出國報告（出國類別：其他）

2017 年第 2 屆自動化與控制及機器人工程國際研討會
(2017 2nd International Conference on Automation, Control and Robotics Engineering, CACRE 2017)

服務機關：國立虎尾科技大學

姓名職稱：阮岱珈副教授

派赴國家：捷克布拉格

出國期間：106 年 06 月 26 日~106 年 07 月 02 日

報告日期：106 年 09 月 02 日

摘要

此次參加於捷克布拉格舉辦之第 2 屆自動化與控制及機器人工程國際研討會，從開始參與投稿起，等待稿件的接受與否之回復期間經過修正接受後並得舉證文章屬於自己所撰寫並無抄襲，以及接受後註冊、繳費，直至參加研討會回國，中間歷經了近 2 個月的作業時程，也相當的繁雜，所幸順利完成。

因在國內環境較少已外文接觸，更別談以外文交談，值至最近幾年開始接觸國際研討會，從一開始的生疏，同時也因此而減少了於會場跟人交流互動的勇氣，但經由此次的投稿和發表經驗，更加了投稿與主動參與國際性研討會的信心，同時也可知道在相關領域上他人(國際性)的研究方向與內容，進而讓自己有更大的思考方向，而經由研討會的交流能讓台灣在更多國際舞台展現。

目次

目的

本次參加於捷克布拉格舉辦之第 2 屆自動化與控制及機器人工程國際研討會(2017 2nd International Conference on Automation, Control and Robotics Engineering, CACRE 2017)的目的，最主要可提升自己的文章在國際性的曝光度外，也可藉由參國際性的研討會知道國際性他人在相關領域的研究內容與概況，並可藉由國際性研討會的參與，讓自己更加熟悉投稿國際性研討會的作業流程，從而建立與增加參與國際性研討會的信心。

過程(會議議程、議場主題、與會參與各項研討或報告議題及其內容重點摘述、見聞或新知；如發表研究或報告，個人所發表內容摘要、現場報告或討論交流情形等)

此次參加於捷克布拉格舉辦的 106 年 6 月 27 日~104 年 6 月 29 日之第 2 屆自動化與控制及機器人工程國際研討會，相關議程如下表。

Conference Program

2017 2nd International Conference on Automation, Control and Robotics Engineering (CACRE 2017)

Time: June 28-30, 2017

Venue: Prague, Czech

June 28-Wednesday	8:30am-5:00pm	Regiatration

June 29-Thursday	8:30am-10:20am	Keynote Speech 1
	10:20am-10:50am	Coffee break
	10:50am-12:30am	Keynote Speech 2
	Lunch Time	
	1:40pm-3:20pm	Session A1+Session B1
	3:20pm-3:40pm	Coffee break
	3:40pm-5:30pm	Session A2+Session B2

June 30-Friday	8:30am-10:30am	Invited speech
	10:30am-10:50am	Coffee break
	10:50am-12:30am	Session C1+Session C2
	Lunch Time	
	2:00pm-5:30pm	Technical/Lab tour(pending)

論文摘要如下:

本研究對於生產風扇轉向器軸件射出成型之塑件案例進行探討，使用 POM 塑鋼，以傳統冷澆道生產塑件，因零件須預留孔洞故需測滑塊設計，模具塑件射出後澆道所產生的廢料較多，使成本提高，在大量生產時備料成本相對提高。且廢料經絞碎處理後回填除了會影響品質，並產生高達 130 分貝的

噪音對人體造成影響，因此以熱澆道系統代替傳統模具。實際測試結果顯示，生產周期縮減 6.25%，而生產之良率提高約 50%，材料成本可降低約 2%，因熱澆道模具所增加之費用一年內即可回收，何況品質的提高和降低噪音對工作人員之受益更是無從估計。

活動行程

而我們的活動行程包括起程和回程如下列活動行程表，時間上掌握的很好。而於會場上因平時在國內因很少以英文交談，所以在簡報時聽人的問答時顯得較生疏，同時也因此而減少了於會場跟人交流互動的勇氣，但經由此次的投稿和發表經驗，更加了投稿與主動參與國際性研討會的信心，同時也可知道在相關領域上他人(國際性)的研究方向與內容，進而讓自己有更大的思考方向。

