ANNUAL REPORT COMPREHENSIVE RESEARCH ON RICE

January 1, 2019 - December 31, 2019

PROJECT NO. RU-7

# PROJECT TITLE: Automotive Interior and Plastic Bag with Rice straw and Hulls


PROJECT LEADER:

Joseph Greene, Ph.D.

Department of Mechanical Engineering Mechatronic Engineering and Manufacturing Technology
California State University, Chico
400 W First st

Chico, CA 95929-0789


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LEVEL OF 2019 FUNDING: $19, 744

OBJECTIVES AND EXPERIMENTS CONDUCTED, BY LOCATION, TO ACCOMPLISH OBJECTIVES:

The project is in two phases with the first one for an automotive interior part and the second one with a plastic bag. Ford Motor Company engineers are very interested in the automotive project that uses rice straw and hulls as a reinforcement with recycled polypropylene. In 2019, in the automotive project, recycled polypropylene plastic was added to rice straw and hulls at concentrations of 20% and 40%. The rice straw and hulls increased the tensile and impact properties. In the second project, recycled polyethylene plastic was added with rice straw and hulls to make plastic bags as a cellulose replacement. The rice straw and hulls improved slightly the tear strength and the drop impact.

The objectives are as follows in the first project:

1. Compound the rice straw or rice hulls with 40 and 50% by weight concentrations with polypropylene or other plastics.
2. Injection mold the rice straw and rice hulls with polypropylene plastic in tensile and impact bars.
3. Test the plastic interior part for performance.

The second project will produce plastic bags with rice straw and hulls as a cellulose replacement and low-density polyethylene plastic.

Roplast Industries in Oroville, CA, has expressed interest a cellulose-polyethylene plastic bag to create a textured surface for the plastic bag. They are interested in producing the new cellulose bag in the next several months, if an appropriate manufacturing process can be developed. Rice straw and hulls contain about 50% cellulose. Producing a plastic bag with 5% cellulose from rice straw and hulls is very desirable. Plastic bags should expand into the area of more appealing textures. Cellulose can provide an attractive surface with a textured feel. Research is needed to develop low-cost sources of cellulose.

The objectives are as follows:

1. Compounded the rice straw and hulls with 2% to and 5% by weight concentrations with polyethylene.
2. Produced blown film plastic from the recipes.
3. Test the plastic film for bag performance.

SUMMARY OF 2019 RESEARCH (major accomplishments), BY OBJECTIVE:

The project is in two phases with the first one for an automotive interior part and the second one with a plastic bag. Ford Motor Company engineers are very interested in the automotive project that uses rice straw and hulls as a reinforcement with recycled polypropylene. In 2019, in the automotive project, recycled polypropylene plastic was added to rice straw and hulls at concentrations of 20% and 40%. The rice straw and hulls increased the tensile and impact properties. In the second project, recycled polyethylene plastic was added with rice straw and hulls to make plastic bags as a cellulose replacement. The rice straw and hulls improved slightly the tear strength and the drop impact.

Objective 1. Compound the rice straw or rice hulls

The first area is to compound the recycled polypropylene plastic with natural fibers. In this area, we acquired fibers, additives, and plastics. We compounded the materials with a Leitztriz twin screw extruder. Compounding is necessary to combine the recycled PP plastic into plastic pellets with rice straw and hulls.

We compounded the materials with a Leitztriz twin screw extruder. Compounding is necessary to combine the PP plastics into plastic pellets with rice straw and hulls. Additives can be combined with the recycled PP plastics and the natural fibers to create a strong part.

The twin screw extruder, American Leitzritz Model ZSE-18HP twin-screw extruder system, with 40:1 L/D is shown in Figure 1. In the feed zone, the particles are conveyed away from the hopper and fed into the heated barrel. In the transition zone, particles are melted and the melt homogenized, completing a process that started at the end of the feed zone. This section is designed to enhance the friction and contact with the barrel. Finally, in the metering zone, screw section is designed to act efficiently as a pump by generating pressure in the now homogenously molten mass of plastic.

