The potential material factor causing not connected and shrinkage product that able to be controlled is too frequent of molten bronze pouring. Meanwhile, cold air and wet sand mold factors unable to be controlled. From the branch of method, there is a potential problem of unmatched mold dimension and molten bronze volume. From those two controllable problems, can be concluded that the potential root cause of not connected and shrinkage product is no calculation of frequency optimization on bronze pouring liquid volume used as standards in the production process.

The potential factors of porous surface are the existence of impurities in the molten metal (sand, resin, or other elements) and the existence of metal tensile strength. Therefore, the process that need to be evaluated is the bronze smelting process which can be contaminated by unwanted elements.

Based on Fig. 6, the potential factors of broken whorl are the poor quality of tapping machine lubricant, worn-out whorl gauge and shaky tapping knife. The maintenance system of the company's machine, especially the tapping machine, should be concerned. Company need to find out the most effective and eficient system that can prevent tear or irregularities on the machine.

The potential factors of skewed product are not asymmetric mold pattern, loose stopper, shifting sand mold in the area of bronze smelt foundry, unfit sand mold, and broken sand mold when pouring molten bronze. Of the factors causing skewed product, the important factor is the sand mold used to form the products. In addition, the factors that could be the root causes are the lack of standard quality control on the sand mold and lack of method to prevent the production of unsatisfactory sand mold.

## IV. CONSCLUSIONS AND FUTURE RESEARCH

This study used MNP chart for multi-attribute quality control (seven correlated defect characteristics) that were divided into two phases, i.e. Phase I and Phase II. In the first phase, it was obtained in-control condition, so that the control limit of MNP chart of Phase I can be used in the Phase II. In Phase II, it was found five out-of-control points which indicates there is out-of-control process. Therefore, it is necessary to identify the defect characteristics that is being the main contributor by calculating the Z statistic score. From the calculation results, the defect characteristics obtained as the main contributor by selecting the largest positive Z score for each out-of-control sample.

From the defect characteristics that have been analyzed, the factors that need to be considered to keep the company's production process remain in-control conditions are as follows: (1) the need of frequency optimization calculations along for bronze pouring liquid volume to be used as standards in the production process, (2) evaluation of bronze smelting process that is still accessible to unwanted elements, (3) effective and efficient machines maintenance system to prevent tear or irregularities on the machine, (4) the need of specific quality control in the sand forming to make sand molds as per the specifications and prevent such nonconformance affects the subsequent production process.

The problem on certain assumptions such as the possibility of autocorrelated processes, as often happens in the case of time series data, is still ignored in this study. Therefore, further studies are expected to incorporate these assumptions into research and anticipate the negative effect of autocorrelation in the control chart. Further research is also expected to compare several multi-attribute control chart that already exists in terms of effectiveness and sensitivity in identifying the out-of-control.

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