A Skill Transfer Method for Manual Machine Tool Operation Utilizing Cutting Sound

Takashi Kawashimo¹, Noriaki Sato², Daisuke Doyo¹, Michiko Anse¹, and Tsutomu Tabe¹

¹ Aoyama Gakuin University 5-10-1 Fuchinobe, Sagamihara-shi, Kanagawa, 229-8558, Japan
a5705030@cc.aoyama.ac.jp
{doyo,anse,tabe}@ise.aoyama.ac.jp
² Murata Manufacturing Co., Ltd 1-10-1 Higashikoutari, Nagaokakyo-shi, Kyoto, 617-8555, Japan
sato_noriaki@murata.co.jp

Abstract. This study focuses on the inheritance of skills that has faced difficulties through the years in Japan. Sensorimotor knowledge, which is hard to be described by words alone, is often seen in technical skills in a manufacturing environment in Japan. Interpreting sensorimotor knowledge as formal knowledge, attempts have been made to impart technical skills but have faced barriers particularly in lathe processing due to no visual check of finished quality being allowed. Thus, this study suggested training on the inheritance of skills utilizing the level of cutting sound generated in process. Novice workers served as experimental subjects for an experiment to verify the effectiveness of proposed training.

1 Introduction

Japan is rapidly graying in recent years, which has wielded an influence on manufacturing industry. In 2007, baby boomers including skilled workers who anchored a high-growth period in Japan have reached the retirement zone, and this phenomenon has raised the issues of “the inheritance of skills” that many of manufacturers are groping for an avenue to hand down proficient skills to the generations. Upon enforcement of the amended Law concerning Stabilization of Employment of Older Persons, the manufacturers have taken preventive measures including the postponement of the employment period and the acquisition of skilled retirees from other companies to stem the outflow of technical skills temporarily. The measures, however, provide no fundamental solution, and it is still in need of instituting essential measures for skill inheritance.

Manufacturing Research [1] indicates that “machining and assembling” are processes in the course of manufacturing where skill inheritance issues are likely to manifest themselves. This study examines the inheritance of skills in lathe processing, Manual Machine Tool Operation, which is a major process in “machining and assembling.”

Intended for novice and skilled workers, a field hearing as a pilot study was conducted in a medical precision equipment manufacturing plant on the subject of issues
in the inheritance of skills in lathe processing. Preliminary findings showed that vis-
ual observation of a contact between a cutting tool and an object during precise and
quick lathe processing was difficult and that a question as to what could be informa-
tion for making a decision had arisen among novice workers. In their answers, skilled
workers relied on their sensations in the hand and cutting sound for judgment. Their
judgment criteria such as sensations in the hand and cutting sound are classified as
sensorimotor knowledge that is indescribable. In particular, hand sensory information
that skilled workers have will be acquired only after work is conducted on a level with
them, which is difficult to get the difference in work level between novice and skilled
workers across to novices. There have been earlier studies [2] and [3] on cutting
sound, but the analysis of cutting sound has not taken shape and not been applied to
the inheritance of skills. Focusing on auditory information, cutting sound generated in
lathe processing, this study is to not only analyze cutting sound but devise a method
for skill inheritance based on operation analysis so as to facilitate the inheritance. It is
also intended to evaluate the possibility of improvement in work through the adoption
of the proposed method and cutting sound-based training.

2 Lathe Processing and Cutting Sound

2.1 Sound Structure and Analysis Method

Lathe processing is defined as a machining operation that a rotating cylindrical object
is turned and slotted with a cutting tool.

![FFT Separation of Frequency Components](image)

Fig. 1. FFT Separation of Frequency Components

The cutting tool operates interlocked with the lever and handle (this movement is
hereinafter referred to as feed motion, the rate of feed motion as a feed speed, and the
movement of the cutting tool as a feed rate), and cutting sound is produced by turning
the object. Feed speed increases and decreases proportionately with a pushing force
on the lever or rotating force on the handle, and variations in feed speed achieve a
change in pitch of cutting sound.

Target operation in this study is sloting an 80-mm-dia SUS304 stainless steel bar
0.1mm.