STUDY OF VORTEX TUBE COOLING SYSTEM ON TOOL WEAR AND SURFACE ROUGHNESS USING CONVENTIONAL MACHINE

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This report is submitted in accordance with requirement of the University Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Engineering Process) (Hons.)

by

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DECLARATION

I hereby, declared this report entitled "Study of Vortex Tube Cooling System on Tool Wear and Surface Roughness Using Conventional Machine" is the result of my own research except as cited in references.

Signature	: ……………………………………
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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for degree of Bachelor of Manufacturing Engineering (Engineering Process) (Hons). The members of the supervisory committee are as follow:

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(Dr. Mohd Shukor Bin Salleh)

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Co-supervisor

(Mohd Fairuz Dimin)

ABSTRAK

Vortex Tiub merupakan satu alat penyejuk yang digunakan untuk menurunkan suhu pada zon process pemotongan berlaku. Untuk mengatasi masalah pencemaran alam yang berlaku akibat penggunaan ceceair penyejuk, Vortex Tiub merupakan cara yang terbaik untuk mengatasi masalah ini berlaku. Selain itu, kos penggunaan untuk cecair penyejuk memakan banyak perbelanjaan. Tambahan pula, alat ini tidak menggunakan sebarang bahagian yang bergerak and mudah digunakan. Objektif eksperiment ialah mengenal pasti independen dan dependen parameter yang mempengaruhi kehausan mata alat dan kekasaran permukaan apabila mengunakan vorteks tiub sebagai sistem penyejuk. Selain itu, analisis perubahan secara statistik diantara kelajuan pemotongan, kadar suapan, jenis penyejuk berlawanan dengan kehausan mata alat dan kekasaran permukaan. Objektif terakhir untuk mengetahui optimum parameter untuk mengurangkan kadar kehausan mata alat dan kekasaran permukaan. Eksperiment di jalankan menggunakan milling process dan keluli D2 sebagai bahan kerja. Data di analisis menggunakan "*Design Expert*". Secara keseluruhannya, keputusan eksperimen menunjukkan bahawa menggunakan vorteks tiub sebagai penyejuk adalah lebih baik. Jenis penyejuk dan kadaran suapan mempengaruhi respon. Optimum parameter untuk kekasaran permukaan ialah 120 mm/min untuk kelajuan pemotongan dan 0.1 mm/tooth untuk kadar suapan. Berdasarkan analisis permerhatian, menunjukkan bahawa kehausan mata alat wujud pada mata alat ialah "flank wear" dan " build-up edge". Di samping itu, cebisan analisis menunjukkan bahawa eksperimen yang menggunakan vorteks tiub sebagai penyejuk mempunyai keputusan yang lebih baik berbanding menggunakan udara kering sebagai penyejuk. Tambahan pula, analisis untuk permukaan bahan kerja menunjukkan bahawa eksperimen yang menggunakan udara kering lebih kasar berbanding eksperimen yang menggunakan vorteks tiub sebagai penyejuk.

ABSTRACT

Vortex Tube is one of device can be used as coolant to cool down the temperature of cutting zone. The solution of problem environmental, the vortex tube is use to prevent that problem occur again. Besides that, cost for usage of vortex tube is very economical. In addition, this device is easy to adjust and no moving part included. The objective of this experiment is to identify the independent and dependent parameters that affect the tool wear and surface roughness when using vortex tube as cooling system. In addition, to analyse statistically the correlation between the cutting speeds, feed rate, type of coolant against surface roughness and tool wear. The last objective is to obtain optimum parameters for the lowest rate of tool wears and surface roughness. The experiment is conducted by using milling operation and D2 steel as workpiece. The design expert is used for analyse the data of experiment. Generally, the result of this experiment is better using Vortex tube as a coolant. The type coolant and feed rate are affecting the response, which is surface roughness. The optimum parameter for surface roughness is 120 mm/min for cutting speed and 0.1 mm/tooth for feed rate. From the observation analysis, tool wear was existed at insert such as flank wear and build up edge. Besides that, the chip analysis show experiment using vortex tube coolant has better performance than dry coolant. In addition, the analysis for surface of workpiece show experiment using dry coolant have rougher surface than experiment using vortex tube.

DEDICATION

Special thanks I dedicated to my beloved family especially my mother, Siti Aidah Binti Abu Darah, My father, Mahmud Bin Balimbang and My Uncle, Adan Bin Balimbang for their continuous support to me in performing this difficult task and completing my final year project. Special dedications for my supervisor, En. Mohd Fairuz Bin Dimin, Dr. Mohd Shukor Bin Salleh and to all my friends and laboratory technician. This project cannot be completed without all of you.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCULTURE

ANOVA	-	Analysis of variance
^oC	-	Degree Celsius
COP	-	Coefficient of performance
DOE	-	Design of Experiment
^oF	-	Degree Fahrenheit
mm	-	milimeter
Vb	-	width of flank wear
min	-	Minute
CFD	-	Computational fluid dynamic
g	-	gram
3D	-	3-dimension
Rpm	-	rotational per minute
Rev	-	Revolution
FKP	-	Fakulti Kejuruteraan Pembuatan
SEM	-	Scanning electron microscope
CCD	-	Couple-charged device
Ft	-	feed rate tooth

Fz	-	feed rate
Vc	-	Speed
W	-	Outer Corner
Mw	-	Margin Wear
CT	-	Chisel edge wear
CM	-	Chisel edge wear
PT	-	Chipping at lips
PM	-	Chipping At Lips
Sqrt	-	Square Root
µm	-	Micrometer

CHAPTER 1

INTRODUCTION

This chapter describes about background of study, problem statement, objectives and scope.

