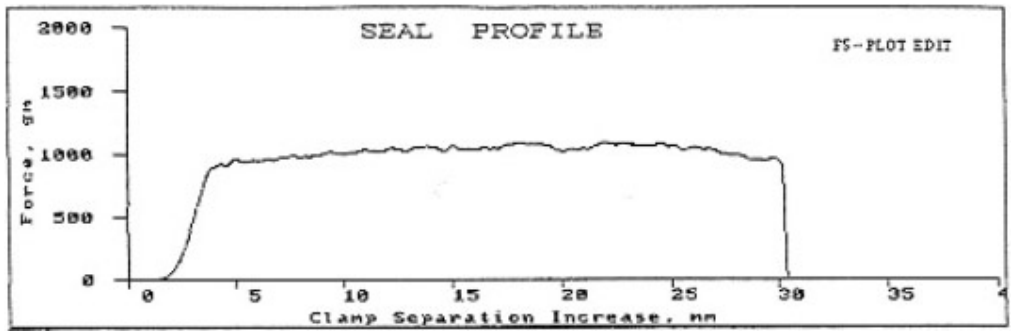

Figure 1. Desirable uniform heat seal profile

The Peel strength test was used to determine the seal profiles of sample bags formed under conditions outlined in Table 1. "Peel Strength" refers to strength of a heat seal after it has cooled to ambient temperature and achieved strength stability.

Test Procedures

Initially, each VFFS machines sealing parameters was programmed into the Theller Hot tack tester using the Peel Strength test option. Testing began with Machine Line A, Bag 1 but continued randomly thereafter. Each seal area (Top, Bottom, and Seam) was averaged from all three bags.

Fourteen virgin film test strips were sealed and tested for Hot Tack. Initial parameters from the 4 VFFS machines were used as the test parameters to eliminate the possibility of sensor readout error on the actual machines. Next, depending on the seal profiles obtained from these initial tests, the variables (dwell time, temp, cooling time, and pressure) will be altered slightly to obtain a normal seal strength profile as shown above.

Chip density testing was performed on sample bags of chips. The contents of each bag were placed into a container of known volume. This container was then lightly tapped three times to ensure that the chips settled naturally. The contents were then measured with a ruler by measuring the height of the container not occupied by chip materials. Once the volume of chips was estimated, bag volume was estimated using measured bag dimensions. Chip volume density was estimated by dividing bag volume by chip volume. Experienced potato chip manufacturers suggest that chips should not take up more than 80 percent of available space in order to minimize catching chip material within seals (Anonymous, 2003).

RESULTS AND DISCUSSION

Test Data & Results

Golden Flake Potato Chip Line. About 65% of all the standard Golden Flake bags had successful peels and only 69% of all bags had acceptable peel profiles. Seal strengths and peel profiles for sealed bags coming off different lines varied in a seemingly random fashion. On several instances, chip and seasoning matter was located between the seal crimps creating a bumpy profile as can be seen in Figure 2.

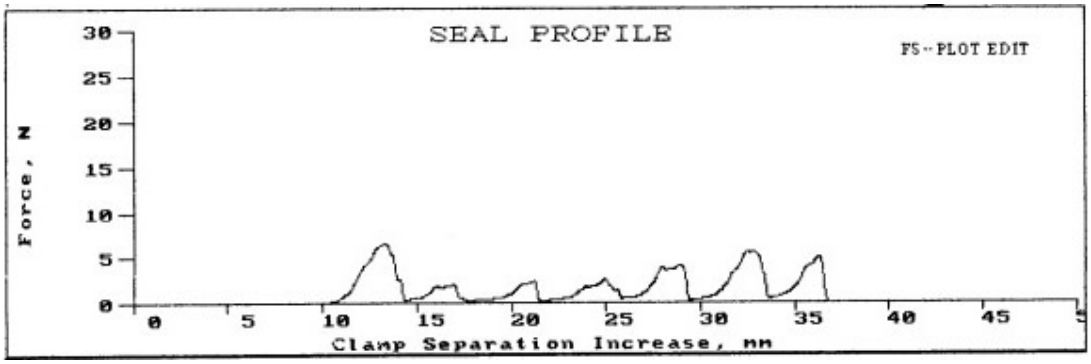

Figure 2. Chip matter between seals

This problem was not specific to Golden Flake, since it was observed in virtually all samples tested.

