Ergonomics Intervention in Mould Handling Task at a Manufacturing Company

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ABSTRACT

An ergonomics intervention was conducted at a manufacturing company based on results from previous ergonomics risk assessment conducted. One of the main concerns was at Injection Moulding Process which involves pushing and pulling the stacker to transport the 300kg – 500kg mould during installation and maintenance activities. The assessments were conducted on both old equipment (stacker) and new equipment (a mobile gantry crane). Two assessment tools were applied to assess the risk for both material handling equipment namely direct push/pull force using Push Pull Guage (Model: Hoggan ErgoFet–300) and paper-based tool called Risk Assessment of Pushing and Pulling (RAPP) tool developed by Health and Safety Executive, United Kingdom. The results were collected and compared. Based on the result, the improvement has been successful implemented where the force required to be exerted has significantly being reduce when using a new material handling equipment, the mobile gantry crane, compare to the old material handling equipment, the stacker. RAPP Tool assessment results also align with this outcome.

Keywords: Ergonomics Intervention, Ergonomics Risk Assessment

1. INTRODUCTION

Ergonomics plays a critical role in mould handling tasks, where workers are often exposed to high physical demands. The main activities involve pushing and pulling manual handling equipment (e.g. stacker etc) to transport the mould besides other activities such as using overhead crane or mobile hydraulic crane to transfer the mould and manually dismantle and handle heavy mould parts. Studies shows that pushing and pulling activities can generate significant biomechanical loads on the shoulders, lower back, and upper limbs [1][2][3]. Ergonomic interventions are essential to minimize these loads, reduce fatigue, and prevent injuries.

An ergonomics intervention was conducted at a manufacturing company based on results from previous ergonomics risk assessment conducted. One of the main concerns was at Injection Moulding Process which involves pushing and pulling the stacker to transport the 300kg – 500kg mould during installation and maintenance. Results from ergonomics risk assessment showed that pushing and pulling forces were measured exceeded the recommend forces.

As an improvement strategy, the company has bought a new material handling equipment to transport the mould, a mobile gantry crane (500kg 'A' Shape Portal Crane). The specification of the crane as shown in **Table 1**.

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Table 1: 500kg 'A' Shape Portal Crane (with Electric Chain Hoist)

Brand / Origin:	Kt / Taiwan
Model:	Ktch005e
Capacity:	500kg
Lifting Height:	5 Meters
Lifting Speed:	4.7m/Min @1.5kw@35%Ed@Single Speed
Travelling Speed:	Manual (Akita/Japan 0.5ton Plain Trolley)
Power Supply:	Single Phase, 220v, 50hz
Control Voltage:	48v
Control Type:	Push Button Pendant Suspended From The Hoist

2. METHODOLOGY

The main aim of this assessment is to re-assess the risk of the pushing and pulling tasks after the improvement had been implemented by replacing the stacker with mobile gantry crane. Three (3) male workers involved in this assessment. Summary of their background are as shown in **Table 2**.

Table 2: Summary of workers' background

Category	Range
Gender	Male
Age	25 - 29 years old
Height	163cm – 172cm
Weight	57kg – 76kg
Experience	1 – 7 years

The pushing and pulling tasks using the stacker (**Figure 1a**) and mobile gantry crane (**Figure 1b**) to move/transport the 300kg-500kg mould for maintenance and installation at the injection moulding machine were assessed and the results were compared.

