**PRESENTER:** Hello, everyone. Good afternoon. Welcome to this session about the powder injection molding. This is a session where it's presented by Zhong Wen from the AAC. Dr. Zhong?

**WEN ZHONG:** Yeah.

**PRESENTER:** Dr. Zhong, yeah. And I am from Autodesk. I'm a software testing engineer in the [INAUDIBLE] team of Autodesk. So now, please, Dr. Zhong can begin through the presentation. OK?

**WEN ZHONG:** Good afternoon, everyone. I'm very grateful to attend this Autodesk university. So I really appreciate Autodesk for giving me this opportunity to give this presentation. Ah, I'm sorry.

So this is the agenda. The topic of this presentation is the powder injecting molding. So this work is carried out in cooperation between Autodesk and AAC Technologies this year. So in this class, I will introduce to you the principle of the powder injection molding and list its applications in AAC Technologies. So here is the class summary.

So within this class, we will be able to know how to predict the various kinds of defects in the PIM. And we can also discover that different problems with the [INAUDIBLE] production. And we can also learn how the Moldflow collaborates with external partners.

So firstly, I will introduce the AAC Technologies to you. AAC Technologies was founded in 1993 and started in Hong Kong in 2005. It has become a global leading supplier of integrity to macro component solutions for communication and consumer electronics products. We provide innovative solutions and technologies, ranging from the [INAUDIBLE] to the haptic vibrators and radio frequency-- oh, OK, thank you-- the radio frequency and mechanical [? integration ?] and the [? MEMS ?] components.

Our [INAUDIBLE] are extensively used in the smartphones, the ultrabooks, the tablets, and the wearables. Also, the other consumer electronic products.

So now, the AAC Technologies has more than 20 research and development centers worldwide with over 1,000 senior research engineers. And overall, we have very close relations, close collaborations, with the [INAUDIBLE] Chinese universities, such as the Nanjing University and the Huachong University of Science and Technology.

So far, we have eight professors from the above universities from the above universities that have become our counselors. And our company spends 7% of our revenues to invest in the research and development each year.

As of now, AAC Technologies has experienced engineers in a wide range of disciplines. And we have the advanced simulation capabilities. Besides the collaboration with the universities, we also have extensive third party collaborations. In fact, the powder injection molding simulation is a collaboration with Autodesk. It's one of the best examples.

So here is our revenues in 2015. You'll see that dynamic components which is including the speakers, the receivers, and the speaker boxes, these are our advantage products which take account for about 49% of our revenue. Moreover, [INAUDIBLE] our speaker boxes, for now, we have occupied 40% of global market share.

So the non-acoustic components, such as the haptics, the radio frequency, and the mechanical components of the cell phone, and the MEMS components have shared the rest of the 51%. Therefore, AAC Technologies is the world's leading micro-component provider.

So powder injection molding technique has been used in the manufacturing of our products. In order to investigate the flowing, the separation between the particles and the [? banners ?] in the injection and the defects of distribution, we carried out the collaboration study with Autodesk this year. And we obtained many achievements in this area.

So during the next few minutes, I will give you an overview of the powder injection molding technique. So in this section, we will be clear on those questions I ask below. That is, what is PIM? And why do we use PIM? Who invented it, and who owns it now? When and where was it invented? And how is PIM done?

So now, PIM, the powder injection molding, is a rapidly growing technology for producing complex geometry, [INAUDIBLE] components from ceramics and metals. In fact, it's a merge of two technologies, which is the plastic injection molding and the powder metallurgy. So the PIM parts shoot with high precision and reproducibility. So it [INAUDIBLE] suitable for the manufacturing of the small metal parts.

Because of the strength is relatively high, especially in the small parts, powder injection molding is one of the most commonly used methods for producing the [INAUDIBLE] range of the smaller components, especially in the consumer electronic industry.

The reason for using the powder injection molding is as follows. Firstly, the PIM is clearly an interdisciplinary technique combining metallurgy with the processing of plastics. Therefore, the PIM products take advantage of both of the two processes, such as it has the material flexibility of powder metallurgy and the design flexibility of the injection molding of plastics.

Moreover, highly complex parts without a machinery process, such as the [INAUDIBLE], the polishing, or the cutting, this is not needed in the PIM. So it is a [INAUDIBLE] process, which makes PIM economically effective.

Secondly, the process is capable of providing not only shape complexity, but also high precision and high performance in the material mechanical properties after the [INAUDIBLE]. Certainly, the PIM technique is a net-shape manufacturing process.

