Design of Portable Hot Dimpling Machine for Aerostructure Contoured Part by Modifying Squeezer Chicago Pneumatic CP214

THESIS

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PREFACE

After thanking Allah Almighty and my family for their endless support, I would like to thank whoever who help me to accomplish this undergraduate thesis report. I am grateful to my lecturers, advisors, parents, fellows, coworkers, and others for their guidance, reviews and recommendations. Learning and working with these people was a steep learning curve for me as they did not only polish my problems solving skills but also gave me many insights to look and see into everything.

This report is my undergraduate thesis with a specialization in the Design of a Portable Hot Dimpling Machine for the Aerostructure Contoured Part by Using Pneumatic Squeezer Chicago Pneumatic CP214 which consists of an arrangement of introduction, literature review, methodology, design, qualification and conclusion. I hope this thesis report provides a little acquaintance about how to design tools in the component assembly area.

Always have a great day. Best regards.

Bandung, 30 September 2023

Harisya Prayekti Dewi M.

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ABSTRACT

The development of a portable hot dimpling machine is essential for meeting the production requirements of PTDI, particularly for the N-bell 412 Helicopter Program, which requires dimpled sheet metal parts with smaller flange sizes. The existing stationary hot dimpling machine (CP450) cannot process parts with flange sizes smaller than 20 mm, while the new parts require a flange size of 15 mm. This research focuses on modifying the pneumatic Squeezer CP-214 into a portable hot dimpling machine to meet these requirements, in compliance with Bell Specification BPS 4135. The design process includes identifying shop floor needs, establishing target specifications, generating and selecting product concepts, testing prototypes, setting final specifications, and planning for downstream development. The modification involves adding components such as a heating installation, timer, and pressure gauge. The power consumption of the heater needed to dimple parts at a temperature of 315°C is calculated to be 401.2 watts. Qualification tests on specimens made from 2024 T3 and 7075 T6—such as visual inspection, break tests, pry tests, and penetrant tests—show no cracks, scratches, or ruptures, and confirm that the dimpled parts meet the required standards. The results indicate that the modified portable hot dimpling machine is effective and suitable for implementation on the shop floor, offering a practical solution to PTDI's production challenges while adhering to the specifications outlined in BPS 4135.

Keywords: pneumatic squeezer CP-214, flange size, hot dimpling process, Bell specification BPS 4135, aerospace manufacturing

ABSTRAK

Dimpling sering digunakan dalam proses perivetan di industri manufaktur pesawat terbang, terutama untuk material dengan ketebalan lebih tipis dari kedalaman kepala rivet countersunk. Proses dimpling dapat dilakukan dengan dua metode, yaitu cold dimpling dan hot dimpling. Cold dimpling digunakan untuk material yang lebih lunak seperti aluminium seri 2000 atau 6000 pada kondisi perlakuan panas T3 atau T4, sementara hot dimpling digunakan untuk material yang lebih keras seperti aluminium seri 7000 pada kondisi T4 atau T6. Di PTDI, proses hot dimpling sangat bergantung pada mesin dimpling CP450, yang hanya dapat memproses bagian dengan flange minimal 20 mm, sementara untuk Program N-Bell 412 dibutuhkan bagian dengan flange minimal 15 mm. Untuk mengatasi kendala ini, dilakukan modifikasi pada pneumatic Squeezer CP-214 untuk menghasilkan mesin hot dimpling portabel yang dapat memproses bagian dengan flange minimal 12 mm. Modifikasi ini mengikuti Spesifikasi Proses Bell 4135 revisi B, yang mencakup penambahan komponen seperti rak troli, pemanas dengan rentang suhu hingga 350°C, sistem pengatur suhu, dan sistem pengatur tekanan kompresor dengan rentang 0-40 psi. Mesin yang dimodifikasi ini telah diuji dengan spesimen aluminium 2024 T3 dan 7075 T6 dan memenuhi standar kualitas yang diperlukan, tanpa adanya retakan atau kerusakan pada bagian dimple. Hasil uji kualifikasi menunjukkan bahwa mesin dimpling panas portabel yang dimodifikasi ini efektif, efisien, dan sesuai untuk diterapkan di lantai produksi PTDI, memberikan solusi praktis untuk tantangan produksi, serta memastikan kepatuhan terhadap spesifikasi BPS 4135.