Hot Tack tests were initiated with same parameters as the Golden Flake lines. Initially the first variable changed was a temperature increase from 265°F to 275°F. After several tests, this proved to be the cause of an increasing arch forward in the profiles. The test temperatures were then lowered to 257°F and then again to 244°F. These changes caused a peak at the end of the profile indicating that the last part of the seal was stronger than the interior areas of the seal, which may result in a bursting effect when bags are opened (Figure 3).

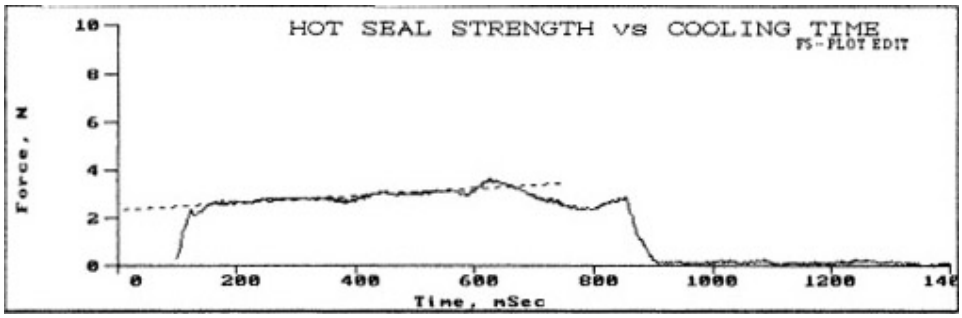

Figure 3. Seal strength peaks at edge of seal

Seal temperature was set back to 265°F and dwell time was increased from 0.45 to 0.50 seconds. This resulted in a bumpy profile. Dwell time was increased again to confirm this trend. Increase in dwell time also created a peak at the end of the profile similar to the increased temperatures. Dwell time was then reduced to 0.40 seconds, which resulted in an acceptable profile, but seal strength

was reduced by as much as 30 percent. This trend was confirmed by reducing dwell time to 0.38 and 0.36 seconds. However at 0.38 seconds and 265°F, seal profile appeared optimal, but with a strength reduction of about 18%.

Mrs. B's© Line. The Mrs. B's line did not perform as well as the Golden Flake potato chip line. Only 11% of all tests resulted in peel behavior, while none of these provided desirable peel performance. Delamination of seals accounted for about 88% of all test profiles. Chip and seasoning matter was present between many of the seals as can be seen in Figure 4. Initial force required to pull seals apart was fairly high. An average of 26.18 N (+/- 3.3 N) was needed to separate each seal in all three seal areas. This initially high force, followed by an abrupt decline in force, indicated that seal would open in a tug and burst manner.

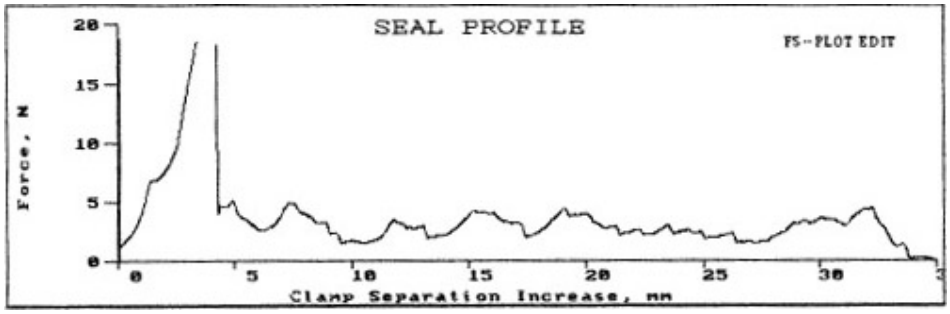

Figure 4. Delamination and chip debris

Initial hot tack testing parameters were sealing temperature of 310°F, and dwell time of 0.34 seconds at 46 PSI. This resulted in a flat curve with a large peak at the end as evident by Figure 5.