The material waste in the PIM process is relatively smaller than the other metal forming technologies. The mechanical properties from the PIM process are superior from casting. In the PIM process, there is fine particle size and high sintered density. So it can achieve over 97% of the [INAUDIBLE] theoretically. Maybe it could achieve more. And finally, the PIM products have properties equivalent to the wrought alloys.

In fact, the powder injection moldings can be divided into two main components, which is a ceramic injection molding and a metal injection molding. So in the 1930s, the ceramic injection molding technique arose coincidentally with the plastic injection molding technique. In the 1970s, the metal injection molding technique is innovated by Permatech in the USA.

In the 1980s, metal injection molding is developed in Europe and Japan. In 1990, the product line of metal injection molding is built in Israel. It's built in Israel. And today, the powder injection molding has become the hottest component forming technology.

So the powder injection molding technique is just like making bread. So here is making break. At the beginning of the process, we obtain flour from the raw wheat. Then, the flour is mixed with water. It's mixed with water in the machines to obtain the homogeneous mixture. And then, the shaped mixture will be made in the mold by a human being itself. And finally, the shaped mixture would be baked in a [INAUDIBLE] to make the water disappear.

So the powder injection molding process would be the same with the bread baking. Let's see it. So here is the powder injection molding process.

The first task to be considered when planning powder injection molding production is to select the material, which is the powder and the binder. So the wax-based polymers are usually used in my company as the binder.

The mixture, the wax-based [INAUDIBLE] are often used as a binder. The mixture should be milled in the [INAUDIBLE] machines to make a homogeneous feedstock. Before the injection molding, the feedstock should be cut into the small particles and elements. Then, the feedstock is formed into the desired shape in the injection molding.

In fact, there is no fundamental difference between powder injecting molding and the plastic injection molding. [INAUDIBLE] its original material is different. So this process is just the same.

It should be noted that one flat surface has to be designed in the powder injection molding at least. Because in the [INAUDIBLE] process, we must have a flat surface to support the [INAUDIBLE] here.

After the injection molding, the green part is sintered in the fire. And the binder is removed. Oh, I'm sorry. After that injecting molding, the binder is removed by the chemical or thermal, or combined thermal and chemical process, here. We called it debinding.

So the detail debinding method is decided by the binder materials we choose. After debinding, as the binder is almost removed from the green part, so the strength of the brown part is very weak. So we have to sinterate it in the fire to increase its strength. After sintering, we usually obtain our final MEM parts. So this is the PIM process.

Here are some of the PIM products. You see, there is the electronics, the consumer, and automotive, the medical, and mobile. So in our company, our MEM products are usually in this catalog.

Pick one example. Most of the SIM card holders in cell phones is manufactured by metal injection molding technology. Besides, in our company, there is also-- the [? mass block ?] of our haptic vibrators is also used by the powder injection molding.

As I just said, the difference between plastic injection forming and the powder injection molding is the original material. So at this step, I will introduce the PIM materials here.

We call it feedstock. It is a mixture of the powder, the metal powder, and the binder. In principle, all [INAUDIBLE] sinterable powders can be used, can be mixed with a suitable polymer based binder to make the feedstock. Generally speaking, the powder can be divided into two mainly components, which is the gas atomization powder and the water atomization powder.

There are mainly two main components, two systems in the bender system, which is the wax-based system and the POM-based system. In the wax-based systems, the paraffin wax is used as the main body, while the polymer is used as the backbones. In the POM-based systems, POM is used as the main body while the stearic acid is used as the backbones.

So these are a sample of our feedstocks. So here is the metal particles. Here is the sustained steels. And this is the binder, you see? Always, the metal particles are surrounded by the binder homogeneously. So this feedstock is the best choice for the processing.

As I just said, there are two phases in the feedstock, which is the powder and the binder. So these two phases are the main-- these two phases influence injection flowing properties most in a process. First, it's the powder dimensions.

There are two parameters in the powder dimensions. The first one is the size of the particles. The diameter of the particles in our company is always from one micro [INAUDIBLE] to 30 micro [INAUDIBLE] with nearly normal distribution.

So the other parameters is the powder loadings. Here is two different items to characterize these atoms. Which is the volume of friction and the weight of friction. Here, we use the volume of friction most. It is defined as the ratio of the volume between the powder and the suspension.

