UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Potential Application of Ferrofluid for Robot Gripping Mechanism

Thesis submitted in accordance with the requirements of the Universiti Teknikal Malaysia Melaka for the Bachelor Degree of Manufacturing Engineering (Robotics and Automation) with Honours

By

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This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (*Robotics and Automation*) with Honours. The members of the supervisory committee are as follow:

Muhamad Arfauz Bin A. Rahman
(PSM Supervisor)

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DECLARATION

I hereby declare that this report entitled **"Potential application of Ferrofluid for Robot Gripping Mechanism"** is the result of my own research except as cited in the references.

Signature	:	
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ABSTRACT

Ferrofluids are magnetically controllable fluids where it can be used in positioning system as an active medium. With an applied external magnetic field, the capability of the ferrofluid is the main properties for the research. In this study, ferrofluid are used to develop a potential application in gripping mechanism. The properties and the influences of the ferrofluid in positioning are gathered and the research start with identify the title main element which is ferrofluid and the robot gripping mechanism. Through the literature review, the mechanisms are developed and the development of the robot gripping mechanism presented in order to come out with a replica. The methodology consist the method used and explanation related to the robot gripping mechanism development. Furthermore, the conceptual design presented for design development and the selection is according to the Pugh screening concept. Then, detail design through the simulation, replication and analysis process. The simulation output shows how the mechanism works and gives better understanding about the ferrofluid movement. Analysis on the force and the moment for the finger and shaft presented according to free body diagram from the replication. In this case the spring constant or force constant of the spring determined in order to know the suitable spring force. In addition, the viscosity of the ferrofluid discussed as it reflect proportionally to the current.

ABSTRAK

Ferrofluid adalah cecair magnet yang dapat dimanipulasikan dengan kehadiran suatu medan magnetik. Dalam kajian ini, cecair magnet digunakan sebagai satu medium penggerak yang berpotensi dalam mekanisma cengkaman pada robot. Ia dimulakan dengan menghuraikan isi-isi yang terdapat di dalam tajuk yang melibatkan cecair magnet dan mekanisma cengkaman robot. Pengumpulan maklumat dilakukan melalui rujukan jurnal-jurnal, melayari internet serta buku dan setiap maklumat yang berkaitan sahaja yang diambil. Seterusnya, kaedah-kaedah yang akan digunapakai digariskan dengan menerangkan proses-proses yang terlibat dalam menghasilkan simulasi dan replika. Oleh itu, lakaran mekanisma secara dua dimensi dihasilkan untuk setiap idea yang tercetus dan semua lakaran tersebut akan dipilih menggunakan kaedah matrik Pugh, di mana rekabentuk yang mendapat markah tertinggi akan dipilih. Berdasarkan rekabentuk tersebut, lukisan tiga dimensi, simulasi dan replika pula dihasilkan untuk memberi gambaran yang lebih jelas berkenaan rekabentuk dan mekanisma pergerakan cecair magnet. Akhir sekali, analisis dibuat ke atas mekanisma tersebut terhadap daya dan momen yang dihasilkan serta pekali spring dan kelikatan cecair magnet untuk mendapatkan kesesuaian daya yang diperlukan oleh cecair magnet untuk menggerakkan aktor.

DEDICATION

For My parents.

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LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

nm	-	nanometer
µm	-	micronmeter
2D	-	Two Dimensional
CAD	-	Computer Aided Manufacturing
3D	-	Three Dimensional

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Materials that are attracted by magnetic fields are called magnetic materials (Robert J. Fowler, 2003). The most common magnetic materials are iron, iron compound and alloys containing iron or steel (Robert J. Fowler, 2003). These magnetic materials are also called ferro magnetic materials as ferro is a prefix that means iron. In general, ferrofluid is magnetic iron in liquid form. Electricity and magnetism cannot be separated as magnetism created by an electric current. It is known that an electric current produces a magnetic field (Robert J. Fowler, 2003). The main application areas which is sealing, damping and heat transfer, continue to dominate the commercial activities but in each category new market opportunities have resulted in the development of mechanical devices and ferrofluids. There is now an increased use of ferrofluids in stepper motors, and D'Arsonval meters are at the stage of testing. In both cases one of the objectives is to damp the system and improve product performance. Transducer have become more importance of the magnetic fluids and, as a result, new sensor products are now in the manufacturing field.

