PURDUE UNIVERSITY | Agricultural and Biological Engineering

CAPSTONE/SENIOR DESIGN EXPERIENCE 2020

Title: Purdue Student Soybean Innovation Competition

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I. Problem Statement and Background

The capstone project is to design a novel soybean-based product in the Purdue Student Soybean Innovation Competition.

- Utilize renewable resources to create industrial or food products.
- Save petroleum resources and help with the environment.
- Gain ideas for potential economic development.
- Get practical experience in the application of coursework and technical areas.

The team designed a soybean-based smartphone case.

- Indiana produces tens of soybean annually.
- Soybean plastic has enough strength and hardness.
- Demand of phone case is forecasted to increase as technology develops.
- People will prefer eco-friendly products, regarding environmental protection.

II. Decision Making

➢ **Patent search**

- Methods of preparing thermoplastic soy protein plastics.
- Methods of building mold for phone cases.
- Manufacturing process and technology of phone case.

Patent search was conducted using USPTO.org, Espacenet.com, Google Patent, Lens.org, Patentscope.wipo.int, and Globaldossier.uspto.gov.

Several classifications for patent searching included H04B1, C08L89, C08K5, A45C11, A45C13, G06F1, A23J3.

Profam 974 (Soybean Protein Isolated 90% protein) was chosen as raw material.

➢ **Marketing analysis**

- Industry analysis

Cell phone manufacturing
Phone accessory manufacturing

- Product analysis

Eco-friendly material
Device protection

- Marketing volume

Databases: Mintel; IBIS world.

- Price estimation

- USA: 120M phones per year.
- World: 1.4B phones per year.
- 5G technology keeps the market growing.
- The product can help sell 400 tons of soybean annually.

➢ **Criteria**

Natural renewable materials applied.
ASTM D6400 standard.

III. Designs and Tools

1. **Oven, centrifuge, experimental apparatus** - prepare soy protein plastic from soybean protein. (Figure 1)
2. **CAD, CAM, machining tools** - design and manufacture mold for casting the phone case. (Figure 2)
3. **Dake operation presses, MTS (tensile testing machine)** - cast phone case with prepared mold and soy plastic. (Figure 3)

Figure 1

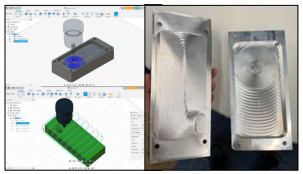

Figure 2

Figure 3

IV. Final Design and Evaluation

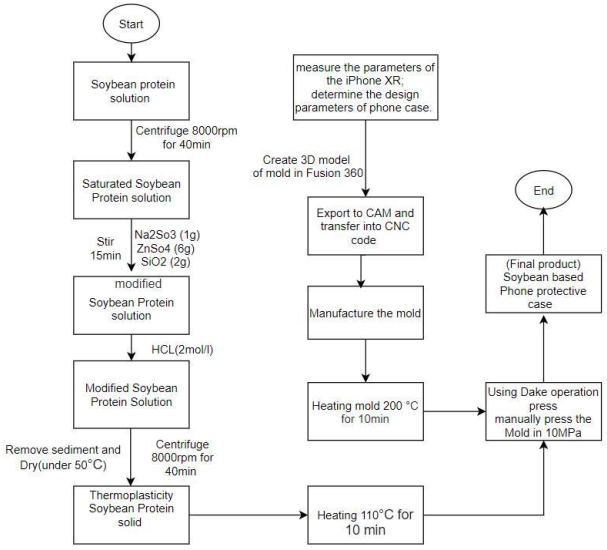

Figure 4: Flowchart

Batch size approximation: One shift 8 hours. One batch 1200 cases, 4 hours.

V. Quality of Solution

- Waterproof property of soybean plastic - good performance in the preliminary test.
- Scratch-resistant test – good for daily use.
- Simple drop test – little deformation and protective.
- Compression test on soy plastic - good mechanical properties in certain water concentration (using MTS)

Alternative solution (component of plastic):

- Soybean protein plastic (adding soybean fiber).
- Plastic made of soybean fiber and other composites.
- Soybean protein plastic (using Arcon S-Soy Protein Concentrate)

Figure 5: Final Prototype

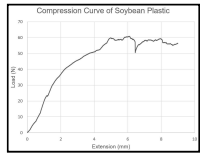

Figure 6: Compression test on 13mm x 13mm x 19mm plastic cylinder

VI. Economic Analysis

Raw materials		Vendor/Source		quantity/case	$/case	$/year
SPI	79.3/kg	ADM		0.06kg	4.758	30927
Urea	22.04/kg	Amazon		0.04kg	0.8816	5730.4
NaOH	130/kg	Amazon		0.01kg	1.3	8450
Na2SO3	24.2/kg	Amazon		0.0005kg	0.0121	78.65
SiO2	400/kg	Amazon		0.001kg	0.4	2600
ZnSO4	7/kg	Amazon		0.003kg	0.021	136.5
HCl(2M)	52/L	Amazon		0.05L	2.6	16900
				Material cost:	9.9727	64822.55
				Material cost (includes loss):		72025.06
Operation Cost:						
Lindberg Blue Oven (drying and heating)		750 Watts	13140 kWh/yr		**Electricity cost:**	1382.328
					Mold cost:	500
					Total cost:	73907.38
					Annual sale:	132000

Table 1: Budgetary income and expenditure of the product

Assumptions:
1. Annual phone case production quantities is 6500 of one model, such as iPhone XR, (according to annual retail quantities of iPhone XR).
2. Each phone case weighs 60g. 90% of raw materials are converted to final product.
3. The annual retail quantity is 6000.
4. Advertising cost and packaging cost will be $82907.38.
5. The retail price is $22.
6. Raw material cost will be lower when purchased in the industry level.
7. Consider the operation cost of different machines and labor costs, based on the improvement of the industrial process.

VII. Product and Process Implementation plans

Study on influential factors of mechanical property of soybean plastic, such as water concentration, thermoplastic property, microstructure. etc.

Conduct tests for product evaluation and process improvement:

- Professional scratch test (Scratch Tester).
- Impact test for the whole phone case (Impact Tester, Drop Tester)
- Biodegradability analysis (Scanning Electron Microscopy. etc)
- Professional waterproof test.

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