High Definition Manufacturing Cell Model

Wayne Wakeland
Portland State University, wakeland@pdx.edu

Leupold & Stevens, Inc.

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High Definition Manufacturing Cell Model

Wayne Wakeland
Leupold & Stevens, Inc.
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Model Summary

- Four CNC turning centers
- Plus several smaller pieces of equipment for deburring and finishing
- Purpose was to study:
  - Capacity
  - Staffing requirements
  - Alternative equipment configurations
Model Level of Detail

- Simulates the manufacture of 20 different parts
  - From 8 different sizes of bar stocks/extrusions
- Each part has a unique routing through the cell
  - Some parts require extra deburring or finishing steps
  - Others do not
One possible finishing process shown to be a bottleneck regardless of staffing levels
- Tumbling followed by bead blast
This further motivated the search for alternative processes
- An alternative process was found
- The model showed it would not be a bottleneck
The model also showed that three operators could run the cell
- Contrary to expectations of process engineer
- Later validated in actual operation
Leupold & Stevens

• Leading manufacturer of high quality riflescopes
  • Used by hunters and competitive shooters
• Founded in 1907
  • Began producing current line of products in 1947
• Currently exploring Lean manufacturing
  • After decades of using traditional batch processing
    • where parts are manufactured and finished in large batches
    • and stored in a stockroom before being issued to final assembly work orders
A New Product, the CQT, was being Developed

- Became a demonstration product for Lean manufacturing
- Substantial investment
  - Unique metal parts to be built on a daily basis...
  - In response to the immediate assembly needs
- After fabrication in the CNC turning center, parts also require additional operations
  - To achieve the desired surface finish
  - Some of this processing is done within the cell
Potential Process Bottleneck

- After fabrication and partial finishing, parts then go to a subcontractor
  - Located 17 miles away
  - Who “anodizes” the parts
  - To make the aluminum black and tougher
- Two to three days later, the parts return
- They are built into finished products within another two or three days
Throughput Goal

- One week
  - From barstock to finished product
- Very aggressive
  - Since historical throughput times range from 6-10 weeks
Would it be feasible to build one day’s worth of parts every day?

By setting up a highly efficient “rotation” through the parts

There was concern about the finishing process for the external parts

Called “tumbling”

Would this prove to be a major bottleneck?
Modeling Challenges A

- To write a substantial subroutine
- That simulates the actual cutting of parts from raw material
  - loading another bar stock when needed
  - changing to the next part number once the daily quantity is completed
  - determining whether or not the next part requires a material change
  - etc.
Modeling Challenges B

- To enhance the processing logic
  - So that the model can run through the parts rotation forwards or backwards
    - as is done in the real world
    - to avoid a part changeover at the start of each rotation

- To correctly specify the priority logic
  - To indicate which tasks are done by each resource
Additional model features

- Realistic animation
  - Not just for the operators as they carry out the various tasks
  - But also for the trays of parts as they are processed
  - And accumulate, prior to going to the subcontractor

- Spreadsheet data links
  - For process cycle times, setup times, and material consumption amounts
  - To allow for the possibility of live linkages to the process data stored in the company’s MRP system
IF OWNEDRESOURCE() < 1 THEN GET RES_G200 OR RES_Flex

IF V_NEWPN = 1 THEN  //need to do changeover
{
    WAIT ARR_G200ChgOvrTimes[V_PN + V_Offset]
    V_G200ChgOvrTime = V_G200ChgOvrTime + ARR_G200ChgOvrTimes[V_PN + V_Offset]
    A_Length = A_Length - ARR_G200SetupPartsPerChg[V_PN] * ARR_G200FTPerPart[V_PN]
    V_NewPN = 0
}
ELSE WAIT M_BarChgTime

IF V_PN = 10 THEN SEND 1 ENT_PSExtrusion TO LOC_BarPrepPSR
FREE ALL

startofloop:
    IF V_QtyBuilt < M_KANBANQty THEN
    {
        IF A_Length < M_MinBarLength + ARR_G200FTPerPart[V_PN] THEN
        {
            ROUTE 1
            RETURN
        }
    }
}
ELSE
{
    V_PN = V_PN + V_Dir  // get ready to make next part
    V_QtyBuilt = 0
    IF V_PN = 0 THEN GOTO done
    IF V_PN > 1 THEN IF ARR_G200LastPart[V_PN - 1] = 1 THEN GOTO done
    IF ARR_G200NewMtl[V_PN + V_Offset] = 1 THEN
    {
        V_NewPN = 1
        V_Route = ARR_G200StartVRoute[V_PN]
        ROUTE 2 +V_Offset  //need to do changeover; offset is added
        RETURN
    }
    ELSE
V_Route = V_Route + V_Dir    // increment or decrement which route to take