活動行程表

日期	起訖地點	工作摘要
6/25	虎尾-桃園	啟程準備搭機
6/26	桃園機場-香港-維也納(奧地利)	搭機
6/27	維也納-布拉格(捷克)	搭機至會場
6/28-6/30	布拉格	參加第 2 屆自動化與控制及機器人工程國際研討會 (2017 2nd International Conference on Automation, Control and Robotics Engineering(CACRE 2017)
7/1-2	布拉格-維也納-香港-桃園-虎尾	返國

會議主題:

目前全球在自動化，控制和機器人工程技術的發展越來越多。這被認為是使製造企業降低生產成本並提高其全球競爭力的重要一步。

這次會議提供一個展示最新進展和交流思想的平台。在機器人操縱器，自動化和控制系統的所有實際和理論方面徵求貢獻。這些包括但不限於運動學和動力學建模，設計和優化，尺寸合成，性能映射，控制，運動規劃，具有致動冗餘的操縱器，校準，電纜驅動平台，運動模擬器，醫療應用，微機器人，可重構機器人，生物靈感機器人，遠程操縱。提出先進理念和新型工業應用的論文特別受歡迎。還要求貢獻解決技術狀況，現有機器人，自動化和控制系統的局限性以及潛力，並為這些領域的未來展現出遠景。

世界各國先進國家無不卯足全力積極投入研究和發展，我們當然亦不例外，而借此參加於於捷克布拉格舉辦之第 2 屆自動化與控制及機器人工程國際研討會(2017 2nd International Conference on Automation, Control and Robotics Engineering, CACRE 2017)，了解相關發展與趨勢是相當重要之事，以免閉門造車，經過一連串的努力，總算完滿的結束，以下是與此次研討會論文及會場相關之活動照片。


Hong Kong Society of Mechanical Engineers

Acceptance Notification of CACRE 2017

2017 2nd International Conference on Automation, Control and Robotics Engineering(CACRE 2017)

Prague, Czech
http://www.cacre.org/

Dear Dai-Jia Juan and Yu-Lun Cheng,

We are pleased to inform you that, after our double-blind peer review (please refer to the attached files), your manuscript identified below has been accepted for publication and oral presentation by **2017 2nd International Conference on Automation, Control and Robotics Engineering (CACRE 2017)** held in Prague, Czech from 28 to 30 June, 2017.

Paper ID: C013

Paper Title: Hot Runner Mold Design Of Fan Diverter Parts

All submissions of CACRE 2017 will be peer reviewed by 2-3 experts. All the registered and presented papers will be published in **IOP Conference Series: Materials Science and Engineering(ISSN: 1757-899X)**, which will be indexed **by Ei Compendex, SCOPUS, Inspec, Conference Proceedings Citation Index – Science (CPCI-S)(Thomson Reuters, Web of Science)** and other databases. (pending)

Yours sincerely,
CACRE 2017 Organizing Committees
May.15,2017

1/2

心得

本次參加於捷克布拉格舉辦之第 2 屆自動化與控制及機器人工程國際研討會(2017 2nd International Conference on Automation, Control and Robotics Engineering, CACRE 2017)，總算完滿的結束。最主要除了可提升自己的文章在國際性的曝光度外，也可藉由參國際性的研討會的同時，知道在國際性他人在相關領域的研究內容與概況，並可藉由國際性研討會的參與，讓自己更加熟悉投稿國際性研討會的作業流程，從而建立與增加參與國際性研討會的信心和增進專業知識外，同時也可扮演成功的國民外交，並且也可增加國際化知識進而在教學服務與教學品質上能幫助學生透展國際化的視野。

而因此次地點在歐洲捷克的布拉格舉行，離維也納、德國都不遠，且是剛脫離共產制度不是久遠，還保留得相當神秘色彩，因此歐洲國家因交通方便之故，這次研討會與會人員中有不少歐洲人員參加，更具有國際性。