For example, in our feedstock, the volume of friction is about 61.5%. So these atoms are very important in the injection molding, especially in the simulation. Because you know, if the gradient of the volume fraction changed too much, it will arise many problems.

So the second very important atom is viscosity, which is a characterized property of the binder. So viscosity level is higher than the conventional thermoplastic materials. The [INAUDIBLE] plasticities, which is the drop in the visco-plasticity at higher shear rates, is more pronounced than that in the plastic.

The consequence is that the flow related increase in pressure for feeding narrow cross-section kits compared with large pieces is relatively small. So next, I will let my friend, Mr. Gene from the Autodesk Research Center, introduce the numerical models and the algorithm.

**GENE JIANG:** OK, thanks, Dr. Wen. I'm introducing how to use powder injection molding in [INAUDIBLE]. Now, we have created the new molding process named powder injection molding. When you import your new models into the Moldflow inside 2017, you must [? change ?] your molding process from the semi-plastic injection molding to the powder injection molding.

If you don't do that, you cannot simulate the powder volume concentration for the models. The second step is that now, we support the [INAUDIBLE] and the second [INAUDIBLE]. The first is fill, the fill and pack. We also support the optimization for the different molding parameters. So you can use DOE to run an optimization analysis.

Now, we just support the 3D mesh type. Because of the powder parts are mostly very small, so we should give more finer mesh than the common conventional semi-plastic injection molding parts. So please use about more than 12 layers 3D meshing layer to create the mesh.

And then, as Dr. Zhong Wen talked about, the MEM material is really important to the powder injection molding. so you must give the correct powder material properties. Now, we support the two powder types.

First is metal. Second is ceramic. When you use powder material, please notice that the viscosity and the mechanical properties of the material are correct.

These properties are very similar to the semi-plastic material. But now, we add a new tab named powder properties. In this tab, we support you to give the powder radius. Generally, the default value is 10 microns.

The initial powder volume fraction is 60. The maximum powder volume fraction is 68. And then, we also support particle migration parameters change the powder in the polymer, how to [INAUDIBLE]. So we support four parameters.

The first is [INAUDIBLE] And the three parameters are lambda one, lambda two, lambda three for the changes on particle [INAUDIBLE]. The k is used to adjust the force of the particle [? segregation ?]. If the k value is large, becomes large, the powder [INAUDIBLE] will become more large.

And then, first part of the settings also has some-- yeah?

**AUDIENCE:** [INAUDIBLE]

**GENE JIANG:** First, fill and pack control. Please use similar to the semi-plastic injection molding. But because you consider the initial gravity and wall-slip effect for the powder. And as you know, most powder parts are really small. So please change the integration time step from 5% to a low value, such as 0.1%.

And then, you can run an analysis. So you will find that we have [INAUDIBLE] powder concentration parameters in the log. We also have a filling [INAUDIBLE]. You will see that the time integration step is really small, about 0.001.

Now, I'll introduce how to calculate the powder segregation in our Moldflow software. As you know, the left is injection area. And the polymer is injected along this area. So the velocity in the center is very large. About the velocity near to the flow [INAUDIBLE] area is very slow.

So the velocity gradient can be [INAUDIBLE] shear rate. So the shear area, the shear [INAUDIBLE] is large. But in the center area, the shear area is really small. So we can we can look at the particle as one ball.

So the different [INAUDIBLE] will cause the particles to migrate. So in the end of the flow, you will find that in the center areas, the powder concentration and also some near the frozen area also the powder is also concentration.

When the [INAUDIBLE] to calculate as a powder concentration, we mainly consider two factors. The first is shear-induced. The second is convection. The answer in here I don't list is continued momentum and [INAUDIBLE] your question is, is the slide adjusted to list [INAUDIBLE] how to calculate the powder concentration in [INAUDIBLE] flow.

We use a suspicion balance model. This model has been developed for several years. So to answer your question, we get that powder will change as time equal to the powder migration. And there's-- powder migration flags can be defined by the radius, the powder radius, and the polymer velocity and [INAUDIBLE].

The A [INAUDIBLE] equation [INAUDIBLE] A is our powder radius. And there's an eita 0, eita [INAUDIBLE]. Eita 0 is a polymer viscosity. Eita n is calculated according to-- we're are a particle volume [? flections ?] and the [INAUDIBLE] particle volume [? flections. ?] And then the stress [INAUDIBLE] can be defined as three directions [INAUDIBLE] flow migration and [INAUDIBLE] what a [INAUDIBLE]. So this really also can be changed in your Powder Properties dialog.

