Construction of knowledge management system for precision machining

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Abstract—Mechanical Industry is a typical technology-intensive industry that is the Taiwan industrial development base. Precision machining includes complex professional technical knowledge. Technician uses a self-understanding way to label the machining setting. This setting implies important technical knowledge, but is difficult to teach others. Furthermore, when changes machining parts, technician needs to review and modify machining parameter and program due to the limit of human memory. Manufacturing process may be delayed when machining adjusting can not achieve program optimization. It is common problem face small and medium enterprises. The topic of knowledge management has wide application in knowledge-intensive industry, but less attention in technical field. Technical knowledge tends to be tacit. Personal tacit knowledge must convert to explicit knowledge, and then personal knowledge is possible to preserve and spread to organization. In this research, we select a typical CNC milling parts in precision machining, systematic analyze machining procedure, and utilize documentation strategy to construct machining knowledge management system. The outcome of this knowledge sharing platform can be a template for other precision machining.

Keywords- technology-intensive industry; precision machining; tacit knowledge; explicit knowledge; documentation strategy ; knowledge management system

I. INTRODUCTION

The strategic use of knowledge management (KM) for retaining competitive advantage is well recognized [5, 6, 14, 16, 17]. It is generally believed that most of intellectual assets of a firm exist as knowledge in the minds of its employees [4, 9]. Various practices, tools, and methodologies have been developed for promoting knowledge creation and sharing [3, 7, 10, 12, 15, 17].

Taiwan is an economic structure dominated by small and medium enterprises, that featured by small-scale and small-capital, but also characterized by diversification, flexibility, and competitiveness. Mechanical Industry is a typical technology-intensive industry that is the Taiwan industrial development base. Mechanical Industrial development to date for 40 to 50 years, that holds and an important position in the domestic and foreign market. A typical precision machinery firm can process various parts, mold design, and machine assembly. Precision machining includes complex professional technical knowledge.

Technician uses a self-understanding way to label the machining setting. This setting implies important technical knowledge, but is difficult to teach others. Furthermore, when changes machining parts, technician needs to review and modify machining parameter and program due to the limit of human memory. Manufacturing process may be delayed due to machining adjusting can not achieve program optimization. It is the common problem face small and medium enterprises.

The topic of KM had wide application in knowledge-intensive industry, but less attention in technical field. Technical knowledge tends to be tacit. Both Nonaka and others emphasize the importance of tacit knowledge [6, 8]. Further, Nonaka considers tacit knowledge to be more valuable than explicit knowledge. Personal tacit knowledge must convert to explicit knowledge, and then personal knowledge is possible to preserve and spread to organization.

In this research, we select a typical computer numerical control(CNC) milling machining parts in precision machinery firm, systematic analyze machining procedure, utilize documentation strategy to construct machining knowledge management system(KMS). The outcome of this knowledge sharing platform can be a template for other precision machining.
technical elements. The cognitive elements center on the “mental model” of individual, which consist the schemata, paradigms, perspectives, beliefs, and viewpoints. Meanwhile, the technical elements of tacit knowledge include concrete know-how, crafts, and skills. On the other hand, explicit knowledge refers to knowledge that can be transmitted using formal, systematic language. The tacit and explicit dimensions are not mutually exclusive. Instead, these two dimensions are simply different to various degrees and constitute knowledge spectrum.

Assuming that knowledge is created via the interaction between tacit and explicit knowledge, Nonaka devised four modes of knowledge conversion, as illustrated in Figure 2 [6].

1. Socialization: from tacit to tacit. Socialization is a process of sharing experiences and thereby creating tacit knowledge, such as shared mental models and technical skills.

2. Externalization: from tacit to explicit. Externalization is a process of articulating tacit knowledge into explicit concepts. It is a quintessential knowledge-creation process in that tacit knowledge becomes explicit, taking the shapes of metaphors, analogies, concepts, hypotheses, or models.

3. Combination: from explicit to explicit. Combination is a process of systemizing concepts into a knowledge system. This mode of knowledge conversion involves combining different bodies of explicit knowledge.

4. Internalization: from explicit to tacit. Internalization is a process of embodying explicit knowledge into tacit knowledge. It is closely related to “learning by doing”. When experiences through socialization, externalization, and combination are internalized into individuals’ tacit knowledge bases in the form of shared mental models or technical know-how, they become valuable assets.

### III. SYSTEM FRAMEWORK OF CNC MACHINING PROCEDURE

Milling machine utilizes milling cutter to process parts. Apart from operates flat, grooves, teeth, thread and spline, milling can also operate sophisticated parts. Its performance is higher then lathe. CNC milling controls machining system through computer generating digital signals, to drive milling machine perform precision machining [13]. One of CNC milling’s characteristics is storing milling operating actions in controllers in advance, and executing designated process accordance with the corresponding procedure.

<table>
<thead>
<tr>
<th>Tacit Knowledge</th>
<th>Explicit Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Socialization</td>
<td>Externalization</td>
</tr>
<tr>
<td>From</td>
<td></td>
</tr>
<tr>
<td>Internalization</td>
<td>Combination</td>
</tr>
</tbody>
</table>

The structure of CNC milling machine is based on Z-axis for cutter spindle to rotate, and XY plane for the parts to move. In short time, milling machine performs multi-cutters machining that includes precision or rough cutting and moves parts simultaneously. Therefore, no matter small or mass production, milling can execute economic machining.