1.1 Background of study

The research background of final year project details describes the vortex tube cooling system, application and also the example of application this device.

1.1.1 Vortex tube cooling system

Vortex or swirling flow tube has attracted increasing interest due to its industrial application and benefit for the last few decades. George Ranque discovered the vortex tube in early 1930. Ranque was developed vortex tube and conducting an experiment. From his observation, the hot air exhausting from one end and cold air from the other end. In spite of that, Ranque was ignoring about the pump and begin the promoted potential of a new device that creates warm and cold air without using any moving operation part with built the small firm. Unfortunately, he presented the paper about the vortex tube to scientist society in France and failed to commercial it because met with rejection and passivity (Yilmaz et al., 2009). The vortex tube disappears into inconclusiveness until 1945, the scientific paper of vortex tube released a widely by Rudolph Hilsh was German physicist (Exair Cooperation, 2013).

"Friendly little demon" is one of the devices can produce, carry out and divide the warm and cold molecule of air suggested by James Clerk Maxwell. He was a great physicist and also suggesting about heat involves the movement molecules (Exair Cooperation, 2013). In addition, the ability of vortex tube is separate air stream into a difference of flow separate air stream into a difference of flow as one, which air inside the inlet is cool while outer is warm without any operation part and it also was significant instrument based on Silverman (1993). The system separation the temperature in vortex tube was not clearly understood, so, this instrument was described using Maxwell Demon in short meaning is dividing heat from cold without using any operation. In figure 1.1 shows the basic construction of Ranque-Hilsch Vortex Tube consist of the control valve, hollow cylinder, exit vortex spin chamber, hot air, cold air exit and input air inlet.

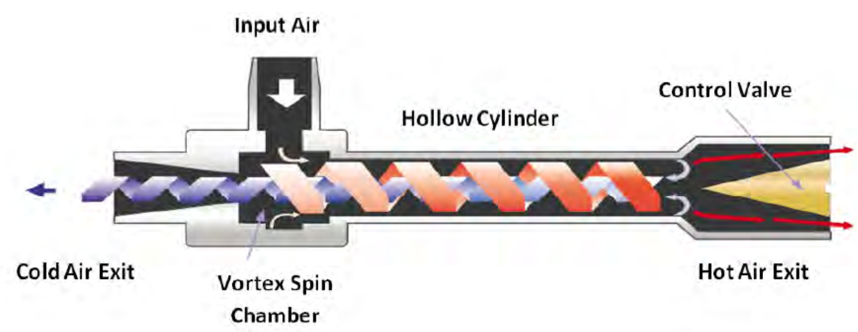

Figure 1.1: The basic construction of Ranque-Hilsch Vortex Tube, (Exair Cooperation, 2013).

Through the air inlet, commonly the take in the compressed air is dragging in tangentially. The air flows into the vortex tube and changed into turbulence flow. Then, it travels into the hollow of the cylinder and flows out at the hot air exit which at periphery position as hot dry air. When a few of the air is spontaneously flow back into the hollow cylinder, a second turbulence flow happens inside the first turbulence flow and travel out at the cold air exit as a cold air. The amount of air out at both ends forced by the control valve at the hot air exit controls (Exair Cooperation, 2013).

1.1.2 Vortex Tube Application in Machining

Currently, the application for vortex tubes is used commercially in low-temperature device and applications, for instance, dehumidifying gas samples, to test temperature sensors, to cool food, to chill environment chamber, to cool electric control cabinets, to set solders and to cool parts of the machine (Von, 1950). Vortex tubes are widely used for low equipment cost, safety, and compactness. In the chemical industry, vortex tubes are used for electricity production and snowmaking and etc. Heating and cooling application, gas liquefaction, separation of gas mixture and drying of gases are included in a basic factor for chemical application industry (H. Khazaei et. al, 2012).

The application for vortex tube is used for an automobile of the fuel tank. This device is blow molded and clamped to fixture to prevent any distortion during the cooling cycle. The period of cooling process for this device is over 180 seconds needed for each tank during the production process. Vortex tube was connected to a compressed air line and set up to the cooling rack. Vortex tube brought out inside the tank of fuel produced the cold air. Reduction of time cooling period was three-minute to two minutes for each tank and improved the productivity. The size of vortex tube can be small and light depends on users and application devices. This application have been used is Model 3250 from Exair company, which is the tiny size and low weight and also no moving part involve show in Figure 1.2 (Exair cooperation, 2002).