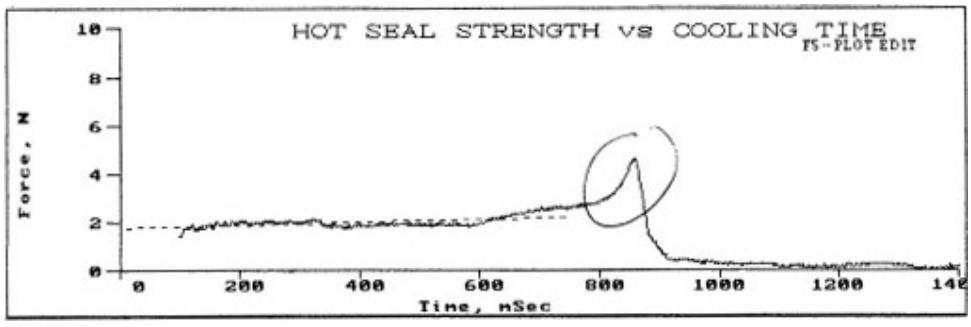

Figure 5. Improved seal profile for Mrs. B's Brand chips

Initially dwell time was increased to 0.38 sec, which evened out the curve but resulted in a slightly melted seal. Temperature was then dropped to 285ÖF at 0.38 sec dwell time and 46 PSI. This profile became closer to ideal except for a larger peak at the end of the test as seen in Figure 6.

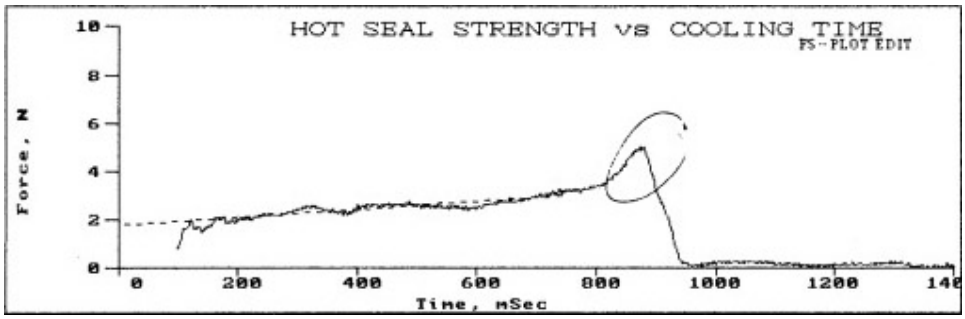

Figure 6. Improving seal profile for Mrs. B's Brand chips

Dwell time was reduced to 0.34 sec and then increased to 0.420 sec, which resulted in an unfavorably curved profile and then flat profile with a peak, respectively. Dwell time was increased again to 0.45 sec, which melted the seal. To compensate the temperature was reduced to 275°F with 0.45 sec dwell time and 46 PSI. This produced the best profile, however, the seal was still slightly melted. Temperature was reduced again to 265°F, which resulted in a near ideal profile. Seal strength remained an issue, as this seal was relatively weak. The force required to separate the seal was about 2.15 N. Dwell time was increased to compensate to 0.46 sec, which increased seal strength to about 2.59 N. This profile was not as even, as can be seen in Figure 7.

