OPTIMIZING EQUIPMENT CONVERSION SETUP & RECIPE RELEASES

IE3100M/ IE3100R SYSTEMS DESIGN PROJECT AY2020/21
DEPARTMENT OF INDUSTRIAL SYSTEMS ENGINEERING & MANAGEMENT
GROUP MEMBERS: DAI XINA, HOKIEWAN THEZEUS, KERK ZHI SHENG, HENG DINGWEN, WAYNE
SDP SUPERVISOR: DR CHAI KAH HIN
MICRON SUPERVISORS: MR BRANDON LEE HOWE KWAN, MR CARLO RYAN LORENZO, MR EDWARD LOE SEN LIM

01 PROJECT DESCRIPTION

IN A BACK-END SEMICONDUCTOR MANUFACTURING PLANT, ONE OF THE MAJOR WASTES OF PRODUCTIVE TIME CAN BE ATTRIBUTED TO EQUIPMENT CONVERSION SET-UPS. SUCH CONVERSIONS ARE HIGHLY TRIGGERED BY THE DIE-ATTACH ('DA') AND WIRE-BOND ('WB') EQUIPMENT DUE TO THE DIFFERENT PRODUCT SPECIFICATIONS REQUIREMENTS AND THE NUMEROUS SUB-PROCESSES NEEDED. EACH OF THESE CONVERSIONS CONSUME A SIGNIFICANT AMOUNT OF TIME AND THUS IMPEDES THE OVERALL PRODUCTION RATE. CURRENTLY, A TEAM OF EMPLOYEES HAS BEEN TASKED TO PLAN THE EQUIPMENT CONVERSION MANUALLY.

OBJECTIVES

- OPTIMIZE EQUIPMENT CONVERSIONS
- REDUCE CYCLE TIME AND THUS INCREASE FACTORY OUTPUT
- IMPROVE WORKSTATION BALANCING
- REDUCE MANUAL LABOUR AND DIGITALIZE PLANNING PROCESS

METHODOLOGY

PROBLEM DEFINED → DATA ANALYSIS → SOLUTION MODELLING → OPTIMIZING MODEL → OUTPUT RESULTS

02 PROBLEM BACKGROUND

PROCESS FLOW

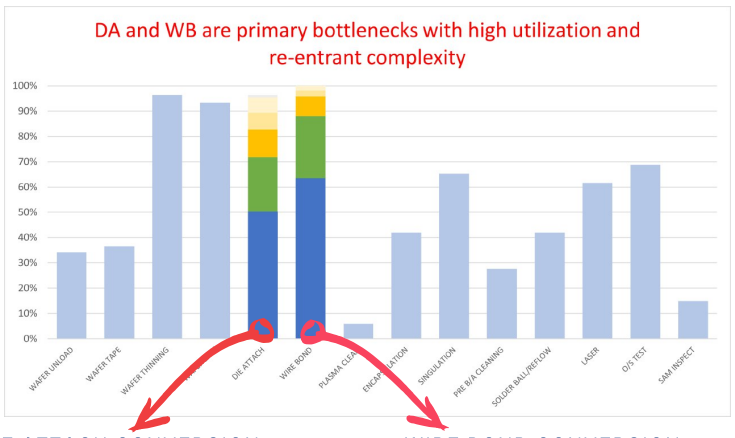
GENERATE SUPPLY SOLVE BASED ON DEMAND → FIRMING PLANNED ORDERS → SEQUENCING - REVIEW FIRMED ORDERS → CREATE PRODUCTION ORDERS + EXECUTION

CURRENT ISSUES

MANUAL PLANNING PROCESS

- 88 MAN-HOURS PER WEEK IS REQUIRED TO COMPUTING 1 DAILY COMMIT
- HIGH WASTE (PRODUCTIVE TIME) DUE TO EQUIPMENT CONVERSIONS