The k also introduced in the previous slide, you will found is [INAUDIBLE] it changes a k, a case where k values are-- the larger k values, the migration will be large. OK, this way also [INAUDIBLE] new powder in our [INAUDIBLE]

Put powder volume concentration, you found that around is a gate. Like, generally, it has one black line. So we can use our [INAUDIBLE] to simulator the black lines in the mudflow. So your can see result really consistent. So OK, that's all. Please Dr. [INAUDIBLE] to introduce case validation.

**PRESENTER 2:** So as Mr. [INAUDIBLE] said, we have the Moldflow software to simulate the power engine [INAUDIBLE]. So now we have validators and numerical models by the experiments. This work is accomplished in our company with Mr. [INAUDIBLE].

**PRESENTER 1:** Yeah.

**PRESENTER 2:** So this is the part we use to do calibrations in the numerical model. This is the runner, the ingestion gate. And this is a product.

We call it block. So this model is very simple and we chose this because it is easy to manufacturing. And we can ensure the steps in different directions.

So its dimensions are as follows. The volume of the runners and blocks are listed here. The runner volume is 4,261 cubic millimeters. And the runner volume ratio is 98.85%.

So here, we imported the 3D models into the Moldflow to build up the 3D model. So here are the meshed type we chose for the block is 3D tetra. As Mr. [INAUDIBLE] has just said, the Moldflow is just supported this element tab for the powder injection molding.

In order to accelerate our calculation, the runner is meshed with the [INAUDIBLE] elements. So in order to obtain a more accurate flow pattern around the interface between the runner and the part, we meshed more finer around the gate area at this picture. So you'll see the gate area is at this location.

So here is the material properties of our materials. We choose the stainless 316L materials in the metal injection molding. So here is the PVT and the viscosity chart part.

As I have just assigned, the material properties is very important for the power [INAUDIBLE] converting simulation. So when we obtained these curves from our supplier, we also carried out the experiments to calibrate the material properties. It just seems that is very good.

So here is our injection machine. So the powder injection molding experiments are carried out in this machine. It is Arburg injection machine.

So these are the parameters of the machine. So here is our validation process. Before we inject the materials, we have dried the 316LA materials for about 10 hours using the plastic dryer machine.

And also, we warm up the injection machine. We clean the barrel, the screw, and the injection machine using the PIM material. And then we inject the samples and adjust the perimeters of the injection machine and the temperature machine.

So you know at the beginning of the injection, the production is always unstable. So in the validation, we choose the stable quality product, which means we choose the production after the 20 products, the first injected 20 products, which means the first fully injected 20 products will be discarded. So in the experiment, we obtained different products using the different modeling process parameters.

And besides, we recorded the modeling parameters from the machines which are including the provision, the mode, and the melt temperature, the injection speed, and the pressure profile for each element, for each test. So here is the actual experiment processes. You'll see in different conditions, the screw position, the melt temperature, the mold temperature, the cushion position is changed. Usually, we use the multistage feeding control and the multistage packing control to complete the powder injection molding. So here is the detailed parameters.

Here is the parameter settings in the Moldflow software. I think Mr. [INAUDIBLE] has just introduced this here. So we have powder [INAUDIBLE], the volume fractions, and the mechanical coefficient.

So here is our result. This is the 20% filled volume. The left is the simulation [INAUDIBLE] out and the right is our experimental data.

So from this picture, that [INAUDIBLE] is just the same I think. So the same situation appeared in the 38% field volumes. So simulation result agreed well with the experiment.

However, in the 52.8% field volumes, there's little differences between the two pictures. So in the 76.1% filled volumes, the differences between the simulation result and the experiment result is a little unpreferred. However, in the funnel of the [INAUDIBLE], which means the 86.1% percent fuel volumes that post the results also agreed well, which means the simulation result is similar with the experiment data.

So at the end of the filling, you see the flow surface of the simulation result agreed very well with the experiment that this [INAUDIBLE]. So the flow simulation result shows very, very well, we think. Here is the powder concentration result which has just been introduced by Mr. [INAUDIBLE].

So you'll see the powder volume concentrations location is just as-- the very same with the [INAUDIBLE] of the blank [INAUDIBLE] in the product. So I think the experiment results-- so I think the experiment results [INAUDIBLE] in these defect predictions. I have just-- we can see these pictures.