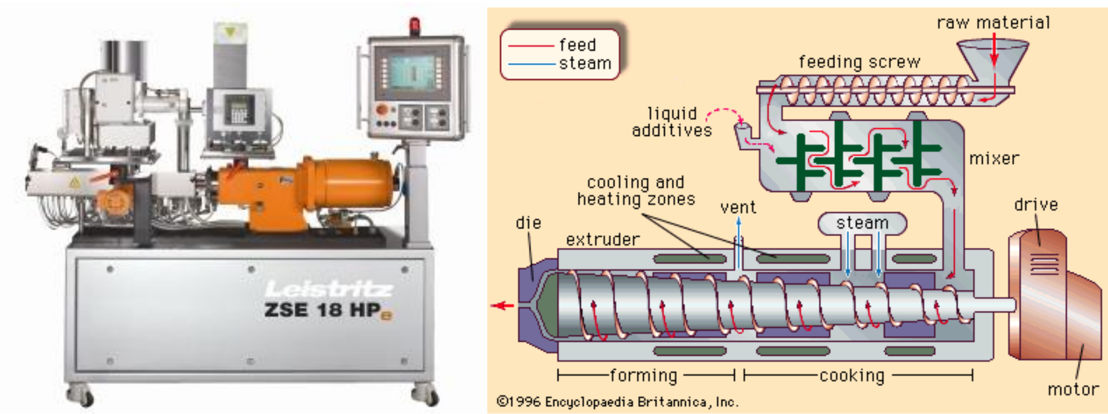


Figure 1. Leitztriz twin screw extruder with 40:1 L/D and 18 mm diameter.

The deliverables for the first area are production of five pounds of several recipes of PP and rice straw and hulls with additives.

Objective 2: Injection mold the rice straw and rice hulls with polypropylene plastic in tensile and impact bars.
The third area is to mold the tensile bar mold with several recipes for impact on the ARBURG injection molding machine. Figure 2 lists the picture of the Arburg 28-ton injection molding machine at Chico State University.


Figure 2. Arburg 28-ton injection molding machine.

Injection molding is a process where solid plastic is melted, injected into a mold, and then cooled back to a solid. Plastic injection molding equipment, typically, comprises an extruder and a compressions press. The plastic pellets are placed in the hopper and fed through the extruder in three main heated zones. The temperature profile in the three zones is dependent on the plastic type. The first zone is called the feed zone. The second zone is called the compaction zone. The third zone is called the metering zone.

Students compounded the plastic and rice straw and hulls and molded the parts.
Figure 3 and 4 shows the students with the molding machines.


Figure 3. Student working on the twin screw machine adding rice straw and hulls.

Figure 4. Student working on the injection molding machine.

Objective 3: Test the plastic interior part for performance.

The fourth area of the research will conduct testing on the molded parts from the third area. In 2019, we made ten or so tensile bar and impact bar parts and then tested the plastic parts for tensile strength, impact strength, and quality appearance. Figure 5 illustrates the tensile machine.