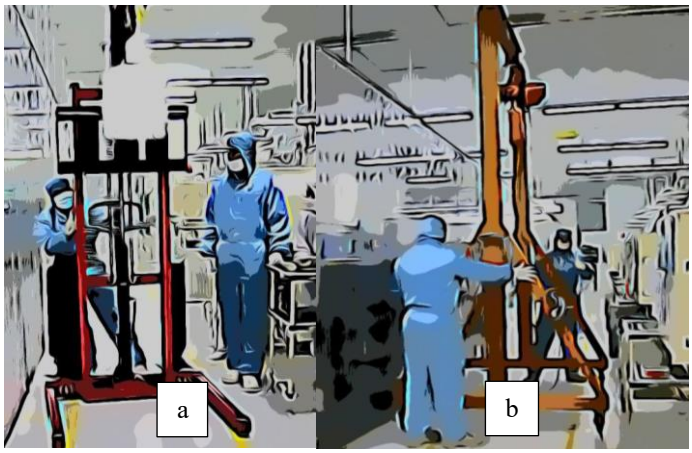

Figure 1: Pushing and pulling task to move the mould

Two assessment tools were applied to assess the risk for both material handling equipment. The first assessment tool use was direct measurement for the force being applied for both pulling and pushing activities to move the mould for both material handling equipment. The second tool, Risk Assessment of Pushing and Pulling (RAPP) tool developed by Health and Safety Executive, United Kingdom [4] was used to assess the same task for both material handling equipment.

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2.1 Direct Measurement

The assessment was conducted by comparing the measured push and pull forces with the recommended force by DOSH Guidelines on Ergonomics Risk Assessment at Workplace 2017 and HSE-UK guidelines on pushing and pulling task.

The push and pull force were measured using the following equipment a digital push-pull force gauge produced by Hoggan Scientific LLC (US), model *Hoggan ErgoFet – 300* (**Figure 2**) with the capability of maximum force load capacity of 300lbs (135kgf). **Figure 3** shows example the measurement of pushing and pulling during assessment.

Figure 2: Hoggan ErgoFet 300 push-pull force gauge

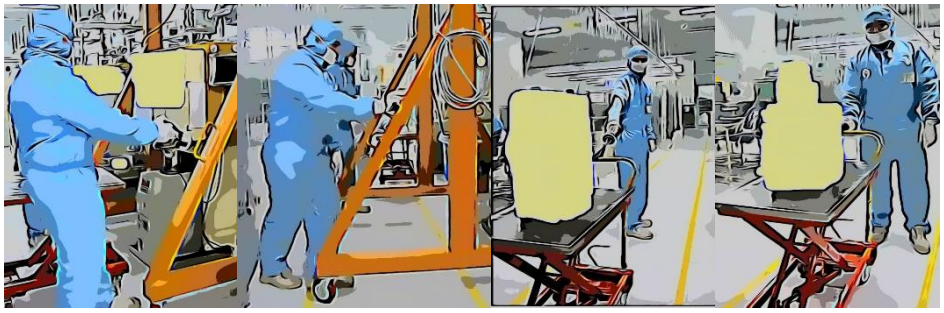

Figure 3: Example of pushing and pulling force measured during assessment

For comparison, only initial force was measured because for the old stacker, distance travelled during installation or maintenance of the mould were too close (about 4ft). It was observed the worker needs to keep push and pull to turn the stacker to required position. In addition, for record purpose, some other data were collected during assessment.

2.2 Risk Assessment for Pushing and Pulling (RAPP) Tool

RAPP tool was used to assess both pushing and pulling using stacker and mobile gantry crane. This tool is designed to help assess the risks in manual pushing and pulling operations involving whole-body effort such as moving loaded trolleys and etc [4]. RAPP can be used to assess both moving loads on wheeled equipment and moving loads without wheels. For this assessment, moving loads on wheels were applied.

The total scores help prioritize those activities/operations that need most urgent attention and help check the effectiveness of any risk-reduction measures. The colour bands help determine which risk factors of the operation require attention. The scores can be used for comparison purposes. **Figure 4** shows the level of risk and score interpretation for RAPP Tool.