建議事項

在經費之申請與補助上，應可更加彈性，因為對手中沒有計劃的同仁，要出國參加國際性會議，是相當不易的事，所以若能鼓勵沒有計劃的同仁也能多參加國際性會議，並給予相對如機票的補助，相信對學校整體國際化之發展會更有幫助。

Hot Runner Mold Design of Fan Diverter Parts

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Abstract. In this study, we discuss the case of plastic parts for the production of fan steering gear shaft parts injection molding, and use POM plastic steel to produce plastic parts from traditional cold runners. Because of the parts have a hole, which need side slide. The runner produce more waste after plastic parts injection make the runner waste account for the cost is relatively high, the cost of stock preparation is relatively increased when the product quantity demanded is great. After the crushing treatment of the waste, the backfill will affect the quality, and in the crushing process, the volume generated will make the operator to withstand up to 130 dB of noise. The actual test results show that the production cycle reduce 6.25%, while the production yield increase by about 5% and material costs reduced by 2% . It can be recovered within a year, not to mention the increase of the quality and reduction the noise on the staff of the benefit is impossible to estimate.

Introduction

Traditional cold runner plastic injection molding, need more longer runner cooling time, the plastic loss of the runner and waste treatment, virtually reduce the efficiency and yield of molding, increase production costs. Use hot runner to conduct plastic injection production of mold, generally widely use the mode of large-scale components or multi-component molding [1], mostly still only used in 3C electronic products and high-priced parts [2], while the use environment of traditional mold is used for thin parts and multicavity molds(for example one mold eight cavity molds) such as a beverage cup. For the product of the large ratio of thickness and depth, its cooling speed shall be quick, or the front end has solidified, the latter section has not filled yet, so the plastic injection cycle shall be quick, and using hot runner can solve this problem.

If the length of general plastic pass the runner and the injection parts is relatively long, the temperature is more difficult to control, the product has the problem that the precision is difficult to control, is the opportunity to use hot runner, and the hot runner can shorten the cooling time and (multiple difference) can improve the yield. In the production process, the plastic kept at a constant temperature molten state for a long time [3], compared to the cold runner, the hot runner will not remain the waste in the cooled runner. Although the waste can be reused after backfilling, however, there is a certain proportion of limitation of backfilling waste, cannot more than 20-25% of the part material, so as not to affect the quality is too large, and need to increase facility cost of waste treatment. The noise generated in the crushing treatment process of waste is up to 130dB, and it is an occupational injury to the health of the staff, and the heating electric energy that the hot runner need to increase itself is equal to the electric energy that the runner cooling and waste treatment need, not increase the waste of the additional energy. So the production of hot runner compared to the traditional cold runner injection molding process can reduce about 20 to 25% of the waste, while no waste generated, so do not have to deal with waste, and will not produce noise due to dispose the waste.

But even if the hot runner is used that the production would not always be perfectly conducted, it cannot be produce for the inapplicable plastic fiber reinforced material, because contain-fiber may accumulate at injection port, and make the hot runner cannot inject. However the production cost of the mould of hot runner at early stage is more than 2~4 times of the cold runner, and its structure is relatively complicated and accurate, the maintenance of mold is relative difficult [4]. But at the beginning, although the cost of hot runner is much higher than that of the cold runner, but with respect to the sophisticated parts and costly components, such as the connecting plastic components using on the car, using hot runner is the economical choice.

Currently, hot runner applications has more than 10 years , though already getting mature, but because of the substantial increase in mold production costs, the traditional industrial application of hot runner production is still small. In this paper ,we used the rotation shaft parts of traditional fan steering gear as the example as shown in Fig. 1, to investigate the niche of hot runner process production, because of its shape is similar to long shaft parts, the runner waste caused by mold arrangement account for the components material is up to 20%, in order to solve the related problem due to the waste disposal arising in the process of traditional cold runner, although the cost of hot runner mold is several times more than the traditional mold, general practitioner cannot accept, but if we have an in-depth understanding that we can know that using hot runner mold process assessment could save material fees, reduce costs of waste disposal, and avoid the damage to the staff of noise caused by crushing treatment of waste backfill and the deterioration of quality, it can also reduce the stress changes in hot and cold mold and extend the operation time. On the whole, the long run will be able to significantly reduce manufacturing costs and get better product quality, so that the degree of use of hot runner can easily accepted and promotion, which is the research motive of this article.