So the powder volume variations severely in the [INAUDIBLE] area-- so here and here. So in order to-- so this is the surface model. You know, this is a surface model.

So in order to investigate the detail distributions inside the surface, we have [? sintered ?] the block. And then we're cutting the block in the heat area and along this direction, along this direction. So after the [INAUDIBLE], the polymer is almost [? completely ?] removed from the part. So here listed is just the metal and [INAUDIBLE] the void space.

So here we can see there is two main cracks near the gate. It's here and here. So always if these areas have a low powder volume fractions-- so if this has very low powder volume fractions in the center [INAUDIBLE], this area will have more possibility to generate the crack defect. So in a simulation, we can see that the area A has a very low powder volume concentration. So we think the simulation result works very well with the experiment [INAUDIBLE].

So here is our conclusion. We built a good cooperation between the AAC and the Autodesk, and the powder volume concentration plot can show the powder concentration in the model compared to the real product. And most of the flow patterns are similar as to the reality.

So when you use the PIM module, the properties of the PIM material is very important. And they use a [INAUDIBLE] model design for the powder injection molding process and adjust the parameters of the power injection molding in the moldflow. On behalf of my company, I want to send my appreciation to many Autodesk friends. They are Mr. Chen, Mr. [INAUDIBLE], Mr.

[INAUDIBLE], and Mr. [INAUDIBLE]. Thank you. So if there is any questions-- yeah.

**AUDIENCE:** Do you use a standard [INAUDIBLE] same as [INAUDIBLE]?

**PRESENTER 2:** Pardon?

**AUDIENCE:** For the molding portion, do yo use a standard screw-in barrel, or do you have a special [INAUDIBLE]?

**PRESENTER 2:** Special. [INAUDIBLE].

**AUDIENCE:** Special [INAUDIBLE].

**PRESENTER 2:** Yeah, special [INAUDIBLE], yeah.

**AUDIENCE:** What is the common polymer used for the binder?

**PRESENTER 2:** We use the wax-based system.

**AUDIENCE:** Wax, but you also-- you had a was [INAUDIBLE] and another polymer, right?

**PRESENTER 2:** Yeah.

**AUDIENCE:** So what is that? [INAUDIBLE]

**PRESENTER 2:** It is [INAUDIBLE] yeah, POM, yeah. However, [INAUDIBLE] there are many other polymers in here.

**AUDIENCE:** When it's in pellet form in the feed throat, does it abrade the screw, or is it protected by the polymer? Does the metal abrade the screw-- when it comes out of the feed throat against the screw, does it abrade the--

**PRESENTER 2:** You mean in the center or in the injection?

**AUDIENCE:** In the injection.

**PRESENTER 2:** There is no protect.

**AUDIENCE:** There is no protect or abrasion?

**AUDIENCE:** [INAUDIBLE] doesn't affect where the--

**AUDIENCE:** Is it where the screw--

**PRESENTER 2:** Yeah, where screw, yeah. It will, it will.

**AUDIENCE:** [INAUDIBLE] the screw.

**PRESENTER 2:** Yeah, yeah, yes.

**AUDIENCE:** Thank you.

**PRESENTER 2:** Because the powder is very--

**AUDIENCE:** Abrasive.

**PRESENTER 2:** Yeah, abrasive compared with the plastic. Yeah.

**AUDIENCE:** But once it's molten, then it's OK in the mold, right?

**PRESENTER 2:** Yeah.

**AUDIENCE:** OK.

**PRESENTER 2:** Right.

**AUDIENCE:** I'm just curious. [INAUDIBLE] the green state [INAUDIBLE] designing.

**PRESENTER 2:** Yeah.

**AUDIENCE:** Is there a secondary [INAUDIBLE] that you use?

**PRESENTER 2:** In my company, there is usually not. Yeah, it's just one [INAUDIBLE], yeah. I think it is decided what [INAUDIBLE] we choose. Yeah.

**AUDIENCE:** [INAUDIBLE] holds it together [INAUDIBLE]

**PRESENTER 2:** Yeah. OK.

**AUDIENCE:** [INAUDIBLE] very interesting. How does the particle set [INAUDIBLE] how does the maximum [INAUDIBLE]

**PRESENTER 2:** General-- sometimes we use a SEM equipment to scan the powder, the feedstock, and then get the [INAUDIBLE] radius and then get the average radius to input [INAUDIBLE] software to run the [INAUDIBLE]. Don't-- yeah.