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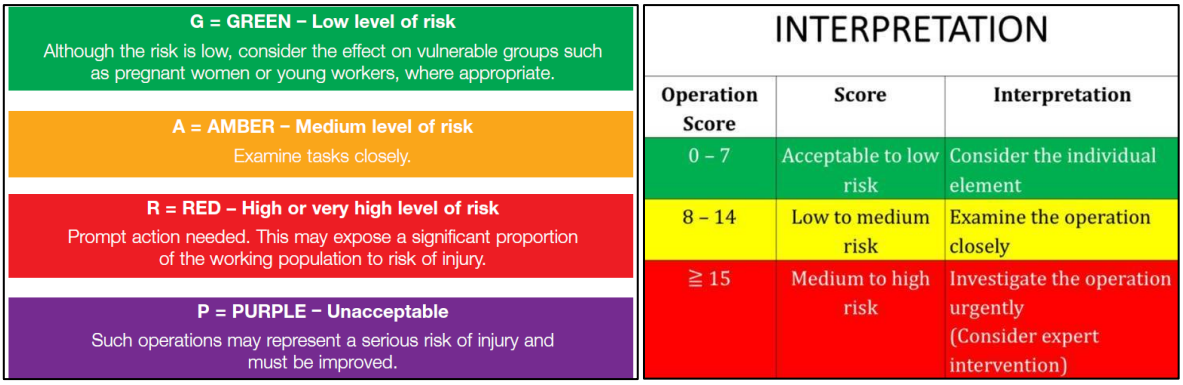

INTERPRETATION

Operation Score	Score	Interpretation
0 – 7	Acceptable to low risk	Consider the individual element
8 – 14	Low to medium risk	Examine the operation closely
≧ 15	Medium to high risk	Investigate the operation urgently (Consider expert intervention)

Figure 4: Level of risk and score interpretation

3. RESULTS

Table 3 showed the comparison results between stacker and mobile gantry crane. The followings are the summary of the **Table 3** results.

a) Stacker requires higher force compare to mobile gantry crane due to direction of the movement and obstacles. Stacker requires to turn while mobile gantry crane is not.
b) It is easier to lift the mould using electric powered chain block at the mobile gantry crane compared to the foot pumping on the stacker.
c) The stacker requires only 1 worker to operate. On the other hand, mobile gantry crane requires 2 workers
d) Initial force for both pushing and pulling using stacker exceed the recommended value (based on HSE UK, Guidelines on Ergonomics Risk Assessment at Workplace 2017) and on the other hand, mobile gantry crane require significantly less forces.
e) RAPP score for stacker is 12 (Medium Risk) while for mobile gantry crane is 2 (Low Risk)

It was found the measured force during assessment were higher compared to recommended value. Please refers to **Table 3** for details.

In addition, force for pushing and pulling trolley carrying the mould from the mould room before being transferred on to stacker or the new mobile gantry crane was also measured (**Figure 6**). The results for initial force is less than the recommended force of 200N (approx. 20kgf). The actual measured for were 13.6kgf for pulling and 18.4kgf for pushing. Similarly, result for force to keep in motion was 7.1kgf which is less than recommended 100N (approx. 10kgf).

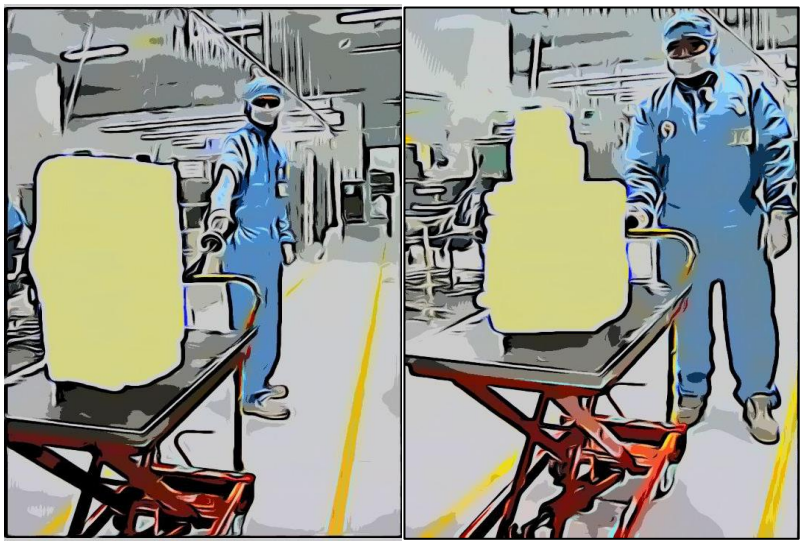

Figure 6: Measuring pulling and pushing forces for trolley carrying mould

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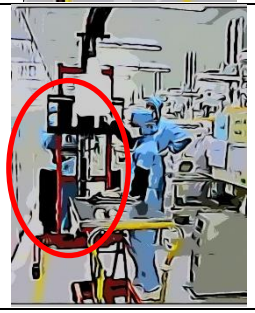
Table 3: Comparison results between pushing and pulling tasks using stacker and mobile gantry crane