PROBLEM IDENTIFICATION

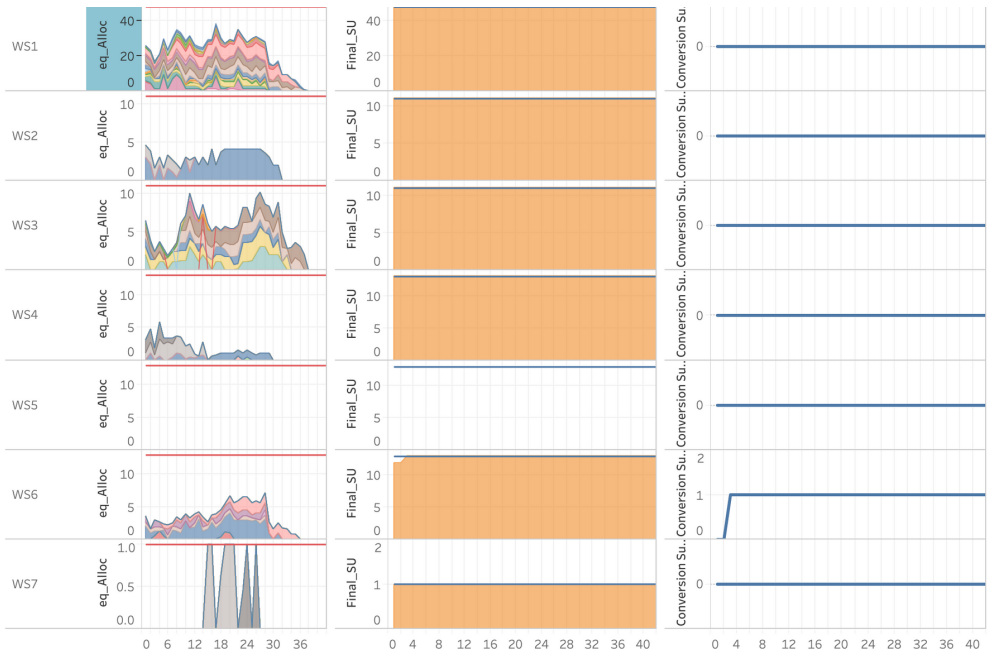


DIE ATTACH CONVERSION **240 MINS** VS. WIRE BOND CONVERSION **40 MINS**

THUS, THE PROJECT FOCUS TO OPTIMIZE DIE-ATTACH CONVERSIONS AS IT WILL MAKE MORE SIGNIFICANT IMPACT ON THE PRODUCTION RATE

03 RESULTS

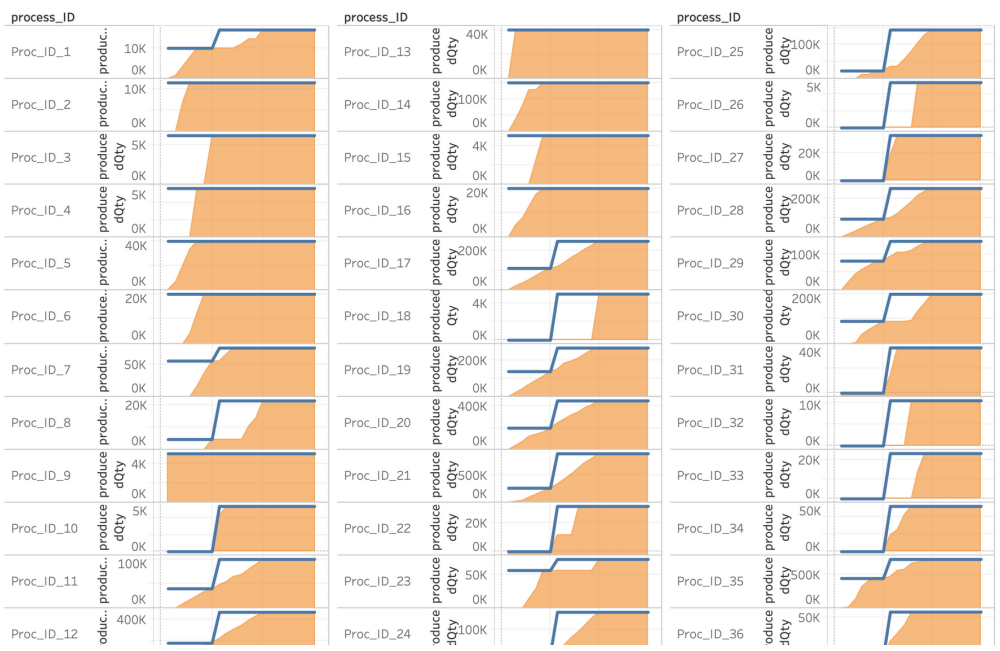
EQUIPMENT ALLOCATION



MODEL

- Y-AXIS OF LEFT GRAPH SHOWS HOW MUCH EQUIPMENT WE NEED, AND RED LINE REPRESENTS THE MAXIMUM NUMBER OF EQUIPMENT WE HAVE IN THAT WORKSTATION
- NUMBER OF EQUIPMENT UTILIZED IS WITHIN THE POSSIBLE RANGE OF CURRENT NUMBER OF EQUIPMENT

