Explanation of Zirconia Ferrule Blank’s Production System

TAMMY MACHINERY CO, LTD.
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I Introduction

1. What’s “ferrule”

   Any more, the communication means which optical fiber was used for is not only for the long-distance communication such as some of the telephone companies. For example, it develops in the building for making better use of LAN and the Internet. In addition, it develops in the short distance in the family use, too. It is expected to increase the demand for the "patch code", due to increasing the communication in the short distance and the number of circuits. (“Patch code” is fixed a connector on both ends of the optical fiber). The main part of the optical fiber connector is “ferrule”. The connector of the optical fiber is required the precision of the μm unit to restrain the loss of the light to a minimum. It is different from connector of electric wiring. The material of ferrule is used zirconia ceramic for the keeping of the precision quality.

2. Importance of Blanks.

   Of course, a progress in precision machine processing is important to make the high precision ferrule. But, the precision of the blank before machine processing, gives a big influence of yield at final step, too. As before, the blank was made by extrusion moulding. In the present, injection moulding which PIM (powder injection moulding) was used for is the main stream.

3. Problem until now.

   Recently, PIM technology is useful technology, for example it is the production of the watch parts by MIM. But, it is difficult to make the mould that when the a high precision parts like a ferrule blanks made. The problem was how to make a thin pin (about φ0.150) and a thin hole. But now, many manufacturers can already make a thin pin.

   The problem in production of mould is the following point. ①The production of high precision mould parts. ②Keeping of the mould’s precision during injection moulding ③The design affected by the characteristic of special compounds, used PIM

   Without understanding the above, only a pipe with thin hole is made, a good ferrule blank can’t make it.

4. TAMMY’s moulds and systems.

   TAMMY’s moulds are supplied to the leading plastic makers which products ferrule blanks. Because of that, TAMMY’s moulds is good for the high precision mould, which is maked by the original way, and is affected by the characteristic of PIM. This mould is accepted even if a plastic ferrule mould is taken.

   The system base is mould, which is the biggest factor (structure, production and blank design) of the ferrule blank’s production.

   Because of that,
   ①High precision = a few loss in the later process ②The system adapt PIM = man-hour reduction, high yield

   Thus, it is possible high quality and the low cost on this system.

   Refer to following page for the details of the system.
Ⅱ Quality Guarantee

Promising dimension

<table>
<thead>
<tr>
<th>Item</th>
<th>Allowance</th>
<th>Measurement instrument</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside diameter</td>
<td>(φ2.6*)±0.03</td>
<td>Micro-meter</td>
</tr>
<tr>
<td>Inside diameter</td>
<td>(φ0.11*)±0.003</td>
<td>Pin gauge</td>
</tr>
<tr>
<td>Concentricity</td>
<td>◎φ0.03</td>
<td>ID center –OD meas.</td>
</tr>
<tr>
<td>ID hole length</td>
<td>(11.* *)±0.1</td>
<td>Updial gauge and jig</td>
</tr>
<tr>
<td>Total length</td>
<td>(12.* *)±0.5</td>
<td>Calliper</td>
</tr>
</tbody>
</table>

Note: The method of concentricity = our company designated machine is used and measuring point is specified by our company.
Note: Concentricity = essentially, ratio of less than 20 μm is more than 80%.
### System

#### 1. Abstracts (process flow)

**Blank production**

- Compound for injection molding
  - Uses the mixture of Zirconia powder and thermoplastic resins etc. (the binder)
  - This binder has both easy moulding and stable debinding.

**Mould**

- A thin pin (about 150 μm) is held in mould to do the formation of small hole.
  - Using high precision Mould = It is possible to make the high spec blanks.
  - Cavity is individual centering
  - Core insert is fixed

**Injection moulding**

- It is molded as well as usual plastic injection moulding.
  - It makes use of the accumulated foundation technology of PIM.
  - Sprue and a runner part crush it, and it is used as a "100%" recycling material.

**Debinding**

- Binder element is thermal decomposition (2–3 days)
  - It gets rid of binders steadily by the multiple step control.

**Sintering**

- Electric elevating furnace is used (1–2 days)
  - The use of furnace of the good control form of the heat distribution.

**Inspection**

- The measurement of the micron meter and special observing of ceramic materials is nec
  - We propose of the ideal way of measuring it and the way of observing it.

**(Grinding process)**

**(Flange fixed)**

**(Fiber Assembling)**

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*For ceramics injection moulding of zirconia ferrule.*

It makes use of

1. Mechanical engineering = precise shaping technology (mould, moulding).
2. Inorganic chemistry = ceramics powder metallurgy technology.
3. Organic chemistry = binder and debinding.
2. Material

1. The characteristics of compound

- This binder has both easy moulding and stable debinding.
- There are a few dimension changes in case of recycling material use.
- There are often a few occurrences of the bad smell in debinding, that the binder is good thermal degradation.
- The occurrence of contamination and void is restrained as much as possible.