	Description	Stacker		Mobile Gantry Crane	
1	Route and direction of movement	Involved pushing and pulling in very short distance while turning the stacker to align with the machine. Body of the worker show it's a very hard. Furthermore, smaller casters also contributed and make it more difficult.		Involve only pushing and pulling in one direction. There no turning involved.	
2	Lifting and lowering the mould	Using foot pump to lift the mould. The body reaction when performing the task can be observed and complain from workers on the significant effort required when pumping to lift the mould.		Using electric powered chain block.	
3	Number of workers	1		2	
4	Initial force measured (with mould) Recommended force = less than **20Kgf [5], [6]**	Push: **37.4**Kgf – **39**kgf Pull: **36**Kgf – **40**kgf For two-person push – **21**kgf-**23**kgf Two-person pull were not possible due to space restriction and the handle size and shape.		Push: **6.5**kgf – **14.7**kgf Pull: **7.9**kgf – **14.5**kgf ***Reasons for huge range:*** Orientation of the casters before pulling or pushing – if the casters facing toward moving direction, it will require lower force compare to the other direction or the casters turn halfway • Timing to pull or push – if the other person already started to pull/push and it's it started to move, it will result in lower force for the other person. • Power cable may affect pulling force if the wheel touches the cable	
5	RAPP Score	**12 (MEDIUM RISK)**		**2 (LOW RISK)**	