PRODUCED VS PLANNED OUTPUT



MODEL

- CUMULATIVE SUM OF DAILY COMMITS (ORANGE) MATCHES MODEL'S GENERATED PLANNED ORDER (BLUE LINE)
- THE GENTLE SLOPES OF THE ORANGE AREA REPRESENTS A SMOOTH DEMAND SIGNAL, WHICH HELPS TO DECREASE EQUIPMENT CONVERSIONS

06 MATHEMATICAL MODEL

OBJECTIVE FUNCTION:

MINIMIZE CONVERSION AND WIP DEVIATION FROM PRODUCTION ORDER

min cost=

$$\sum_w \sum_p \sum_s \sum_{sh} Conv_{w,p,s,sh} * weight\_Conv_{w,p,s,sh}$$

$$+ \sum_p \sum_{we} Above\_PO_{p,we} * weight\_Above\_PO_{p,we}$$

$$+ \sum_p \sum_{we} Below\_PO_{p,we} * weight\_Below\_PO_{p,we}$$

CONSTRAINT #1:

EQUIPMENT CAPACITY LIMIT

$$\sum_w Final\_SU_{w,p,1,sh} >= min\_Eq\_Count_p$$

$$\sum_w Final\_SU_{w,p,1,sh} <= max\_Eq\_Count_p$$

$$\sum_{p,s} Final\_SU_{w,p,s,sh} <= eq\_Count_w$$

CONSTRAINT #2:

EQUIPMENT CONVERSION PER SHIFT LIMIT

$$\sum_{w,p,s} Conv_{w,p,s,sh} <= dA\_Conv\_Count$$

FORMULATION #1:

CAPTURE WIP DEVIATION FROM PRODUCTION ORDER

if (we > 1) {

$$real\_PO_{p,we} + Above\_PO_{p,we} - Below\_PO_{p,we} ==$$
$$\sum_{da \in [7*(we-1),7*we]} (WIP_{p,1,2*da-1} + WIP_{p,1,2*da})$$
$$+ Above\_PO_{p,we-1} - Below\_PO_{p,we-1}$$

}else{

$$real\_PO_{p,we} + Above\_PO_{p,we} - Below\_PO_{p,we} ==$$
$$\sum_{da \in [7*(we-1),7*we]} (WIP_{p,1,2*da-1} + WIP_{p,1,2*da})$$

FORMULATION #2:

ENSURE ALL WIP MATCHED AT EACH STEP

if (s < last_Step_ID$_p$){

if (sh+step_Cycle$_{p,s}$ <= 42){

$$WIP_{p,s,sh} == WIP_{p,s+1,sh+step\_Cycle_{p,s}}$$

}

$$WIP_{p,s,sh} ==$$
$$((\sum_w Eq\_Alloc_{w,p,s,sh} * util\_rate_{w,p}) * 3600 * 12) * reverse\_takt\_time_{w,p,s}$$

FORMULATION #3:

CAPTURE EQUIPMENT CONVERSION OCCURANCE

if (sh > 1){

$$Eq\_Alloc_{w,p,s,sh} <= Final\_SU_{w,p,s,sh-1} + Conv_{w,p,s,sh}$$

} else {

$$Eq\_Alloc_{w,p,s,sh} <= initial\_SU_{w,p,s,sh} + Conv_{w,p,s,sh}$$

}

$$\sum_{p,s} Conv_{w,p,s,sh} == \sum_{p,s} Reduce\_Eq_{w,p,s,sh}$$

FORMUATION #4:

CAPTURE EQUIPMENT SET-UP AFTER EVERY SHIFT

if (sh > 1){

$$Final\_SU_{w,p,s,sh} <= Final\_SU_{w,p,s,sh-1} + Conv_{w,p,s,sh} - Reduce\_Eq_{w,p,s,sh}$$

} else {

$$Final\_SU_{w,p,s,sh} <= initial\_SU_{w,p,s,sh} + Conv_{w,p,s,sh} - Reduce\_Eq_{w,p,s,sh}$$

RECOMMENDATIONS

- SCHEDULER BE ADAPTABLE WITH MORE VARIABILITIES & CONSTRAINTS
- REDUCED MANUAL LABOR COSTS & PRODUCTIVE TIME
- IMPROVE THE CURRENT MODEL TO INCLUDE WIRE BOND STEP CONSTRAINTS
- EXPAND THE USAGE OF THE MODEL TO OTHER OVERSEAS MICRON FACTORIES

TECHNICAL SKILLSETS

- LEAN MANUFACTURING
- MATHEMATICAL MODELLING
- OPERATIONS RESEARCH
- DATA VISUALIZATION
- DATA ANALYSIS
- SYSTEMS THINKING