Keywords: hot dimpling, squeezer CP-214, flange, spesifikasi Bell 4135, manufaktur pesawat

CHAPTER I INTRODUCTION

1. Background

Dimpling is a process of bending and stretching the inner holes edge in sheet metal parts. The inner holes edge is punched until its surrounding is expanded into a flange. Dimpling is applicable for sheets which not thick enough to work with a countersinking machine [1].

A dimpled hole is used where two or more sheets are riveted together. However, not all sheet metal can be dimpled at room temperature. As mentioned in BPS 4135 revision B, sheets made of aluminum alloys, clad or not, to accept rivets, screws, or other types of fasteners with the conic-shaped seating head, the sheets shall be dimpled at a specific temperature [2]. Therefore, hot dimpling process is mandatory for ductile sheets such as 2024 T6/T8 and 7075 T6 to prevent potential cracks [3].

At N-bell 412 Helicopter Program in PTDI, to accomplish new work packages, such as Bulkhead Assy. RH STA 63.68 (PN 205-030-246-101), Bulkhead Assy. LH STA 63.68 (PN 205-030-246-032), Door Assy. (PN 205-030-245-057) and Door Upper (PN 205-030-245-059), PTDI should deliver as many 12 chip sets each by the first quarter of 2020. However, until the second quarter of 2020, PTDI still could not reach the target because the hot dimpling process could not be performed. The actual condition on the shop floor shows that the existing stationary hot dimpling machine CP450 cannot dimple some parts with a short flange. This is because the flange size of the parts in the new work package is 15 mm, while the minimum flange that can be dimpled by CP450 is 20 mm (see Figure (1)).

Regarding to BPS 4135 revision B, an alternative dimpling process can be performed using a Squeezer CP214 with modified dies, where the minimum flange size that the squeezer CP214 can be dimpled is 12 mm. Therefore, an alternative solution is to modify the Squeezer CP214 into a portable hot dimpling machine.

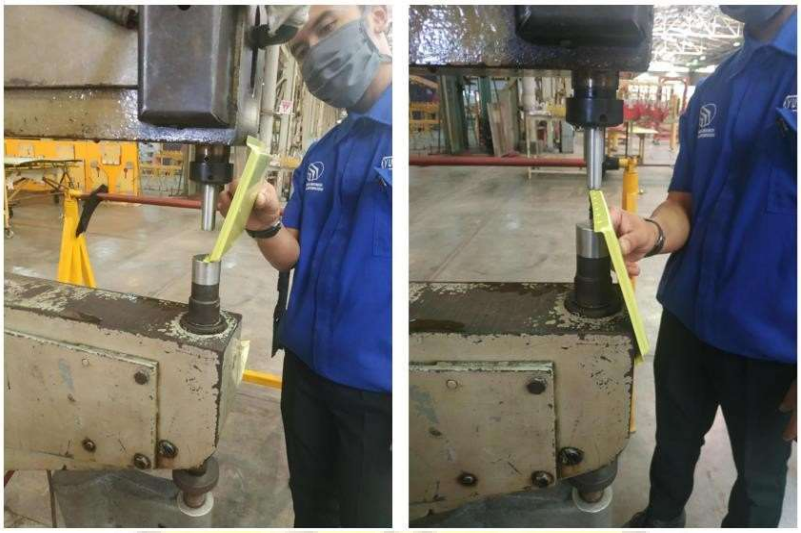

Figure 1 Dimpling trial using CP450 dimpling machine

2. Research questions

The research questions of this thesis are as follows:

- What steps are involved to design a Portable Hot Dimpling Machine.
- What additional components are required to modify the pneumatic Squeezer CP-214 into a Portable Hot Dimpling Machine.
- How much power consumption of the heater to dimple hole at a temperature of 315ºC.
- What qualification tests are needed for the machine to be implemented on the shop floor.