2. Hot runner system

Hot runner is also called micro channel, and the overall system is shown in Figure 1 [1]. It means heating in the electric coil out of the runner tube after injection each time makes the plastic in the runner free of solidification without discharging the waste in the runner when demoulding. The plastic in the runner is not solidified, so the runner is still smooth when injecting next time [5].

As shown in Figure 2 [6], when the common mold uses the cold runner, the hot plastic encounters cold mold, which recues the plastic temperature and causes pressure drop under the friction loss so that when it is injected to the mold hole, the plastic mobility has become poor and caused poorer packing and pressure holding effect and further affects the shape, appearance, dimension precision and physical property of the finished product [7]. And the waste produced must be disposed for secondary processing by the waste machine, as shown in Figure 3 [8]. If hot runner technology is applied to the mold, the temperature of hot runner is the same as that of the nozzle of injection molding machine, so it avoids the condensation of plastic on the surface of runner. Moreover, there is no runner waste when using hot runner system, so it reduces the raw material consumption and thus reduces the product cost.

In the mold cavity, the temperature and pressure are even, the stress of plastic part is small and the density is even. Under the small injection pressure and within a short molding time, the better product is molded under such system than common injection molding system.

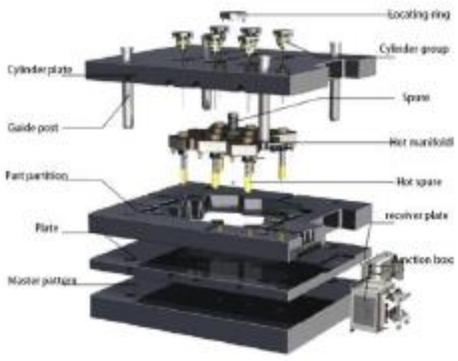

Figure 1. Hot runner explosion drawing

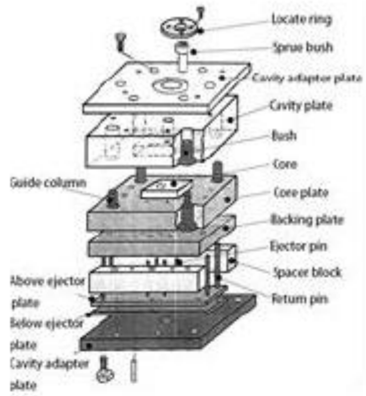

Figure 2. Traditional mold

Figure 3. Waste produced using traditional runner and waste treatment

3. Moldflow analysis of mold

Because of the parts have a hole, injection mold was limited by injection molding machine. Arrangement mode of one mold with eight holes.By using Moldex3D mold flow software, the paper analyses the packing, pressure maintaining and cooling of trial production in the mode of one mold with eight holes, predict the warping analysis of the product, observe the temperature analysis result of hot runner, optimizes the result so as to shorten the mold development and trial error process.

The material model is POM CELCON M90. The component is shown in Table 1 and the processing condition of the injection molding machine is shown in Table 2: the packing time is 1.54s, the injection pressure is 200MPa, the holding pressure is 200MPa and the cooling time is 22.4s. Through software analysis, the better packing time result is 1.564s, the holding pressure is 83.14MPa and the cooling temperature is 212.417 ℃. The mold flow analysis results are shown in Figure 4 to Figure 8 and the design case is rational, which can provide practical production of mold.

Table 1. Material component table

Items	Information
Material type	Thermoplastic
Material name	POM
Supplier	Celanese
Model	CELCON M90
T range	180-200(°C)
Mold T	60-100(°C)
Ejection time	135(°C)
Curing time	135(°C)

Table 2. Processing condition of injection molding machine

Items	Information
Filling time	1.5400(s)
Material T	190. 0(℃)
Mold T	200.00(MPa)
Injection volume	58.5029(cc)
Holding time	11.0(sec)
Max holding P	200.0(Mpa)
Ejector T	134.8(℃)
Air T	25(℃)
Cooling time	22.4(sec)
Cycle time	40.0(sec)