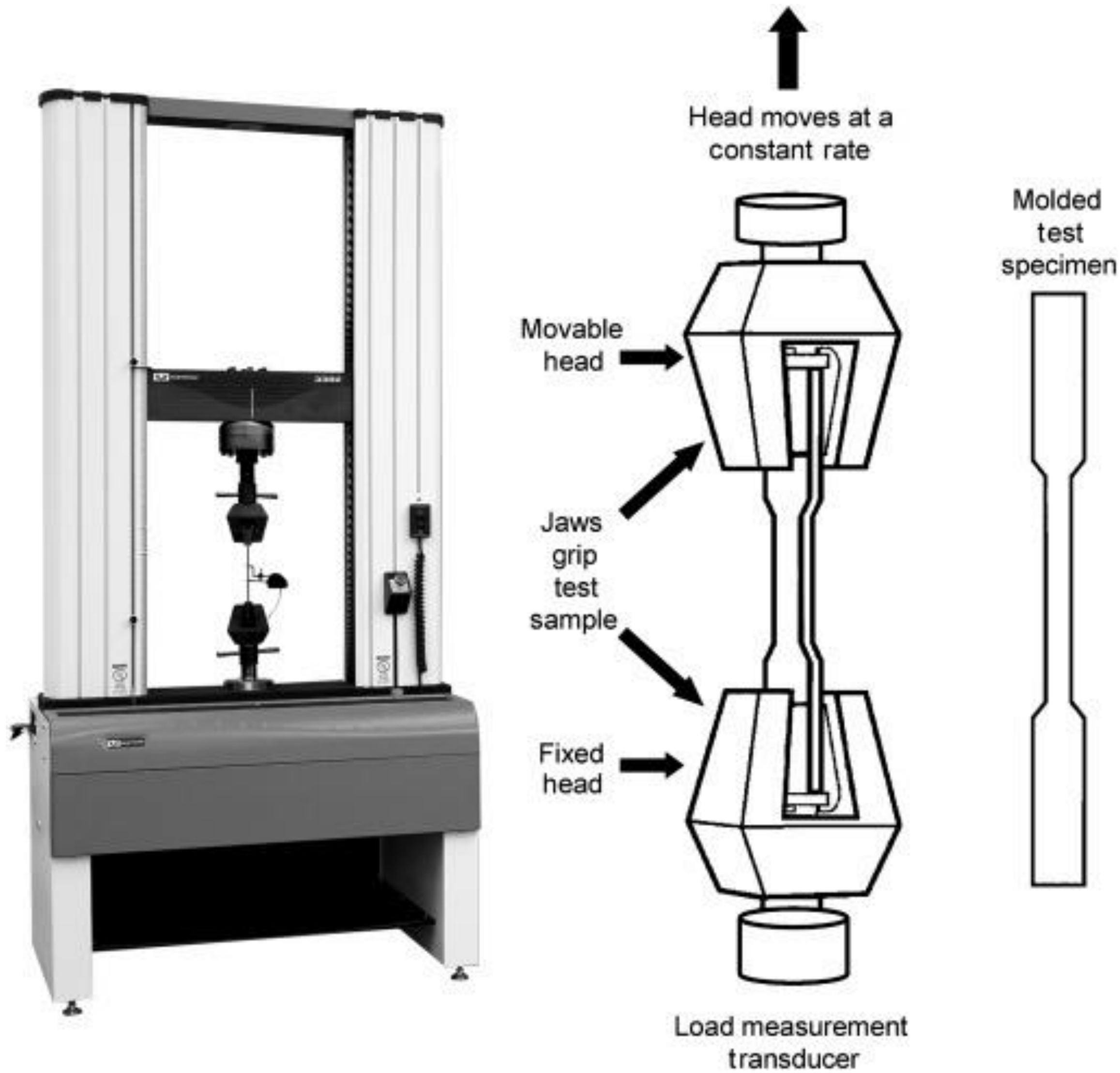


Figure 5. Tensile test machine.

Results from 2019 work show that the strength of the plastic increased with the addition of rice straw and hulls. Figure 6 shows the tensile testing of PP with 20% rice straw and hulls.

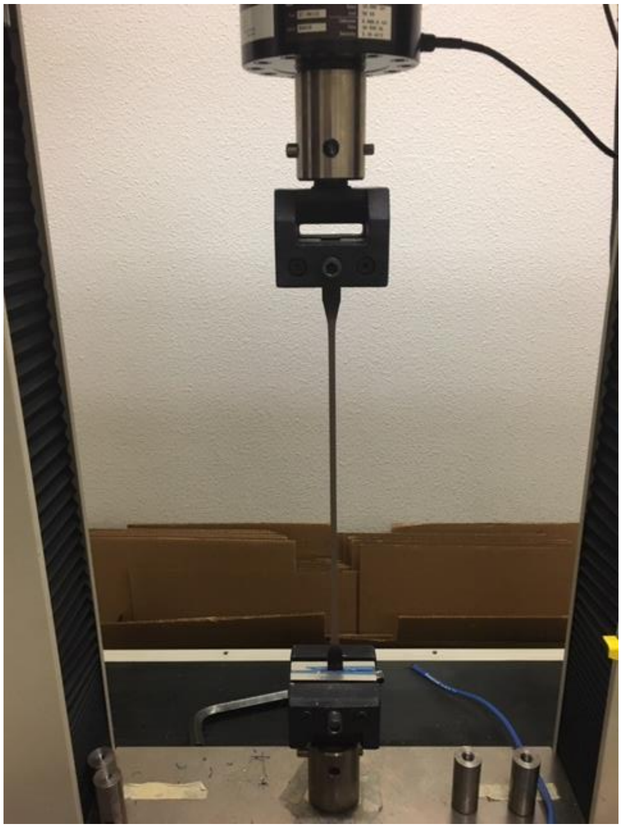

Figure 6. Tensile testing of PP and rice straw and hulls.