3. Research objectives

The research objectives of this thesis are as follows:

- To determine step by step prototyping process the pneumatic Squeezer CP214 from design to qualification.
- To modify the Squeezer Chicago Pneumatic CP-214 into a portable hot dimpling machine by adding components that align with the Bell Specification.
- To calculate power consumption of the heater to dimple part at a temperature of 315 degrees Celsius.
- To test the machine with a destructive and a non-destructive test.

4. Research purposes

The potential benefits of this thesis are as follows:

- For Students: Provide hands-on experience in mechanical design, prototyping, and machine modification within the context of manufacturing and aerospace engineering.
- For Science: Contribute to the body of knowledge on material deformation, specifically regarding hot dimpling processes, which is critical for sheet metal forming in aerospace applications.
- For Academic Institutions: Strengthen the collaboration between academic institutions and industry by addressing practical, industry-driven problems in manufacturing, particularly in aerospace.
- For Industry: Offer a cost-effective solution for PTDI and similar aerospace manufacturers facing challenges with machine capabilities, helping to increase production efficiency and meet manufacturing targets.

5. Research scopes

The research scopes of this thesis are as follows:

- This project is limited and focused on designing a portable hot dimpling machine for contoured parts in the N-Bell component assembly area.
- The limitation of the portable hot dimpling machine specification is under “Bell Process Specification for Dimpling of Aluminum, Magnesium, Stainless Steel and Titanium” revision “B”.

6. Writing systematic

The writing systematic of this thesis is as follows:

- CHAPTER 1 INTRODUCTION: The introduction provides the purpose for why the project “Design of Portable Hot Dimpling Machine for Aerostructure Contoured Part of N-Bell Assembly Program by Using Squeezer Chicago Pneumatic CP-214” is necessary. This chapter consists of research background, objectives, aims, and constraints concerning the project.
- CHAPTER 2 LITERATURE REVIEW: Literature review is to place the research study within the larger whole of dimpling has been studied in the past to grasp the key arguments underpinning the project.

- CHAPTER 3 METHODOLOGY: The objective of this section of the research proposal is to convince the overall research design and methods of analysis is able to solve the problem in N-Bell assembly area that have identified and also enable to accurately and effectively interpret the results of the project.
- CHAPTER 4 DESIGN AND MODELING: This chapter explains the whole design of portable hot dimpling machine for aerostructure contoured part of N-Bell assembly program by using squeezer Chicago pneumatic CP-214.
- CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS: This chapter contains the final result, potential significance, and recommendations towards the project.

CHAPTER V CONCLUSION AND RECOMMENDATION

1. Conclusion

The conclusions drawn from this thesis are:

- For designing a portable hot dimpling machine, the steps are: identifying the shop floor needs, establish target specification, generating product concept, selecting product concept, testing product concept, setting final specification and planning downstream development.
- According to BPS 4135, the modification for the pneumatic Squeezer CP-214 is to add component such as heating installation, timer, pressure gauge, etc.
- The power consumption of the heater to dimple hole at a temperature of 315^{o}C is 401,2 Watt.
- The portable hot dimpling machine is acceptable to be implemented in the shop floor, because:
  - According to visual test result towards specimen 2024 T3 and 7075 T62 is not found any cracks, scratch or rupture indication.
  - According to break test result towards specimen 2024 T3 and 7075 T62 the rupture is straight around the dimple diameter and not found extended crack.
  - According to pry test result towards specimen 2024 T3 and 7075 T62 is found no uneven rupture as to the dimple diameter & no shear cracks.
  - According to penetrant test result towards specimen 2024 T3 cold dimpling and 7075 T62 hot dimpling is not found any indication.

2. Recommendation

The recommendations that can be derived from this thesis are:

- Upgrade or modify the single heater become double heaters to reduce dwell time.
- Establish a spare parts management system to ensure the availability of critical components when needed.
- Re-modify machine if needed so that the machine can be applied in general usage.

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