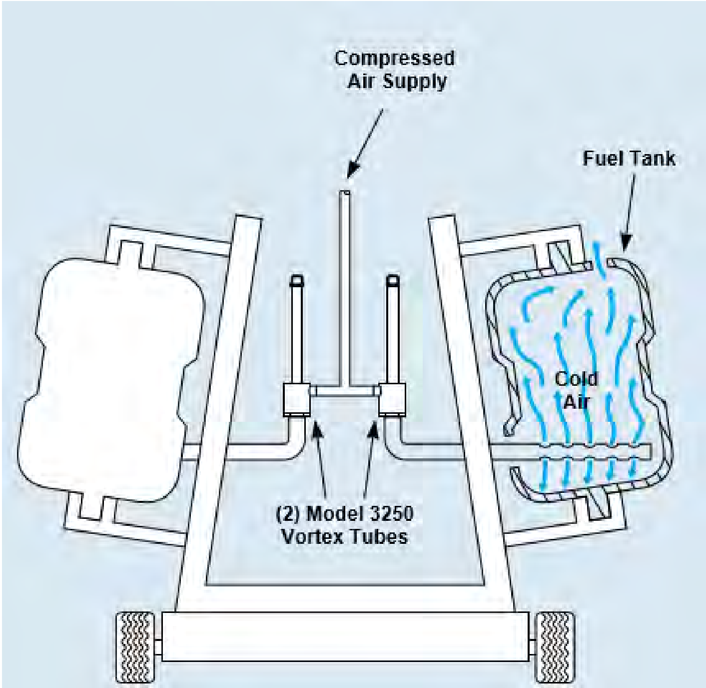

Figure 1.2: Cooling Molded Fuel Tank (Exair Cooperation, 2002)

Besides that, industry application for the small part after brazing is requiring the cooling process. The air conditioner act as the coolant cannot perform well to cool all part and limited production rate. To replace the air conditioner, industry used the Model 3230 Vortex Tube to cool all the small part at a maximum production rate. This model was different to another cooling device because of advantages such as cleanliness, compact design, inherent reliability and low cost show in Figure 1.3 (Exair cooperation, 2002).

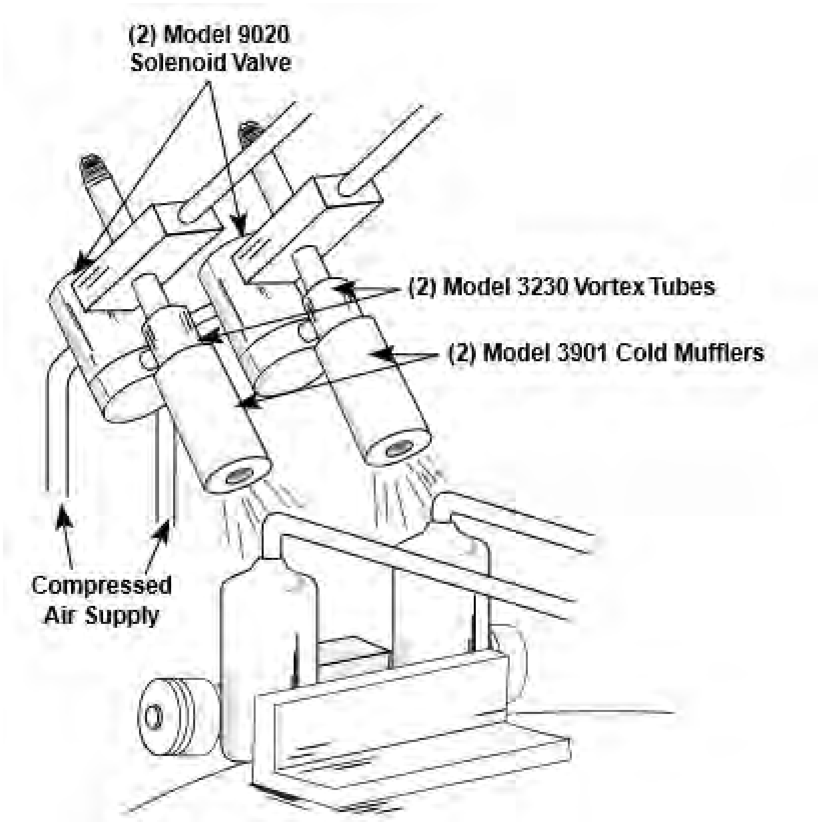

Figure 1.3: The application of Vortex tube for cooling small parts after brazing, (Exair cooperation, 2002).

Moreover, in application industry of toothpaste, the manufacturer is used ultrasonic weld for the seal of plastic tube process. This process was needed the cooling process because the tubes can be at a high temperature and cannot seal then the rejection of product rate was increased. The manufacturer is used this model 3215 Vortex tube to cool down the temperature of the tube using direct cold at clamped condition. The cooling process was happening and transferred via the jaw to the tube during clamped condition. This model made people amazes about the quality and advantages because of low cost, easy to handle, and no moving parts show in Figure 1.4 (Exair cooperation, 2002).