There has been development in the synthesis of the magnetism and magnetic materials due to the potential of various applications. As one of the magnetic material, ferrofluid has been used for biomedical applications and technical applications. In biomedical applications, it is because by their low toxicity and high magnetizations value for diagnostics and treatment of tumor cells such as magnetic resonance tomography (MRT), magnetic drug targeting (MDT), magnetic hyperthermia (MHT) and artificial heart and muscles (Uhlmann, 2006). Biomedical applications focus on the single colloids' properties. While in technical applications there are more on product and process application likes loud speaker, lubricants, and seals in feed-through, cooling, sensors and damping medium (E. Uhlmann, 2006). Technical applications consider the ferrofluids' properties as a whole fluid described by its magnetorheological behavior, magnetization and permeability for magnetic forces. In positioning applications, it still less applies.

Magnetic fluid also called ferrofluid (W. Ochonski, 2005), consist magnetic particles that able to react with magnetic field. Ferro fluids respond immediately to changes in applied magnetic field and removing the field quickly randomize the moment (W. Ochonski, 2005). It explains that the ferrofluid is compliance and we can manipulate it according to the wanted current. The magnetic field can be controlled as known magnetic field move from north to the south. In order to develop the robot gripper, it requires movement and force. Here, ferrofluid will be used as an active medium for generating a variable magnetic force which will acts on actor and enables the movement (E. Uhlmann & N. Bayat, 2004). The magnetic force will be produced from the movement of the ferrofluid that can be control by the current through the coil installed. Using a permanent magnet also can produce a magnetic field, however, coil is better as the concentration of the magnetic field can be manipulate. As a result, it will transmit the force to the actor of the robot gripper.

There is high potential of ferrofluid applying the robot gripping mechanism as the ferrofluid inside can be apply to other application, for example, sensoring mechanism. Also, precise movement can be adjusted through the current applied to the coil. Furthermore, it is a new technological application of the positioning system instead of hydraulic, pneumatic and electrical system.

1.2 PROBLEM STATEMENT

Using electrical supply is one of the common for developing a robot gripper. However, the danger of electrical sparks, non-direct drive motors are geared down and can cause such problems as backlash, friction, compliance and wear which can affect the accuracy and repeatability of the robot (James W. Masterson et al, 1996).Hydraulics can supply large amount of instant power and provide precise motion over a wide range of speeds but it is expensive to purchase and maintain. It is not energy efficient and noisier than electrical units and due to fluid leaks, they are not recommended for clean room environments (James W. Masterson et al, 1996).Pneumatics works at high speeds and is economical to operate and maintain. The disadvantage is air is compressible, making precise placement and positioning more difficult to control. It is difficult to keep air used by pneumatic system clean and dry and noisier than either electrical or hydraulic systems (James W. Masterson et al, 1996). With the use of the ferrofluid, this new technological application can reduce the noise, as the ferrofluid is reflect only with generated coil. Besides, the large amount of power can be produce and provide precise motion.

1.3 OBJECTIVE

- To analyze and evaluate the potential application of ferrofluid in robot gripping mechanism.
- To design and develop a replication of a suitable robot gripping mechanism.

1.4 SCOPE

- To collect, analyze and evaluate the relevant information regarding to the ferrofluid application from previous and current research.
- To design, simulate using Autodesk Maya 8.0 and analyze the robot gripper.
- To develop a replication of robot gripper.

1.5 BENEFIT

The study on the ferrofluid in robot gripping mechanism will be a new application of robot gripper instead of using motor, pneumatic and hydraulic. The ferrofluid will be an active medium to replace the conventional mechanism and it can be exploit for another usage for example, a sensor as ferrofluid is now widely use. Furthermore, it can reduce noise, as we know present mechanism that using motor, pneumatic and hydraulic produce noise. The compliance criteria of the ferrofluid can be manipulate and the relative high range of positioning with an accuracy of only a few micrometer. In addition, it also can be use for a safeguard against overload.

