MEASUREMENT OF LUBRICANT OIL FILM THICKNESS UNDER MINIMUM QUANTITY LUBRICATION MILLING PROCESS

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SUPERVISOR'S DECLARATION

We hereby declare that we have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Science

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Keperluan cecair pelincir banyaj digunakan dalam bidang pembuatan terutama dalam bidang pemesinan disebabkan oleh hasil yang bermanfaat dengan kata lain, keupayaan untuk melincirkan proses pemotongan, bahan yang dapat mengurangkan suhu pemotongan dan juga untuk mengurangkan cip dari terkumpul di atas zon pemotongan. Tambahan pula, pendekatan pelinciran ini juga telah banyak digunakan untuk meningkatkan prestasi pemesinan seperti mengurangkan kekasaran permukaan kerja dan meningkatkan kadar hayat alat pemotong. Secara tradisional, minyak pelinci telah digunakan sebagai kaedah pelinciran semasa proses pemesinan. Bagaimanapun, oleh kerana kepeluan berlebihan yang dibekalkan oleh kaedah tersebut telah menyebabkan risiko bahaya kesihatan, kesan peningkatan kepada kos pembuatan dan kerosakan alam sekitar global. Untuk mengatasi pemasalahan ini, satu improvisasi kaedah pelinciran yang dikenali sebagai Pelinciran Kuantiti Minimum (MQL) telah dilaksanakan. MQL ialah kaedah pelinciran alternatif untuk proses pemotongan yang menggunakan campuran udara termampat dengan pengurangan penggunaan mintak pelincir. Campuran tekanan udara dan minyak pelincir yang dilakukan oleh MQL dalam aplikasi pemesinan telah terbukti menjadi alternatif yang lebih baik untuk kaedah pelinciran telah terbukti dapat mengurangkan penggeseran yang berlaku di zon memotong, dapat mengurangkan risiko bahaya pekerja serta dapat mengurangkan kos pembuatan. Walaubagaimanapun, oleh kerana penggunaan minyak adalah sangat sikit, keberkesanan MQL dalam proses pelinciran adalah sangat bergantung kepada keupayaan minyak untuk menembusi zon pemotongan yang kecil. Ini boleh dicapai dengan mengkaji mekanisma minyak semasa proses pelinciran zon pemotongan, di mana kajian ini masih terhad kerana kebanyakan kajian terdahulu hanya menumpukan kepada keberkesanan pemesinan atau pelinciran tanpa menunjukkan secara terperinci bagaimana tingkah laku pelincir memberi kesan kepada keupayaan pemotongan. Kajian sifat asas minyak pelincir semasa operasi pemesinan adalah sangat penting tetapi kajian ini masih terhad disebabkan oleh kerumitan penyediaan penyelidikan semasa operasi dijalankan serta aliran minyak semulajadi yang tidak boleh diganggu mungkin menyebabkan kebatasan untuk melaksanakan kajian ini. Untuk mengatasi isu ini, satu kerja penyelidikan dengan tujuan untuk menganalisis tingkah laku minyak pelincir dalam aplikasi MQL menggunakan kaedah yang dikenali sebagai pendarfluor teraruh oleh laser (LIF) telah dijalankan. Kajian ini dilaksanakan untuk mengkaji ketebalan minyak semasa proses pemesinan MQL dengan pengubahan kelikatan minyak pelincir dan kelajuan pemotongan mesin. Empat jenis minyak iaitu minyak campuran ester, bunga matahari, minyak zaitun dan minyak semulajadi penaga laut dengan nilai kelikatan, η dari 11.075, 35.260, 35.260 dan 63.223 mPa.s pada suhu 40˚C yang telah dilarutkan pewarna neon pendaflour, Coumarin 153 untuk mendapatkan minyak pelincir. Dalam masa yang sama, kelajuan pemotongan mesin *Vc* dari 14.514, 19.514, 24.514 dan 29.514 m/minit telah diselaraskan untuk melihat purata ketebalan filem minyak pelincir sepanjang jalur pemotongan. Prosedur kalibrasi telah dijalankan sebelum menjalankan operasi pemesinan untuk mencapai hubungan linear antara cahaya dipancarkan dan ketebalan filem minyak pelincir. Dari kajian tersebut, didapati bahawa purata ketebalan filem minyak pelincir meningkat apabila kelikatan minyak menurun. Fenomena ini dijelaskan kerana partikel minyak berlikat rendah yang lebih kecil menjadikannya lebih mudah untuk menembusi dari muncung MQL dan meningkatkan