The testing produced the results that showed that rice straw and hulls at 40% and at 20% increased the tensile load. Figure 7 shows the results. PP and rice straw at 40% was 1,100% stronger than neat PP and that PP and rice straw at 20% was 700% was stronger than neat PP. PP and rice hulls at 40% was 460% stronger than neat PP and that PP and rice hulls at 20% was 450% was stronger than neat PP. The other parts in the graph were made with PP and different combinations of rice straw, rice hulls, and hemp fiber.

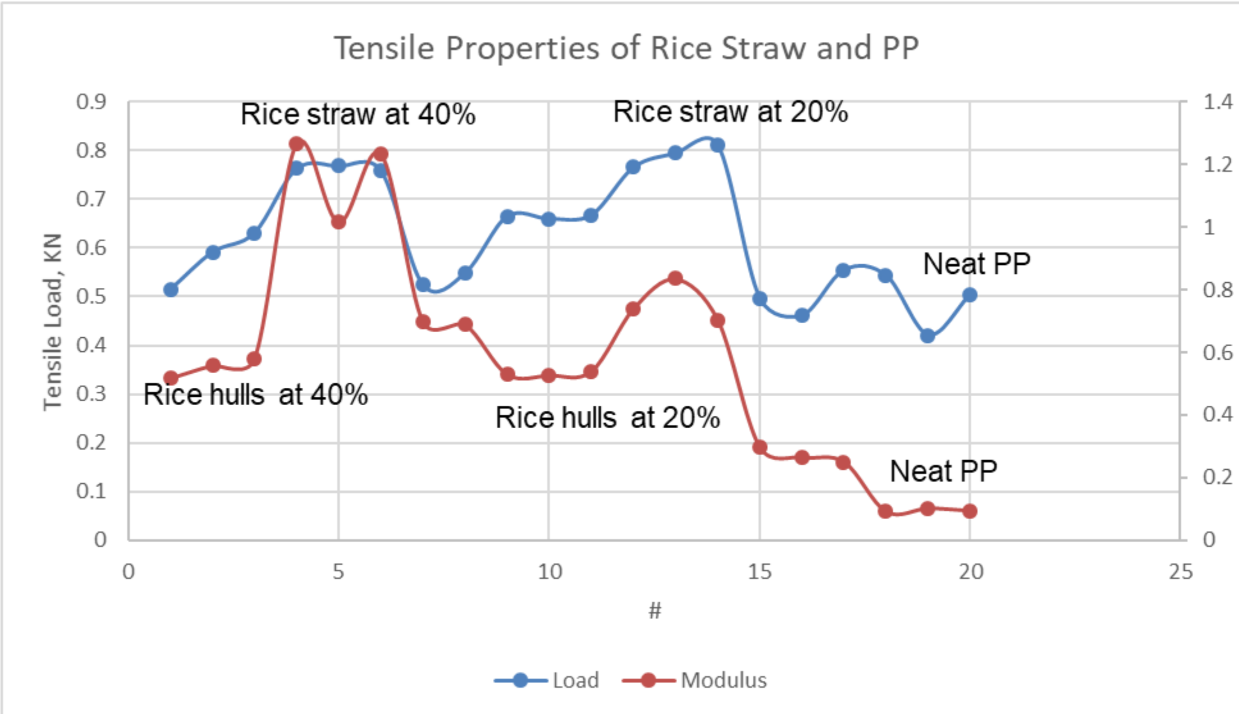


Figure 7. Tensile results for rice straw and hulls and PP.

The impact tests are based on an Izod impact test machine. Figure 8 illustrates the Izod impact test. In this test the sample is placed upright. Then a weighted pendulum swings down and impacts the sample. The energy absorbed by the swinging pendulum is listed on a dial on the machine.

