2022「中技社科技獎學金」
2022 CTCI Foundation Science and Technology Scholarship
境外生生活助學金
Living Grant for International Graduate Students

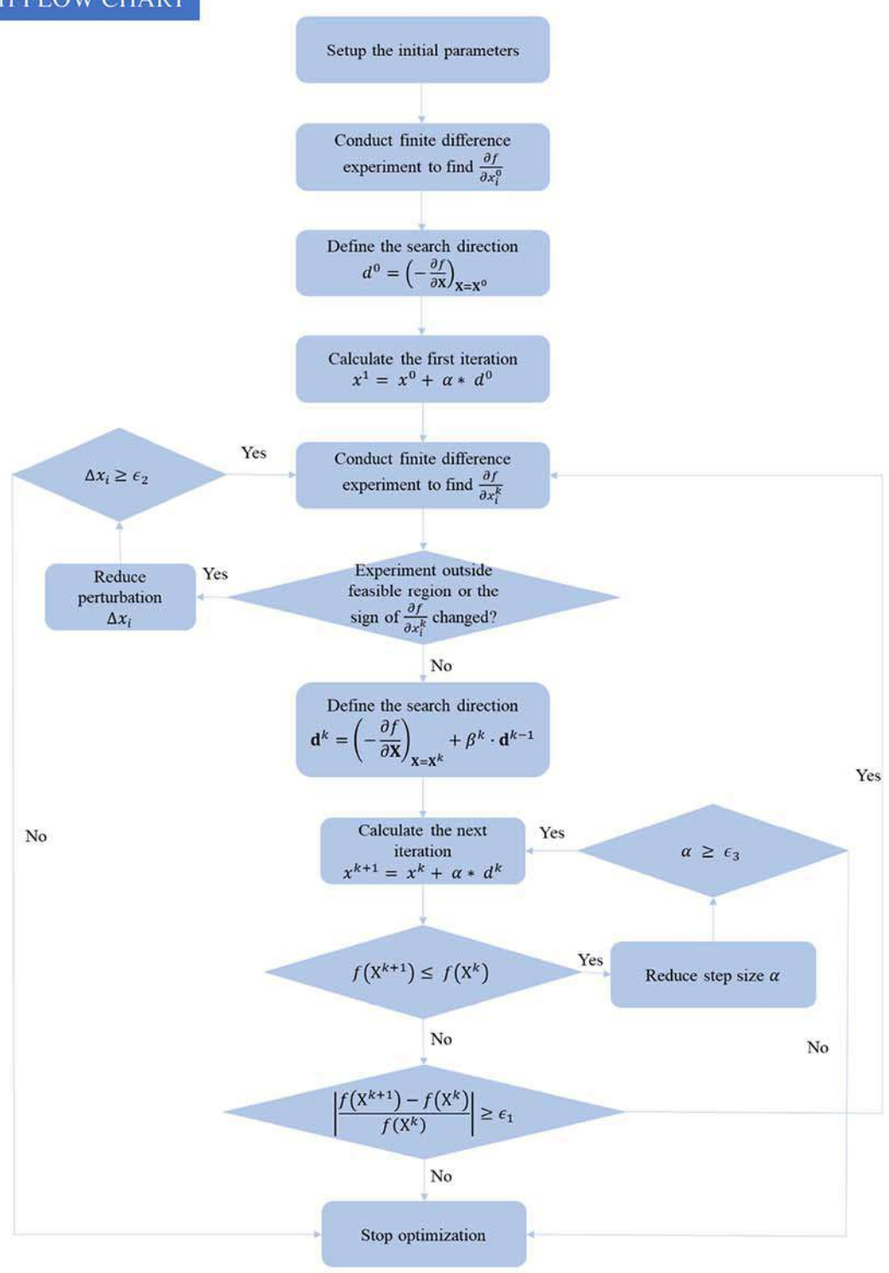
Study on the Integer Optimization of Turning Parameters Based on Tool Wear and Energy Consumption for Multiple Machining Various Part Geometries

Agus Andrianto, Chun-hui Chung
Department of Mechanical Engineering, National Cheng Kung University, Tainan City, 701401, Taiwan

INTRODUCTION

Machining optimization studies have been carried out to obtain low machining costs, optimize the number of workpieces produced, save energy, and improve machining processes. However, most of the studies have not considered the effect of geometric variation on the workpiece; most of the studies have used the conventional tool wear equation. Even though the amount of material removed is the same for straight and profile turning, there is a different wear value of the cutting tool due to the different contact angles that occur during the machining process. In studies that considered variations in the geometry of the specimen, the contact angle varied between the insert tool and the specimen. It is impossible to expect the same performance when machining different parts with the same cutting parameters. In the machining process, insufficient or excessive use of cutting tools is considered a production loss, so the right time for changing cutting tools must be carefully considered. Considering the conditions above, an objective function including the machining cost, energy consumption, and loss of tool usage is proposed in this study. The turning machining process was carried out and investigated to find the integer value of the number of workpieces that can be produced optimally, the effect of geometry, and tool wear.