2. Material list

<table>
<thead>
<tr>
<th>No</th>
<th>Material name</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1110</td>
<td>Zirconia compound (O)</td>
<td>Use of OZC powder</td>
</tr>
<tr>
<td>1120</td>
<td>Zirconia compound (T)</td>
<td>Use of TZ powder</td>
</tr>
</tbody>
</table>

Powder: Y2O3=3mol% and Al2O3=0.25wt%
Binder = Butylmethacrylate, wax, and others

3. Technological information

<table>
<thead>
<tr>
<th>①</th>
<th>The choice of compound in consideration of moulding and debinding</th>
</tr>
</thead>
<tbody>
<tr>
<td>②</td>
<td>Preservation and handling method</td>
</tr>
</tbody>
</table>

4. Others

- We recommend Compound is the same grade to stabilize a process.
- When user's original compound is used, it becomes a conference separately.
- As for compound technological transfer, it is being examined.
3 Mould

1. The characteristics of the Mould

・Individual centering structure is adopted. (The next page reference.)
・Precision emphasis structure is adopted.
(the moveable part which form small clearance is reduced) (The next page reference)
・The time of Core pin is breaking is rather rare
・The producible precision of the key parts which decides concentricity is very high
・It is special designed sprue and runner in accordance with ceramic compound.

2. Mould type list

<table>
<thead>
<tr>
<th>NO.</th>
<th>Mould name</th>
<th>Outside size</th>
</tr>
</thead>
<tbody>
<tr>
<td>2110 SC 4 cavity</td>
<td>210x200x200</td>
<td></td>
</tr>
<tr>
<td>2120 SC 6 cavity</td>
<td>210x200x200</td>
<td></td>
</tr>
<tr>
<td>2130 SC 8 cavity</td>
<td>280x230x220</td>
<td></td>
</tr>
<tr>
<td>2210 LC/MU 4 cavity</td>
<td>210x200x200</td>
<td></td>
</tr>
<tr>
<td>2220 LC/MU 6 cavity</td>
<td>210x200x200</td>
<td></td>
</tr>
<tr>
<td>2230 LC/MU 8 cavity</td>
<td>280x230x220</td>
<td></td>
</tr>
</tbody>
</table>

3. Technological information

① Mould structure
② maintenance (assembling, adjustment)
③ The proposal and design of blank shape

4. Others

・The dimensional data of cavity part are attached.
・It meets hope, and trial data by sintering body and green body are attached.
centering of each cavity

The structure of the precision emphasis

By TAMMY

By other companies

A mold manufactured by the Tammy is fixed structure to restrain play of the pin catcher. The concentricity of green body improves by making a clearance small. And, because it doesn’t move, a life is long without abrasion.
4 Injection Moulding

1. The characteristics of the moulding process
   - We proposed the stable moulding condition which is based on the compound and the mould
   - The electromotive injection moulding machine which is suitable for CIM is used, in consideration of the stability of molding.
   - Sprue and a runner part crush it, and it is used as a “100% recycling” material.

2. Main equipment

<table>
<thead>
<tr>
<th>NO</th>
<th>Equipment name</th>
<th>Specifications</th>
<th>Outside size</th>
</tr>
</thead>
<tbody>
<tr>
<td>3110</td>
<td>Injection moulding machine 20ton</td>
<td>Electromotive</td>
<td>2750x1650x910</td>
</tr>
<tr>
<td>3120</td>
<td>Injection moulding machine 40ton</td>
<td>Electromotive</td>
<td>3340x1715x1015</td>
</tr>
<tr>
<td>3510</td>
<td>Mould temperature controller</td>
<td>Water, max 95°C</td>
<td>250x600x600</td>
</tr>
<tr>
<td>3520</td>
<td>Runner removing robot</td>
<td>Turn type</td>
<td>800x1200x450</td>
</tr>
<tr>
<td>3530</td>
<td>Conveyer</td>
<td>With the reversal mechanism</td>
<td>2000x1000x450</td>
</tr>
<tr>
<td>3540</td>
<td>Sensor</td>
<td>Check moulding material</td>
<td>88x90x38</td>
</tr>
<tr>
<td>3610</td>
<td>Compound dry &amp; storage box</td>
<td>prevention of wet</td>
<td>350x650x200</td>
</tr>
<tr>
<td>3630</td>
<td>Crushing machine</td>
<td>Special specifications</td>
<td></td>
</tr>
<tr>
<td>3640</td>
<td>Finishing zigu</td>
<td>For the gate treatment</td>
<td></td>
</tr>
</tbody>
</table>

3. Technological information

   ① Injection moulding condition
   ② The method of runner recycling
   ③ The method of gate finishing

4. Others

   - As for Injection moulding machine handling, attend the class of the Injection moulding machine manufacturer separately.
5 Debinding & sintering

1. The characteristics of debinding & sintering

・ Concentricity is maintained when material without brim set lying during debinding & sintering, because the high precision mould used.
・ The most suitable debinding condition is proposed in accordance with compound.
・ Sintering condition which is suitable for the use Zirconia powder is provided.