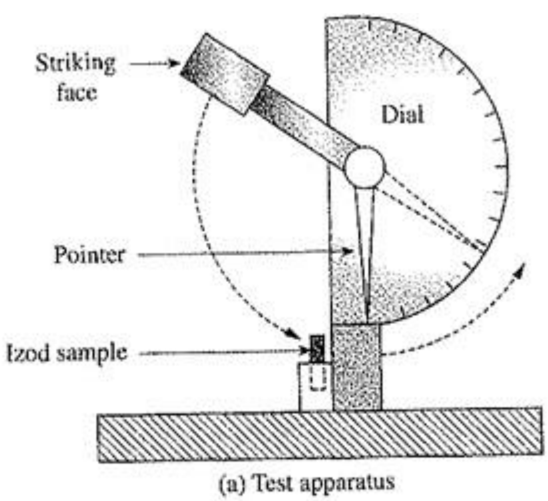


Figure 8. Izod impact test.

Results from 2019 work show that the PP and rice straw and hulls at 40% and at 20% increased the impact strength. Figure 9 shows the results. PP and rice straw and hulls at 40% was lower than neat PP and that PP and hulls at 20% higher impact strength than neat PP. PP and rice straw at 40% was 20% lower than neat PP and PP and rice hulls at 20% was 110% higher than neat PP. The other parts in the graph were made with PP and different combinations of rice straw, rice hulls, and hemp fiber.

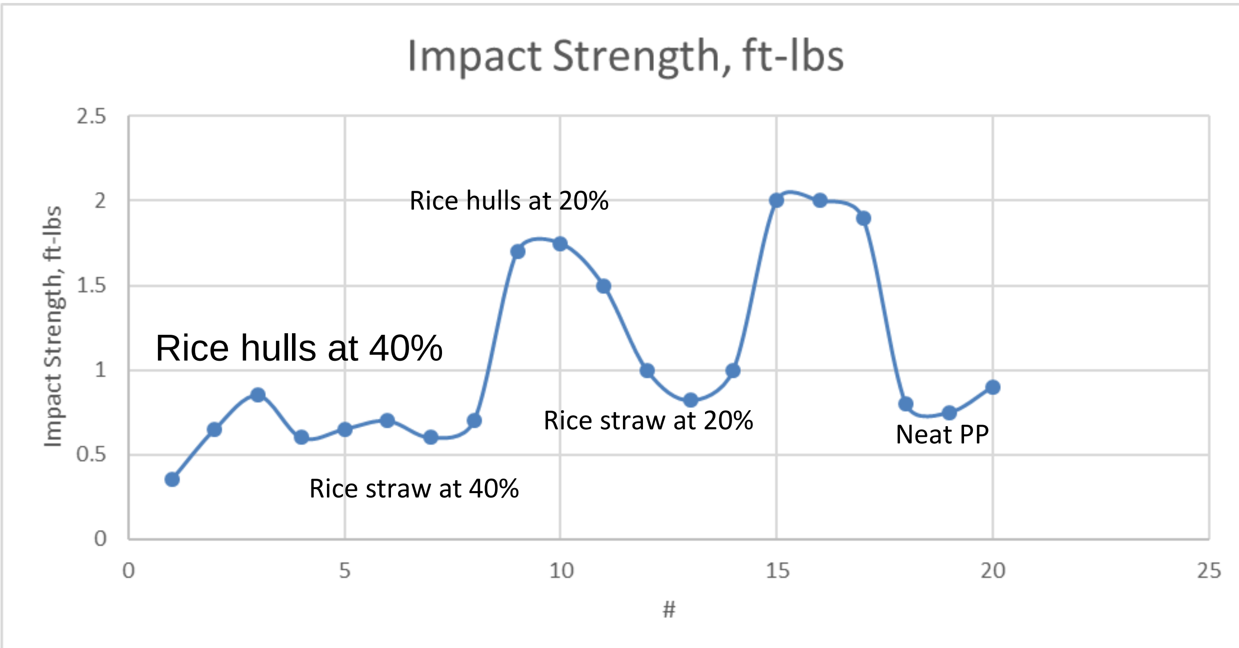


Figure 9. Izod impact test results for Rice straw and hulls.