The system framework of CNC machining procedure documented in this paper includes six areas:

1. **Parts machining sequence**
   - From material to end product may go through several machining process. We record these machining process with parts’ picture in order that technician can easily recognize each step.

2. **CNC program**
   - CNC program includes main program and subroutine. In program coding, technician has to consider five factors: a) Choose CNC machine type and decide machining scope. b) Select gripping method and fixtures of material. c) Cutter setting. d) Decide machining procedure. e) Machining conditions about spindle speed, cutter amount, cutting depth, precision milling preserved, etc.

3. **Cutter machining sequence**

4. **Cutter machining parameter**
   - After CAM generates G-code, technician has to input cutter Radius correction data, etc.

5. **Cutter list**

6. **Cutter adjustment**
   - Technician has to set and adjust origin of program, so that cutter can recognize starter position of machining.

### IV. ONE BEST PRACTICE OF CNC MACHINING PROCEDURE

In this research, we select a CNC machining parts for medical to construct technical oriented KMS.

1. **Document of parts machining sequence**

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In our sample machining parts, from material to end product goes through 4 machining process. We record these machining processes with parts’ picture as figure 3.

Process 1

Process 2

Process 3

Process 4

Figure 3. Machining sequence of medical parts

(2) Document of CNC program

The CNC program of medical parts machining extracts as table I. For each subroutine, we mark corresponding process so that technician can easily recognize each process.

TABLE I. CNC PROGRAM OF MEDICAL PARTS

<table>
<thead>
<tr>
<th>%</th>
<th>O1510(10C2-1ST+2ST+3ST+4ST)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T23M6(6-0)</td>
<td>(O0130)</td>
</tr>
<tr>
<td>G0G90G54X-3.0Y-10.</td>
<td>M01</td>
</tr>
</tbody>
</table>


Table I: CNC Program of Medical Parts

Process 1: Positioning machining parts by the rod of diameter 6.0 mm.

(3) Document of cutter machining sequence

We record cutter sequence in accordance with specific machining process. In our sample machining parts, we have four cutter machining sequences as figure 4~7.

TABLE II. CUTTER MACHINING PARAMETER OF PROCESS 1

<table>
<thead>
<tr>
<th>Specification</th>
<th>Cutter No.</th>
<th>Correction of cutter length</th>
<th>D (Radius correction)</th>
<th>Cutter extending length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ø6 rod</td>
<td>23</td>
<td>23</td>
<td>--</td>
<td>15</td>
</tr>
<tr>
<td>Ø12</td>
<td>25</td>
<td>25</td>
<td>--</td>
<td>38</td>
</tr>
<tr>
<td>Ø3 fixed point drill</td>
<td>1</td>
<td>1</td>
<td>--</td>
<td>15</td>
</tr>
<tr>
<td>Ø3.2 drill</td>
<td>2</td>
<td>2</td>
<td>--</td>
<td>40</td>
</tr>
<tr>
<td>R5 Ball cutter</td>
<td>3</td>
<td>3</td>
<td>--</td>
<td>30</td>
</tr>
<tr>
<td>Ø4 End milling cutter</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>Ø2 End milling cutter</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td>Ø8 End milling cutter</td>
<td>18</td>
<td>18</td>
<td>D12, D19</td>
<td>20</td>
</tr>
<tr>
<td>Ø4 Tapping cutter</td>
<td>19</td>
<td>19</td>
<td>--</td>
<td>25</td>
</tr>
<tr>
<td>Ø63 Face milling cutter</td>
<td>30</td>
<td>30</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

(4) Document of cutter machining parameter

As document of cutter sequence, we record cutter machining parameter in accordance with specific machining process. In our sample machining parts, we have four table of cutter machining parameter. For the limit of paper length, we record cutter parameter of process 1 as table 2.
(5) Document of cutter list
In order that technician manages cutter easily, we record cutter list in accordance with specific machining process. In our sample machining parts, we have four table of cutter list. We demonstrate cutter list of process 1 as table 3 for the limit of paper length.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Cutter No.</th>
<th>Cutter style</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\odot$ 6 rod</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>$\odot$ 12 End milling cutter</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>$\odot$ 3 fixed point drill</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>$\odot$ 3.2 drill</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>R5 Ball cutter</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>$\odot$ 4 End milling cutter</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>$\odot$ 2 End milling cutter</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>$\odot$ 8 End milling cutter</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>$\odot$ 4 Tapping cutter</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>$\odot$ 63 Face milling cutter</td>
<td>30</td>
<td></td>
</tr>
</tbody>
</table>

(6) Document of cutter adjustment
In order that technician set and adjust origin of program easily, we record starter position of machining in accordance with specific machining process. In our sample machining parts, we have four table of cutter adjustment. We demonstrate cutter adjustment of process 1 as table 4 for the limit of paper length.

**V. CONCLUSION**
Technical oriented knowledge is as same important as explicit knowledge. In this research, we integrate KM research, KM practice, and CNC machining technique to construct technical oriented KMS. These articulate documents will be available for technician’s manual or for training.

Implicitness is the inherent property of knowledge. But efficient network will stimulate implicit knowledge to explicit.
When technician’s personal experience and professional skills saved as structured explicit knowledge, organization can preserve and transfer knowledge more quickly and accurately.

REFERENCES


