



# Solvent Base Lamination Process Substitution to Solvent Free for Production Cost Savings

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## ABSTRAK

Industri kemasan di Indonesia terus berkembang pesat, khususnya dalam upaya meningkatkan efisiensi biaya produksi. Salah satu tahapan penting dalam proses produksi kemasan fleksibel adalah proses laminasi, yaitu penggabungan film cetak dan film sealing menggunakan bahan perekat (adhesive). Teknologi laminasi solvent-free muncul sebagai alternatif yang lebih ramah lingkungan karena tidak menggunakan pelarut. Penelitian ini menggunakan metode kuantitatif untuk menganalisis dampak perubahan teknologi dari laminasi solvent-based ke solvent-free terhadap efisiensi biaya produksi. Hasil penelitian menunjukkan bahwa kombinasi laminasi menggunakan Nylon 15 mikron dan LLDPE C8 85 mikron tetap menghasilkan kekuatan rekat yang sesuai dengan standar industri. Teknologi solvent-free lebih efisien karena tidak memerlukan ruang pengering (drying chamber) sehingga konsumsi energi menjadi lebih rendah. Meskipun masih terdapat sedikit residu pelarut, metode ini tetap lebih bersih dan ekonomis dibandingkan metode solvent-based. Substitusi teknologi ini menunjukkan potensi besar dalam menurunkan biaya produksi tanpa mengorbankan kualitas produk. Oleh karena itu, laminasi solvent-free dapat menjadi solusi yang efisien dan ramah lingkungan bagi industri kemasan fleksibel di Indonesia.

## ABSTRACT

The packaging industry in Indonesia is growing rapidly, especially in production cost efficiency. One of the important stages is the lamination process, which is the incorporation of the printing film and sealing film using adhesive. Solvent-free lamination technology emerged as an environmentally friendly alternative because it does not use solvents. This study uses a quantitative method to analyze the impact of technology change from solvent base to solvent free on cost efficiency. The results showed that laminates with 15 micron Nylon and 85 micron LLDPE C8 still produced bonding strength in accordance with industry standards. Solvent-free technology is more efficient because it does not require a drying chamber, so energy consumption is lower. Although there is still a small amount of solvent residue, it is still cleaner and more economical to use. Substitution to this technology shows great potential in reducing production costs without compromising product quality. Therefore, solvent free is an environmentally friendly and efficient solution for the flexible packaging industry in Indonesia.

## 1. INTRODUCTION

In recent years, the packaging industry in Indonesia has experienced significant development, especially in terms of production cost efficiency. The industry has grown with different types of materials such as plastic, paper, metal, cans, and glass. Data from the Indonesia Packaging Federation (2020) shows that the packaging printing industry in Indonesia continues to grow with a packaging composition consisting of 44% flexible packaging, 14% rigid plastic packaging, and 28% paperboard packaging.

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In an era of rapid technological advancement, the packaging industry experiences stiff competition to create products of the highest quality. One of the emerging technologies in flexible packaging is solvent-free lamination, which has become a mature lamination process in many advanced printing industries worldwide (Repeta, 2020; Lee et al., 2023; Zhang et al., 2022). Solvent-free lamination is considered an environmentally friendly joining technology as it eliminates the need for drying ovens and significantly reduces VOC emissions and energy consumption compared to solvent-based methods (Zhang et al., 2022; Novak & Juric, 2021). In addition, solventless systems have shown improved adhesion performance and reduced environmental impact, supporting global goals for sustainable manufacturing (Maulana et al., 2024; Novak & Juric, 2021).

Thus, this study aims to determine the effect of replacing laminates from solvent-based to solvent-free lamination on production cost savings. Through this substitution, it is hoped that more efficient methods can be found without sacrificing production quality or incurring higher costs. This research is expected to make a significant contribution to the packaging industry and increase product competitiveness in the market. Therefore, we propose a solution focused on production cost efficiency and lamination performance by substituting the solvent-based lamination process with a solvent-free approach, aligning with sustainable industrial practices (Chen & Li, 2024; Ebrahimi et al., 2025).