CHAPTER 2

LITERATURE REVIEW

2.1 ROBOT GRIPPER

Gripper is considered as a subsystem of a handling mechanism which provides temporary contact with the object to be grasped (Gareth J. Monkman et al, 2007). From the definition, we can understand that operation of the gripper is grasping an object. However, the term “gripper” is also used in cases where no actual grasping, but rather holding an object, for example in vacuum suction where the force can act on a material. There are many gripper can be found in industry and their functions is depend on the specific application. According to the Gareth J. Monkman et al, their function can be as following ;

(a) Temporary maintenance of a definite position and orientation of the workpiece relative to the gripper and handling equipment.

(b) Retaining of static (weight), dynamic (motion, acceleration or deceleration) or process specific force and moments.

(c) Determination and change of position and orientation of the object relative to the handling equipment by means of wrist axes.

(d) Specific technical operations performed with, or in conjunction with the gripper.

In other word, the main function of a gripper is to grasp and to release workpieces during the material transfer route (Fan Yu. Chen, 1982). In general, the gripper is a specialized device that can do specific task or job used to handle one or few objects in a repetitive operation which required calculated force and versatility.

2.2 ROBOT GRIPPER CLASSIFICATION

One should differentiate between grasping (prehension) and holding (retention) forces. This is important as these are the most used type of gripper in industry. The grasping force is applied at the initial point of prehension (during the grasping process), while the holding force maintains the grip thereafter (until object release) (Gareth J. Monkman et al, 2007). In general, the retention force may be weaker than the prehension force. This is because the grasping force is determined by the energy required from the mechanical motion. Robot grippers may be categorized in broadest manner. Fan Yu Chen (1982) classified gripper into three types which is mechanical finger, vacuum and magnetic, and universal grippers.

The mechanical finger type is widely used in industry where a direct mechanical force according to the number of fingers in gripper. The majority of grippers are of the 2-finger type and 3-finger type of grippers. For vacuum and magnetic type, includes those fitted with suction cups or electromagnets as force-exerting elements. In other hand, universal gripper consists of inflatable fingers, soft fingers, 3-fingered grippers and grippers that are made of mouldable materials (Fan Yu Chen, 1982). The classification by Fan Yu Chen is based on the function years before 1982. As more new type of gripper has been develop nowadays, Gareth J. Monkman et al (2007) has classified it more specific based on the functions, physical of operation and suitability. There are four main groups that been categorized by Gareth J. Monkman et al (2007) which is : Impactive (a direct mechanical force from two or mode directions is applied to the object), Ingressive (prehension of the object is achieved through permeation of the object surface), Astritive (a binding force is applied in a single direction) and Contigutive (non impactive methods whereby a direct contact is required to provide a prehension force in a single direction). These four categories are listed in the table 2.1 and 2.2 below.

Table 2.1 : Gripper classification according to their physical principle of operation (Gareth J. Monkman et al, 2007)

Prehension method	Gripper type	Typical object materials
Impactive		Rigid objects
Ingresive	Intrusive	Flexible Objects : textiles, carbon and glass fibre
	Non-intrusive	Flexible Objects : textiles, carbon and glass fibre
Astrictive	Vacuum suction	Non-porous, rigid materials
	Magnetoadhesion	Ferrous materials
	Electroadhesion	Light sheet materials and microcomponents
Contigutive	Thermal	Flexible Objects : textiles, carbon and glass fibre
	Chemical	Carbon fibre with glue impregnation
	Fluid	Small, light objects (microcomponents)

Table 2.2 : Gripper classification and suitability of object materials (Gareth J. Monkman et al, 2007)

Prehension method	Gripper type	Typical examples
Impactive		Clamps (external fingers, internal fingers, chucks, spring clamps), tongs (parallel, shear, angle, radial)
Ingresive	Intrusive	Pins, needles, hackles
	Non-intrusive	Hook and loop
Astrictive	Vacuum suction	Vacuum suction cup/ bellows
	Magnetoadhesion	Permanent magnet, electromagnet
	Electroadhesion	Electrostatic field
Contigutive	Thermal	Freezing, melting
	Chemical	Permatack adhesives
	Fluid	Capillary action, surface tension