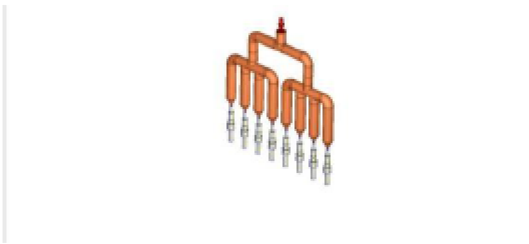

Figure 4. Arrangement mode of one mold with eight holes

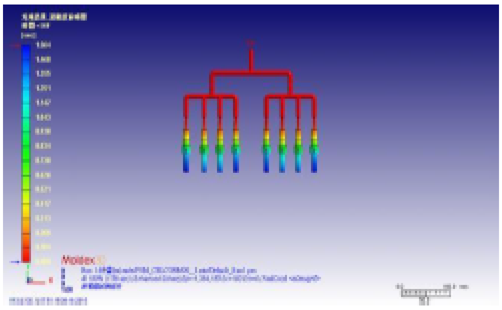

Figure 5. Packing analysis result

Figure 6. Packing analysis & enveloping position

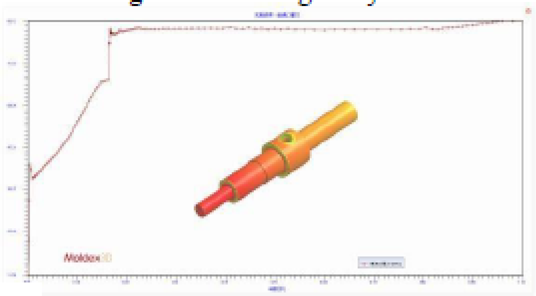

Figure 7. Pressure maintaining analysis

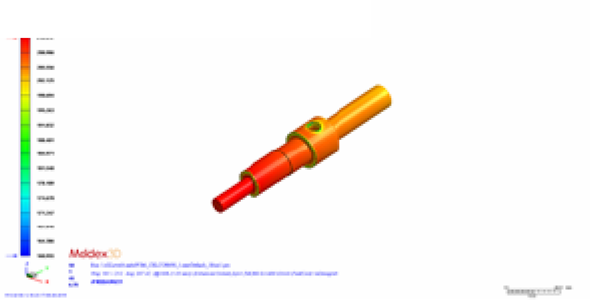

Figure 8. Cooling analysis

4. Mold design and manufacturing

As shown in Figure 9 to Figure 12, the hot runner system diagram of one mold with eight holes, th same arrangement mode as the traditional mold is mapped by referring to the analytic result of mol flow software and using SolidWorks plotting software. After mapping, the mold flow analysis suc as packing, pressure maintaining and cooling of runner should be carried out by using Moldex3I software.