**Conclusions**

Plastic parts were made with recycled polypropylene and 20% rice straw and hulls and 40% rice straw and hulls. The conclusions are as follows:

1. Rice straw and hulls can be blended with recycled poly propylene with a Leitztriz twin screw extruder and rates of 10 pounds per hour.
2. The plastic pellet was produced with good quality.
3. Rice straw and hulls can be injection molded with recycled poly propylene on a 55-ton Arburg injection molder into tensile bars.
4. PP and rice straw at 40% was 1,100% stronger than neat PP.
5. PP and rice straw at 20% was 700% was stronger than neat PP.
6. PP and rice hulls at 40% was 460% stronger than neat PP.
7. PP and rice hulls at 20% was 450% was stronger than neat PP.

The best material for automotive part is recycled PP with 40% rice straw and hulls for the automotive interior part.

Part 2 research: Plastic Bag and Rice straw and hulls.
Objective 1: Compounded the rice straw and hulls with 2% to and 5% by weight concentrations with polyethylene.
Results show that we compounded plastic with 3% rice straw and hulls.

Objective 2: Produced blown film plastic from the recipes.
Results show that we produced plastic bags with 3% rice straw and hulls. We then tested them for drop impact strength and tear strength.

Objective 3: Test the plastic film for bag performance.
We then tested them for drop impact strength and tear strength.

Results from 2019 work show that rice straw and hulls increased the tear strength and drop impact strength of the plastic bags. Figure 10 shows the test equipment for the tear test and Figure 11 shows the test equipment for the drop impact strength.

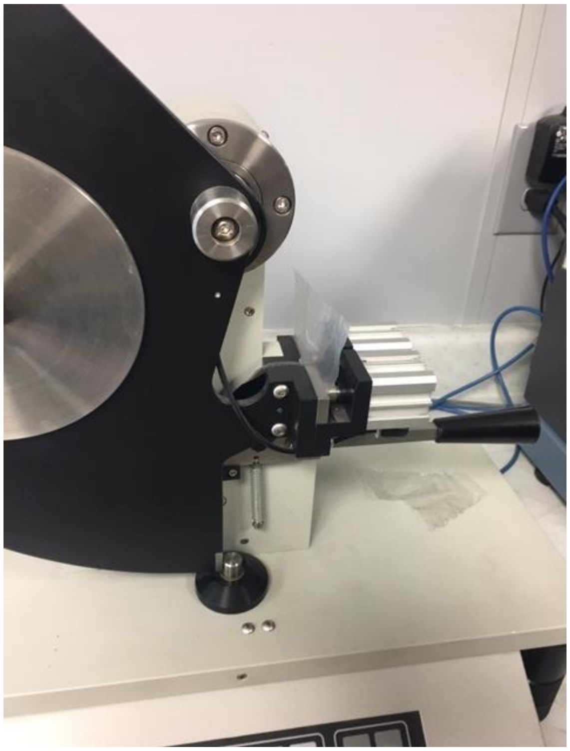

Figure 10. Tear strength tester

Figure 11. drop impact tester

The tear results show that LDPE and rice straw and hulls had equivalent drop impact strength and had 11% higher tear strength as neat LDPE plastic bag. The thickness of the bags was 0.100 in.

### Conclusions

We found that the rice straw and hulls compounded very nicely and made excellent plastic bags. The plastic bags had equivalent drop impact strength and 11% higher tear strength as LDPE plastic film. The project will continue to develop the manufacturing process and produce plastic bags on a production line.

PUBLICATIONS OR REPORTS:

None currently but planning on publication in Society f Plastic Engineers at

ANTEC 2020 in March of 2020.

CONCISE GENERAL SUMMARY OF CURRENT YEAR′S RESULTS:
Plastic parts were made with recycled polypropylene and 20% rice straw and hulls and 40% rice straw and hulls.  Rice straw and hulls can be blended with recycled poly propylene and injection molded with recycled polypropylene. The plastic pellet was produced with good quality. Rice straw and rice hulls increased the tensile strength and impact strength of polypropylene.

We found that the rice straw and hulls compounded very nicely and made excellent plastic bags. The plastic bags had equivalent drop impact strength and 11% higher tear strength as LDPE plastic film. The project will continue to develop the manufacturing process and produce plastic bags on a production line.