IF A_Length < M_MinBarLength + ARR_G200SetupPartsPerChg[V_PN] * ARR_G200FTPerPart[V_PN] THEN
{
    V_NewPN = 0    //bar is not long enough to setup new part, need to get another bar
    ROUTE 1
    RETURN
}
ELSE
{
    GET RES_G200 OR RES_Flex     //bar is long enough to do changeover
    WAIT ARR_G200ChgOvrTimes[V_PN + V_Offset]
    V_G200ChgOvrTime = V_G200ChgOvrTime + ARR_G200ChgOvrTime
    A_Length = A_Length - ARR_G200SetupPartsPerChg[V_PN] * ARR_G200FTPerPart[V_PN]
    FREE ALL
    SUB_G200MakePart()
GOTO startofloop

done:     //should get here only if done with a day's schedule
V_G200_On = 0
V_G200_Done = CLOCK(HR)
WAIT UNTIL V_G200_On = 1
V_DIR = V_Dir * (-1)
V_PN = V_PN + V_Dir
IF V_Offset = 0 THEN V_Offset = 1 ELSE V_Offset = 0
V_NewPN = 0
WAIT 1   // so as to not grab worker before they can unload the last handful
GOTO startofloop
Model Validation

- Modeler and process engineer carefully watched the animation to assure that:
  - Each part is correctly routed
  - Operators perform the work in the correct sequence
- Variables included to allow collection of data needed for validation
- Many potential problems identified & corrected
  - E.g., with the resource/priority specifications in the operation/routing logic
Initial Results: Tumbling Not Good

- Modeling the tumbler was a challenge
  - It contained four cylinders, but only one door
  - The cylinders rotated, with one of them being at the door position at any given time
  - Further, the media in the tumbler had to be washed after every other tumbling run
- The model clearly showed that this would be a major bottleneck
  - And, further, that the problem could not be resolved through optimal operator behavior
- The process was abandoned.
Enter “Shot Peening”

- A different finishing process,
  - Identified by the Manufacturing Engineer
- Much easier to model this process
  - Was quickly shown to be vastly superior
- The equipment was ordered
- The process has proven not to be a bottleneck operation
Staffing Analysis Results

- Three operators should be able run the cell effectively
  - Assuming that the part changeovers could be done in the prescribed time
  - Operators would be kept quite busy, however
    - perhaps busier than their counterparts in the rest of the factory
- Four operators were hired
  - To be on the safe side
- During subsequent months, the production cell often had to run with only three operators
  - They were able to do so quite effectively
Was Daily Part Rotation Feasible?

- The model clearly said No
- This same conclusion was reached using spreadsheet analysis
  - But seeing it in the model was more compelling
- It also showed that a 2-day rotation would work
  - The rotation could be accomplished by running two days worth of parts at a time
  - The process engineer knew that this was theoretically possible
  - But seeing the model results increased his confidence that it could actually be done
- Subsequent operations validated this result
Sample Model Results

- Resource Utilization %
  - RES G300 68.52
  - RES G200 52.54
  - RES ABC 55.37
  - RES Flex 84.73
  - RES G300S 42.70
One Year Later

- Model resurrected to evaluate a swing shift to increase capacity
- Model had to be enhanced significantly
  - Because swing shift would have less operators
  - And would have different objectives
- Management objective: explore alternative staffing and operating rules
  - How many operators would be needed?
  - Should all three primary machines be run at once?
  - Or, should only two machines be run at a time?
More Modeling Challenges

- To update the priority logic to accommodate two shifts with different staffing levels
  - Different operators perform the tasks on swing shift compared to day shift
  - Thus, the resources used on day and swing had to be different
  - And, much of the operation and routing logic had to be modified

- It was difficult to get the downtime logic to work correctly for Locations
  - Resource downtimes worked fine
More Model Validation

- The addition of second shift logic required careful re-validation
  - To assure that parts continued to move realistically
  - The previous validation done for day shift logic was irrelevant and had to be repeated
    - Since totally different resources are used on the second shift
Second Shift Analysis Results

- Two operators would need to run all three machines for a couple of hours
  - But would only need to run two machines for most of the shift.

- One operator could almost, but not quite, run the cell by himself
  - With only slightly reduced output
  - Giving an indication of what could be done when one second shift operator is not available

- Overall, the parts manufacturing cell would have some excess capacity