2. Main equipment

<table>
<thead>
<tr>
<th>NO</th>
<th>Equipment name</th>
<th>Specifications</th>
<th>Outside size</th>
</tr>
</thead>
<tbody>
<tr>
<td>4110</td>
<td>Debinding furnace (ex.)</td>
<td>Effective area 800x800x800 (max 600℃)</td>
<td>1900x2600x1380</td>
</tr>
<tr>
<td>4210</td>
<td>Sintering furnace (ex.)</td>
<td>Effective area 350x700x350 (max 1600℃)</td>
<td>1200x2390x1830</td>
</tr>
<tr>
<td>4510</td>
<td>Setting case</td>
<td>Porous AL2O3</td>
<td>120X120X23</td>
</tr>
</tbody>
</table>

3. Technological information

① Debinding condition (temperature raising pattern and others)
② A setup of device
③ The choice of setting case
④ Sintering condition (temperature raising pattern and others)
6 Measurement

1. The characteristics of the measurement instruments

- We propose measurement and observation method in the needs.
- It is provided by the original specifications and so on with a moderate price.

2. Main instruments

<table>
<thead>
<tr>
<th>NO.</th>
<th>Instruments name</th>
<th>Use &amp; specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>5110</td>
<td>Concentricity measurement instrument</td>
<td>$\mu$m indication and operation by hand/original made</td>
</tr>
<tr>
<td>5210</td>
<td>Pin gauge</td>
<td>Standard gauge, stops gauge/WC</td>
</tr>
<tr>
<td>5220</td>
<td>Wire</td>
<td>Usually check / W wire</td>
</tr>
<tr>
<td>5310</td>
<td>Micro-meter</td>
<td>Outside diameter /</td>
</tr>
<tr>
<td>5410</td>
<td>Magnifier ($\times$10)</td>
<td>Appearance inspection/</td>
</tr>
<tr>
<td>5420</td>
<td>Microscope ($\times$30)</td>
<td>Appearance inspection/</td>
</tr>
<tr>
<td>5430</td>
<td>Halogen light source</td>
<td>Crack inspection/</td>
</tr>
<tr>
<td>5510</td>
<td>Measurement microscope</td>
<td>Form measurement and others /</td>
</tr>
<tr>
<td>5910</td>
<td>An electronic balance (0.01g indication)</td>
<td>Counting number /</td>
</tr>
</tbody>
</table>

3. Technological information

① The requirement dimension of ferrule blank
② The appearance requirement of ferrule blank

4. Others

- Decide an actual measurement item with the later processing makers or section.
IV Grinding process

Processing chart of SC Ferrule (reference)

SC material drawing

Material

Outside coasing
Coarse grinding of outside diameter
Coarse centerless grinder SKS-N250

V end coasing
Length process
Horizontal grinding machine SGM-6301

Pointed end coasing
Horizontal grinding machine SGM-6301
Air Press FCP
clean in water
clean in water ethanol by ultrasonic wave

Inside finishing
Metal fixing
Inside diameter process
Metal fixed machine S-4H
Wire winding machine TWM-1
Wire etching machine TBW-1
Inside Rapping machine TL-3
Clean in hot water by ultrasonic wave
Clean in nitric acid by ultrasonic wave
Clean in water by ultrasonic wave

Outside finishing for concentration
Outside diameter grinding process
Outside grinding machine TS-2A
clean in water
Outside finishing process
**O/D finishing centerless grinder**
MSA-250BN
**Outside diameter finishing machine**
SRL-150E

Coarse grinding of outside diameter
**Coarse centerless grinder SKS-N250**
Clean in water

V end finishing
**Horizontal grinding machine SGM-6301**
Clean in water
Corner grinding of V end

Brushing process
**Outside chamfering machine (Brush type) PM-1**
Clean in hot water by ultrasonic wave
"SAHFURON" ultrasonic wave
Clean in water

Polishing for all corner
Barrel process
**Centrifugal barrel machine HS-4V**
Clean in water

PC polishing process
**Polishing machine GFP-240H**
Clean in hot water by ultrasonic wave
"SAHFURON" ultrasonic wave
Clean in water

Final inspection
**Auto inside diameter selection machine IM-500**
**Auto concentric level instrument CM**
**Auto outside diameter measuring instrument**
**PC measuring system OSR-21**
Check aeviation
Check roughness of surface
Appearance inspection
V Schedule & etc

Starting schedule

| Preparation for equipment introduction | 3～3.5 months |
| Machine setting                        | About 2 weeks |
| Technological guidance                 | About 2 weeks |
| Observation and advice                 | 14～30 days   |

We desire customers to do next terms

① Give securing of technological staff.
   - Mould: Staff can appreciate mould structure, and can take a part and cleane a mould.
   - Injection Moulding: Staff can start machine and change a moulding condition.
   - Equipment: Staff can operate and maintain debindeing furnace and sintering furnace.
   - Material: Staff have knowledge to understand the degradation of polymer and sintering.
   - Measurement: Staff can measure minimum (one) micron meter.
② Give securing of mass production experience manager.
③ Give securing of inspector (good eyesight).
④ Be separated from product according to type in each process
⑤ The environment in process is clean and keep clean.
⑥ Location should do in industry area.

Others.

Customer should make an arrangement of house and the following incidental facilities.

- Power supply.
- Cooling water.
- Air conditioner.
- Compression air.

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