**AUDIENCE:** Could you go back to the slide [INAUDIBLE]

**PRESENTER 2:** PM material. [INAUDIBLE] Go, go, go, go.

**AUDIENCE:** [INAUDIBLE] the question was how does the software use those [INAUDIBLE]

**PRESENTER 2:** Yeah, yeah.

**AUDIENCE:** [INAUDIBLE] the equation. [INAUDIBLE]

**PRESENTER 2:** We use this here. Put it-- powder that is--

**AUDIENCE:** So [INAUDIBLE]

**PRESENTER 2:** Yeah.

**AUDIENCE:** The phi [INAUDIBLE] in the equations [INAUDIBLE] beta m, the phi and the phi m, isn't that the volume fraction--

**PRESENTER 2:** Yeah, yeah, yeah, yeah.

**AUDIENCE:** The maximum volume fraction? Right, so Phi is the currently computed volume fraction of the current node. And you have initial value [INAUDIBLE]

**PRESENTER 2:** Yeah.

**AUDIENCE:** And phi m is the maximum [INAUDIBLE] So it's [INAUDIBLE] equation to calculate the modification [INAUDIBLE]

**AUDIENCE:** Is there a [INAUDIBLE] the diameter [INAUDIBLE]

**PRESENTER 2:** Sorry?

**AUDIENCE:** [INAUDIBLE]

**PRESENTER 2:** But-- particle size is there.

**AUDIENCE:** Oh yeah.

**PRESENTER 2:** Yeah.

**AUDIENCE:** [INAUDIBLE]

**PRESENTER 2:** Yeah, single [INAUDIBLE]. Not a calculator [INAUDIBLE] value yeah.

**AUDIENCE:** [INAUDIBLE] at a certain volume fraction, do you predict jamming?

**PRESENTER 2:** No, no, no. [INAUDIBLE] calculators are particle calculation or [INAUDIBLE]. Yeah, just a [INAUDIBLE] the shear-induced stress. Yeah, maybe in the future, we-- we just finished [INAUDIBLE] research work for this feature. Maybe in the future, we will consider the particle effects of viscosity and as a particle [INAUDIBLE]. Yeah. Yeah.

**AUDIENCE:** I have a question for [INAUDIBLE] you're using a large injection molding machine for a very small [INAUDIBLE]. Is that necessary because of the high viscosity, or was it-- could you use a micro-injection modeling machine for such small parts?

**PRESENTER 2:** [INAUDIBLE]

**AUDIENCE:** [INAUDIBLE]

**AUDIENCE:** [INAUDIBLE] the viscosity is very large.

**AUDIENCE:** So you [INAUDIBLE]

**AUDIENCE:** So we have to use the [INAUDIBLE]

**AUDIENCE:** I notice you had a [INAUDIBLE] mold on that setup over there. Can you use hot drops of this material [INAUDIBLE] hot drops?

**AUDIENCE:** No, hot runner [INAUDIBLE]

**AUDIENCE:** [INAUDIBLE]

**AUDIENCE:** If the material [INAUDIBLE] is it-- can it [INAUDIBLE]

**PRESENTER 2:** Yeah.

**AUDIENCE:** Can you reuse it over and over again?

**PRESENTER 2:** [INAUDIBLE]

**AUDIENCE:** [INAUDIBLE]

**PRESENTER 2:** Go ahead. [INAUDIBLE]

**AUDIENCE:** [INAUDIBLE]

**PRESENTER 2:** Yeah.

**AUDIENCE:** [INAUDIBLE]

**PRESENTER 2:** We also found as an [INAUDIBLE] when the user recycle [INAUDIBLE] you found a [INAUDIBLE] viscosity becomes more [INAUDIBLE] than their original material. So--

**AUDIENCE:** That's the reason materials degraded, right?

**PRESENTER 2:** Yeah. No, no, no, not [INAUDIBLE] degrade. Maybe sometimes some--

**AUDIENCE:** The carrier [INAUDIBLE] the binder--

**PRESENTER 2:** Yeah.

**AUDIENCE:** --every cycle is going to degrade. So it [INAUDIBLE]

**PRESENTER 2:** Maybe more [INAUDIBLE] mold.

**AUDIENCE:** [INAUDIBLE]

**PRESENTER 2:** Yeah.

**AUDIENCE:** [INAUDIBLE]

**PRESENTER 2:** Yeah, yeah, yeah. Yeah. So we found [INAUDIBLE]. In the future, we'll also do something in research [INAUDIBLE]