RESEARCH FLOW CHART



EXPERIMENT SET UP

- The material removal: 337,443 mm^3 for both cases.
- The workpiece: SUS 304 stainless steel with a length of 160 mm and a diameter of 75 mm.
- Cutting tool: Coated carbide insert VNMG160404-MA US735 made by Mitsubishi Materials, Japan.
- CNC turning machine type: Force one FCL-2004 CNC lathe made by Force One Machinery equipped with a Siemens SINUMERIK 828D controller
- Microscope: Nikon optical microscope MM-40
- Tool wear limit: 300 µm
- The initial cutting parameters:
  Cutting speed = 110 m/min
  Feed rate = 0.15 mm/rev
  Depth of cut = 1.5 mm

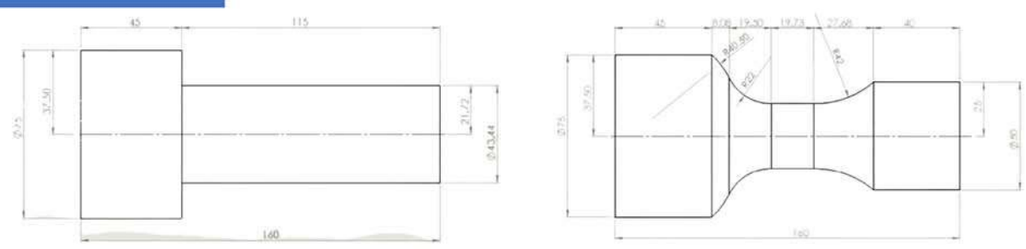
OBJECTIVE FUNCTION

$$C_{all} = \frac{C_t}{P} + C_o \times E\,(v,f,d) + P_r \times P(VB > VB_{limit})$$

$$C_{all} = \frac{C_t}{P} + C_o \times \left(P_i \times \left(\frac{1}{P} \times T_L\right) + \left(\left(P_i + k \times \dot{m}\right) \times T_C\right) + \left(P_i \times \left(\frac{1}{P} \times T_R\right)\right)(v,f,d) + P_r \times P(VB > VB_{limit})\,(v,f,d)\right.$$

Ct	= Tool cost
P	= Number of workpieces can produce
Co	= Operating cost
Pi	= Idle power
TL	= Presetting time
k	= Energy operating constant
Pr	= Price of one product
VB	= Tool flank wear after one operation
m	= Material removal
TC	= Cutting time
$VBlimit$	= Limit of the tool wear
v	= Cutting speed
f	= Feed rate
d	= Depth of cut
Tu	= Total machining time (functions of v, f, d)
VB	= Tool flank wear (functions of v, f, d)

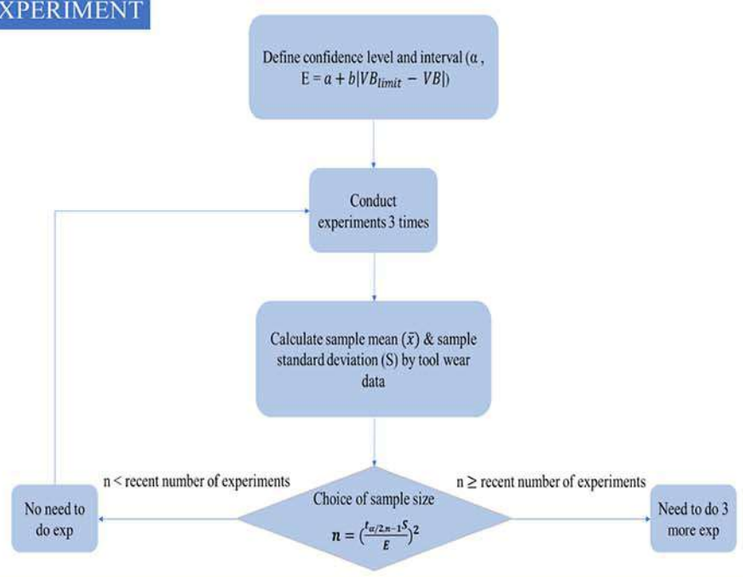
GEOMETRIS



(a) Straight Turning

(b) Profile Turning

FLOW CHART TO DEFINE NUMBER OF EXPERIMENT



PROJECT PLAN

- Research conducted by previous researchers only focused on using one cutting tool to work on one workpiece, while in this study one cutting tool was used for multiple workpieces.
- This research is still in the process of collecting data. An experiment is being carried out by setting the number of workpieces in integers.
- Iteration will be carried out based on the initial points that have been determined, with a parameter increase of 10% from the initial points.
- The calculation of machining costs is based on three cost groups, they are: idle energy cost, operating energy, loss based on cutting tool wear.
- The discussion of the results will focus on the comparison of losses and energy consumption for each cutting parameter in each integer number of workpieces.