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# Design and development of a microgripper for use in pipeline inspection robot

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**Abstract**— A microgripper has been designed here. The 12V D.C. Servomotor and Radial Cam-Knife edge follower mechanism carry out actuation. Two jaws are being deployed, out of which one is fixed, and another is movable. The fixed Jaw has straight fingers, while the movable Jaw hinged with the base carries a pivoted knife edge follower and curved fingers.

**Keywords**— Microgripper, actuation, follower, knife edge

## I. INTRODUCTION

During the preliminary inspection of a power plant's boiler header and other pipelines [1], the nuts, welding rods, and bolts are left behind during the installation [1]. As a result, a need for the removal of these unwanted materials from the pipeline has aroused. Presently the pipeline inspection robots [2,26] identify the areas where these materials are stuck and notify the operator. Accordingly, the sections are cut, and the materials are removed after that. This increases the cost and complexity of the process [2] as well as takes significant time leading to a loss of revenue by the plant. Therefore, the need for a microgripper [15] has aroused that would collect the welding rods and small nuts and bolts during the inspection of the pipeline and will fetch them to the entry [1,2]. As the welding rods, nuts and bolts are very small in size of the order of about 8mm dimension; thus, grippers have to be made up of minimal dimensions to grip the objects accurately and complete the process.

Such grippers are not available commercially in the market. Accordingly, a microgripper has been designed for the mentioned purpose.

Proper caution has been taken while designing the gripper to avoid any intrinsic stiffness [11] in the structure. The symmetric structure [17] is compromised for the sake of using the cam as the guiding device responsible for movement. AL-6061 alloy [16] has been used for most parts to make the overall weight lighter.

The Design of the hinge in the lower part of the movable Jaw [19] was a significant challenge for most of the micro-gripper [19]. Thermal management [10] surrounding the actuator [9] may be an essential design consideration [12] for different applications [8]. But there has been no such issue with the proposed microgripper [20], as the actuator [18] is carefully chosen [5]. No complicated kinematic structure [13] is used while designing the gripper [14], and proper material is used, which reduces the tribological components and tribological behaviour to a great extent [3,4,6,7].

Research on the development of microgrippers is going on in various universities, institutes, and organizations. Literature survey reveals the same.

The microgrippers designed earlier gives gripping force in the range of 20mN to 657.5mN shown in Table I.

Reference No.	Input voltage	Amplification	Motion stroke	Gripping Range	Gripping force
[3]	100V	10.41 (max <sup>m</sup> 22.4)	118.34μm	-	366.7 mN
[4]	0-45V	3.8	180μm	12.7μm	30mN
[5]	6V	-	-	80μm	6575μN
[6]	0.25-5V	-	-	80μm	20mN
Microgripper designed in this paper	12V	40	1200μm	350μm	850mN

They were unable to carry slightly heavy loads of 100 g or higher [3-10]. There was a need to develop a microgripper that could lift loads to 100g or higher. The actuator was made up of an electro-thermal force sensor and piezoelectric transducer [3-10], which either gave thermal issues or developed less power. Therefore DC Servomotor was chosen for a steady and continuous voltage supply with negligible thermal issues. The microgripper made earlier provided a gripping range of 10μm to 80μm [Table I], which was insufficient to grasp bigger objects. For a displacement of 10μm, there was a gripping force of 4.2 mN. So the microgripper is designed with a gripping volume displacement of 89.4m for a gripping force of 850mN. The actuation of the gripper was realized either by Shape Memory Alloys [3], piezo-stack, Z-shaped thermal actuator [4], Chevron actuator [10], or comb-drive actuation [9]. But actuation mechanisms gave an amplification ratio of 3.8 to 50 [Table I]. The amplification ratio is the ratio of twice the output displacement to the input displacement. The microgripper designed here provides an amplification with a ratio of 40 by using a Radial Cam [27] and knife edge follower [28] designed for this purpose which is well above the average amplification ratio given by another actuating mechanism.