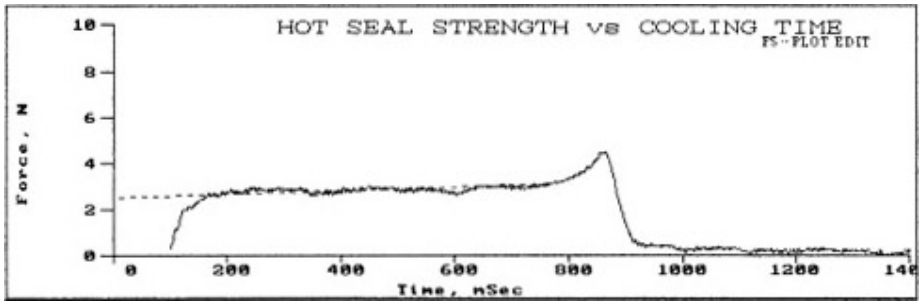

Figure 7. Best seal performance found Mrs. B's Brand chips

Therefore, it appears that significant improvements to Mrs. B's seal characteristics are possible by running at a lower temperature of 265ÖF, and slightly longer dwell time of about 0.46 sec.

Frito Lay© Line. Results showed that only about 55% of all seals resulted in a smooth peel. Remaining seals resulted in delamination and seal breaks. No Frito-Lay samples displayed ideal seal profiles. Profiles indicated several problems including uneven seal temperatures and chip and seasoning matter between seal crimps as can be seen in Figure 8.

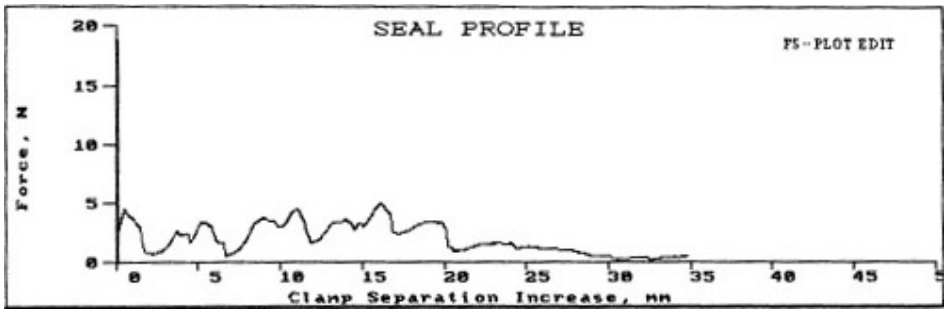

Figure 8. Bumpy seal performance from Frito-Lay due to chip debris

Bulk Density Tests

Industry practice suggests that chip density should not exceed 80% of pouch volume. There are two ways to determine the volume of a pouch. First, a pouch can be filled with a known volume of water until full. Another approach is to calculate the volume of a pouch by using a calculation involving the length, width, height, and air fill space. The latter can be very involved and time consuming, so for the purposes of these experiments the water fill method was used. The following are the results of the Bulk Density tests.

Table 2

Chip volume as percent of total bag volume

Measurement	Golden Flake© Line	Mrs. B's© Line	Frito-Lay©
Pouch Volume (cm^3)	4750.00	3700.00	1000.00
Container Volume (cm^3)	8390.17	8390.17	1191.79
Chip Head (cm^3)	6030.44	6817.02	786.05
Chip Volume (cm^3)	2359.73	1573.15	405.74
Chip Density (%)	49.68	42.52	40.57

CONCLUSIONS

The Golden Flake potato chip line sealing specifications need to be checked and maintained more rigorously. Trials should be done with temperatures approaching 265°F and dwell time of about 0.38 seconds at 42 PSI. Line B is running closest to these specifications and is indicated by its nearly 92% peel success rate.

The Mrs. B's lines sealing specifications need to be considerably altered. Trials should be run with temperatures being reduced from 310 F to about 265°F. As temperature is reduced, dwell

times should be increased from 0.34 s to between 0.45s and 0.46s at 46 PSI.

Bulk density testing results were inconclusive in determining a reason for chip matter being found between the seals. All brands tested had a bulk density of well under the 80% rule of thumb. Other causes for this phenomenon may include drop height of more than 6-8 feet, too much seasoning being added, and/or not enough air pressure to blow past the seal area just prior to sealing.

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