daya sebaran minyak pelincir ke jalur pemesinan. Sementara itu, diperhatikan dari pemenuan bahawa ketika kelajuan pemotongan meningkat, purata ketebalan minyak pelincir juga meningkat. Peningkatan kelajuan pemotongan telah meningkatkan penggeseran antara alat pemotong dan benda kerja yang akhirnya memberikan pelinciran yang baik. Untuk menjelaskan hubungan antara tingkah laku minyak pelincir MQL dan prestasi proses pemesinan, pengukuran kekasaran permukaan benda kerja telah dianalisis. Hasil menunjukkan nilai purata kekasaran permukaan adalah menurun dengan peningkatan kelajuan pemotongan dalam proses pemesinan. Ini dapat disokong dengan hasil yang mengesahkan ketebalan filem minyak pelincir di bawah keadaan yang sama, menunjukkan bahawa lebih banyak pelincir yang dibekalkan pada bahan kerja, menghasilkan kelicinan permukaan bahan kerja yang lebih baik. Walaubagaimanapun, purata kekasaran permukaan di analisis dan menunjukkan graf peningkatan dengan penurunan kelikatan minyak, η. Ini sebaliknya dengan apa yang dicapai pada ketebalan filem minyak pelincir. Walaupun zarah dalam minyak likat rendah lebih mudah untuk menembusi zon pemotongan dan memenuhi laluan pemotongan, minyak tersebut tidak dapat menghalang serpihan besi pemotongan dan dengan itu menyebabkan bahan kerja menjadi kasar.

ABSTRACT

Cutting fluid has been extensively used in the manufacturing fields, especially in the machining areas due to its beneficial outcomes, i.e. the capability to lubricate the cutting process, reduce the cutting temperature as well as to slide away the chips from agglomerated onto the cutting zone. Furthermore, this lubrication approach also has been widely utilised to improve the machining performance such as to minimise the surface roughness of workpiece and enhance the rate of tool life. Traditionally, flood coolant has been used as the lubrication method during the machining process. However, excessive amount of oil being supplied through flood cooling method has caused occupational health hazards, manufacturing cost rising and global environmental damage. To overcome these drawbacks, an improvisation lubrication method known as Minimum Quantity Lubrication (MQL) has been implemented. MQL is an alternative lubrication method for near-dry cutting process using a mixture of compressed air and less amount of lubricant oil. MQL in the machining application proven to minimize friction at the cutting zone, reduce the occupational health hazards as well as lower the manufacturing cost. However, since the usage of oil is very little, the goodness of MQL in the lubrication process highly depends on the ability of the oil to penetrate the narrow cutting. This can be obtained by examining the mechanism of oil while lubricating the cutting zone, where this study is still scarce because most of the past studies were merely focus on the effects of machining or lubrication parameter without showing how the lubricant behaviour related to the cutting performance. The study of fundamental nature of lubricant oil during machining operation is highly important to be observed but nevertheless it is still deficient due to the complexity of experimental setup during the ongoing operation as well as the natural flow of oil cannot be disrupted have caused the limitations to accomplish the study. To cater this issue, an experimental work with the objective to analyse the lubricant oil behaviour in MQL milling process by using a non-intrusive method known as laser induced fluorescence (LIF) was carried out. The study was conducted to investigate the thickness of oil during the MQL milling process under various oil viscosity and cutting speed effects. Four different types of oil, i.e. mixed esters oil, sunflower oil, olive oil, and calophyllum inophyllum oil with dynamc viscosity values at 40˚C of 11.075, 35.260, 35.260 and 63.223 mPa.s , respectively were dissolved into a fluorescent dye, i.e. Coumarin 153 as the working fluid. Concurrently, machining cutting speed of 14.514, 19.514, 24.514, and 29.514 m/min were set to observe the average lubricant oil film thickness along the milling path. Calibration procedure was carried out before conducting the milling operation to achieve a linear relation between emitted light intensity and the lubricant oil film thickness. From the study, it was found out that the average lubricant oil film thickness increased as the oil viscosity decreased. This phenomenon is explained due to the smaller particles of low viscous oil that made it easier to penetrate from MQL nozzle which increased the spreadability of lubricant oil onto the milled path. Meanwhile, it was observed that as the cutting speed increased, the average lubricant oil film thickness also increased. The increment in cutting speed has raised the friction between cutting tool and workpiece which eventually led to providing a good lubrication effects. To clarify the relation between MQL lubricant oil behaviour and the performance of milling process, the measurement of surface roughness of workpiece was analysed. The results showed that the average surface roughness decreases with the increasing of machining cutting speed. This is supported by the findings that confirmed the results of lubricant oil film thickness under the same conditions, indicating that more lubricant supplied on the workpiece gives better surface finishing of workpiece.

However, it was found that the average surface roughness increased with the decreasing of dynamic viscosity, η. This is contradict with what was found in lubricant oil film thickness. Although the small particles of low viscous oil was easier to penetrate the cutting zone and spread along the milled path, the oil unable to repel the flying chips and thus made the workpiece rough. Finally, the findings from this research study was able to fill the gap of knowledge in clarifying the oil film thickness behaviour on the machining performance.

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