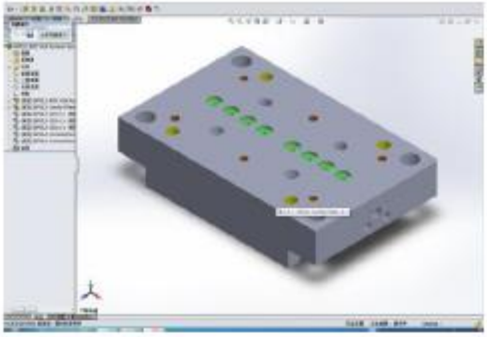

Figure 9. Male mold

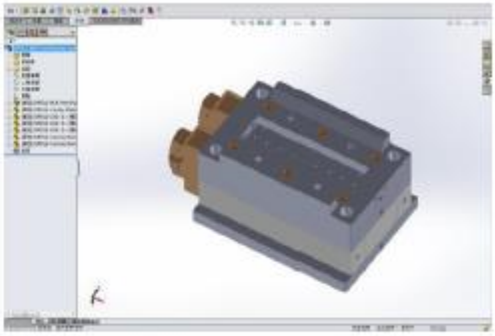

Figure 10. Master pattern of mold

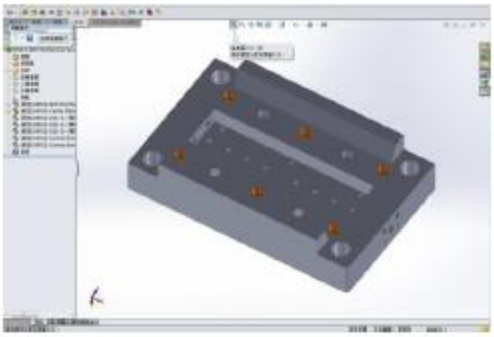

Figure 11. part partition

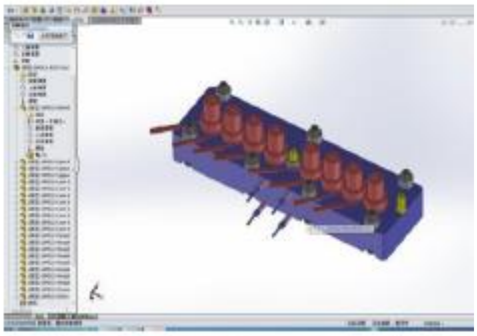

Figure 12. hot runner plate

Taking the analysed parameters as reference for mold development can reduce the trial error proces The manufactured result is shown in Figure 13. to Figure 15.

Figure 13.Noumenon of mold

Figure 14. Part partition

Figure 15. Hot runner gate

5. Analysis and comparison

Using the Injection rate, holding pressure and holding time as experimental factor, each factor adopted 3 levels, used statistical analysis software minitab to conduct Taguchi statistics could obtain L_9 (3^4) orthogonal table, the combination of each experimental parameters repeated 3 times and conducted 27 experiments, and the injection and measurement results are as shown in Table 3.

Figure 16. injection Experiment

And then according to the injection experiment of plastic parts of experimental combination shown in Figure 16, due to the shape of the shaft is step-shaped and its number is large, it can`t be detected by general projector, so chose flat head gauge at 0.01mm precision to measure the deflection on CNC , firstly using standard round bar with HSS TOOL μ-class as the calibration benchmark of the base and the fixture, the deflection is in the 1μm, after calibration, the measurement component of the Run Out value is shown in Figure 17 and Figure 18. And Run Out value of the shaft parts needed to measure is the smaller the better, is a smaller-the-better type characteristic.

Figure 17&18. Instrument calibration

After experiment, get the SN ratios. And the optimal parameters of injection rate, injection pressure, holding pressure and holding time are 68mm/s, 58kg/cm ², 35% and 3.6 second respectively.

Table 3. Experiment parameters and SN ratios

No.	Injection rate	Injection pressure	Holding pressure	Holding time	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	SN
1					0.12	0.23	0.67	0.22	0.43	0.26	0.19	0.57	
2	60	58	25	3.0	0.17	0.2	0.28	0.18	0.3	0.12	0.34	0.14	9.99
3					0.16	0.18	0.19	0.35	0.16	0.27	0.64	0.29	
4					0.24	0.09	0.07	0.52	0.19	0.17	0.19	0.29	
5	60	63	30	3.6	0.36	0.28	0.29	0.45	0.02	0.28	0.04	0.26	11.71
6					0.22	0.25	0.36	0.03	0.18	0.32	0.25	0.11	
7					0.35	0.16	0.37	0.34	0.33	0.25	0.21	0.08	
8	60	68	35	4.2	0.07	0.48	0.18	0.36	0.23	0.17	0.55	0.33	10.85
9					0.32	0.2	0.21	0.15	0.12	0.38	0.17	0.25	
10					0.51	0.29	0.49	0.03	0.15	0.15	0.29	0.27	
11	64	58	30	4.2	0.57	0.54	0.2	0.14	0.17	0.31	0.24	0.4	10.63
12					0.01	0.15	0.25	0.17	0.31	0.23	0.06	0.06	
13					0.25	0.2	0.53	0.51	0.39	0.46	0.57	0.24	
14	64	63	35	3.0	0.34	0.07	0.05	0.37	0.3	0.19	0.13	0.22	9.13
15					0.09	0.16	0.52	0.2	0.48	0.22	0.53	0.43	
16					0.45	0.63	0.05	0.12	0.57	0.23	0.29	0.31	
17	64	68	25	3.6	0.56	0.64	0.47	0.18	0.25	0.34	0.3	0.08	9.08
18					0.37	0.25	0.01	0.12	0.02	0.24	0.3	0.42	
19					0.06	0.02	0.01	0.05	0.28	0.07	0.15	0.28	
20	68	58	35	3.6	0.38	0.4	0.13	0.28	0.1	0.29	0.14	0.27	13.12
21					0.22	0.12	0.2	0.14	0.39	0.3	0.01	0.17	
22					0.23	0.4	0.34	0.07	0.08	0.48	0.14	0.22	
23	68	63	25	4.2	0.45	0.25	0.05	0.08	0.28	0.14	0.16	0.36	10.77
24					0.57	0.01	0.23	0.27	0.37	0.12	0.24	0.43	
25					0.02	0.22	0.46	0.52	0.03	0.3	0.1	0.44	
26	68	68	30	3.0	0.45	0.22	0.46	0.52	0.07	0.1	0.22	0.29	10.41
27					0.08	0.01	0.18	0.14	0.19	0.26	0.26	0.5	