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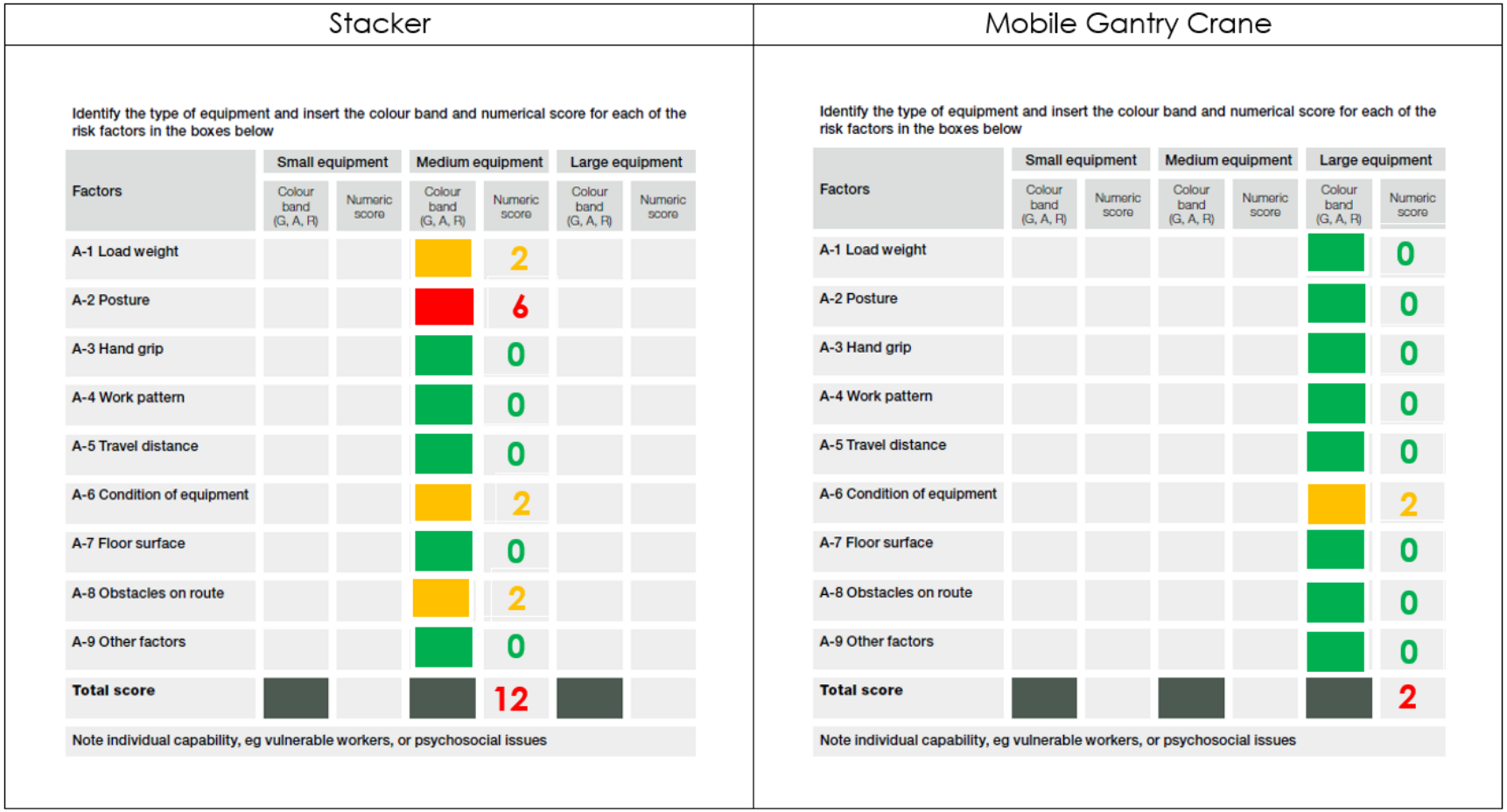
Based on results from RAPP assessment (Figure 5), stacker has higher risk especially on posture component when performing the task. This is largely due to the weight being handle, the condition of the equipment especially small casters, and the requirement to turn while aligning the stacker to the machine. On the other hand, only load weight is the slightly concern for the mobile gantry crane.



Stacker

Identify the type of equipment and insert the colour band and numerical score for each of the risk factors in the boxes below

Factors	Small equipment		Medium equipment		Large equipment	
	Colour band (G, A, R)	Numeric score	Colour band (G, A, R)	Numeric score	Colour band (G, A, R)	Numeric score
A-1 Load weight				2		
A-2 Posture				6		
A-3 Hand grip				0		
A-4 Work pattern				0		
A-5 Travel distance				0		
A-6 Condition of equipment				2		
A-7 Floor surface				0		
A-8 Obstacles on route				2		
A-9 Other factors				0		
Total score				12		

Note individual capability, eg vulnerable workers, or psychosocial issues

Mobile Gantry Crane

Identify the type of equipment and insert the colour band and numerical score for each of the risk factors in the boxes below

Factors	Small equipment		Medium equipment		Large equipment	
	Colour band (G, A, R)	Numeric score	Colour band (G, A, R)	Numeric score	Colour band (G, A, R)	Numeric score
A-1 Load weight						0
A-2 Posture						0
A-3 Hand grip						0
A-4 Work pattern						0
A-5 Travel distance						0
A-6 Condition of equipment						2
A-7 Floor surface						0
A-8 Obstacles on route						0
A-9 Other factors						0
Total score						2

Note individual capability, eg vulnerable workers, or psychosocial issues

Figure 5: Comparison of results between stacker and mobile gantry crane using RAPP Tool

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4. CONCLUSION

In conclusion, the improvement has been successful implemented where the force required to be exerted has significantly being reduced when using a new material handling equipment, the mobile gantry crane, compared to the old material handling equipment, the stacker. RAPP Tool assessment results also aligned with this outcome.

Based on the feedback from worker, the task becomes a lot easier and it require less force and efforts compare to previous material handling equipment.

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