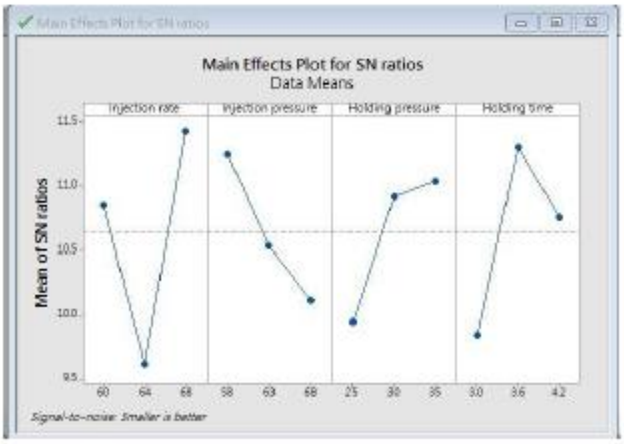

Figure 19. SN ratios

The injection molding of product using traditional cold runner needs longer gate cooling time, plastic loss of gate and waste treatment, which reduces the productivity and increases the cost. The waste produced in the gate can be recycled and mixed with new raw material for secondary injection molding and completing the consecutive processing work, but waste backfilling also affects the product quality and the maximum waste packing ratio cannot exceed 20% to avoid affecting the quality of plastic parts. Meanwhile, the noise produced in the treatment process is as high as 130 decibel, which affects operator's hearing seriously. In addition, the waste grinding process also needs additional energy and thus forms energy waste. Therefore, compared with the injection molding with traditional cold runner, the production using hot runner can reduce the waste by 20%-25% and thus reduces the noise of disposing the waste.

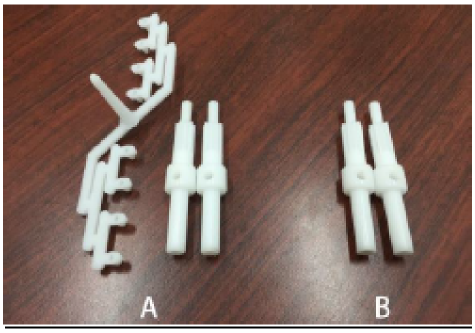

Figure 20. (a) & (b) Parts and wastes produced by using traditional cold runner

6. Conclusion

The application and production of hot runner mold centers on large plastic parts or electronics parts with high unit price. The mold manufacturing cost is over two or three times than that in traditional form, so it is seldom applied to traditional home appliances with meager profit.

The manufacturing with hot runner system mold can increase the annual yield. The single production cycle of parts injected by the hot runner is shortened from the original 85s to 80s, with 6.25% shortened than the original production cycle. If one day is calculated as eight working hours, one mold with eight holes can increase 170 parts, the annual increased yield reaches over 45,000, and the increased capacity can reach over US$3,900. Moreover, there is no waste produced and no need waste recycling, which enhances the production yield rate from 99.9% to 99.95% ,while the production yield increase by about 5% and material costs reduced by 2% and reduces the noise greatly that operators don't have to bear the noise as high as 130 decibel.

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