## 2. METHOD

The research was conducted experimentally at PT PNM using quantitative data processing. This approach was chosen because it aims to analyze efficient production costs after the change of the lamination process. Each lamination process requires the cost of the materials used such as the type of film (nylon and LLDPE) and *adhesive*. The data was analyzed using overall calculations.

**Table 1.** Comparison of Solvent Base Lamination Process with Solvent Free

Process	Lamination Dimensions		Film Cost	Amount of Adhesive Used		Adhesive Cost	
	Film Width (m)	Film Length (m)		Solvent Base	Solvent Free	Solvent Base	Solvent Free
Lamination (NYLON)	940	1000	Rp 798.680	9,3 kg	2,046 kg	Rp 247.427	Rp 116.011
Lamination (LLDPE)	940	1000	Rp 1.992.641				

## 3. RESULT AND DISCUSSION

The results of the study showed that the process of substitution of the solvent base lamination process to solvent free could show a percentage decrease of 4.32%. The price for Nylon film is recorded at IDR 798,680 per sample size, while the price of LLDPE film is IDR 1,992,641 per sample size. Thus, the total price of the film material used in the lamination process for the two types of film is IDR 2,791,321.

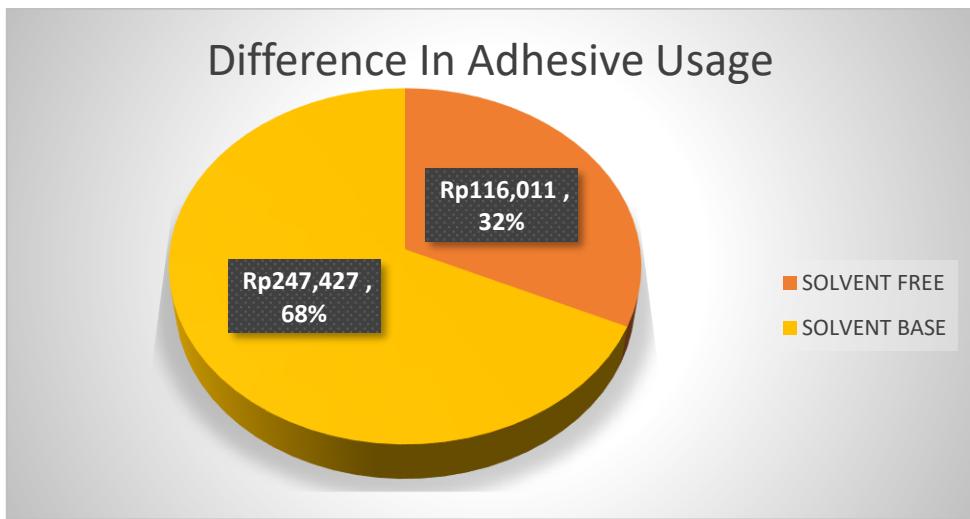
In the use of *adhesives*, there is a significant difference between *the solvent base* and *solvent free* methods. In the *solvent base* method, the total adhesive used reached 9.3 kg at a cost of IDR 247,427. In contrast, the *solvent-free* method only uses 2,046 kg of adhesive, at a cost of Rp 116,011. The difference in the use of adhesive materials shows that *the solvent free method is* more efficient in terms of adhesive consumption. From these results, it is obtained from the following formula:

### 1. Formula For Finding The Usage

$$\text{Film Length (M)} \times (\text{Film Width} - 0,01 \text{ Meter}) \times \left[ \frac{\text{Coating Weight (G/M}^2\text{)}: \text{Solid Content}(\%)}{\text{Total Ratio Material}} \right] \times \text{Ratio}$$

### 2. Calculating The Price Of Adhesive

$$\text{Usage} \times \text{Price/KG}$$



**Figure 1.** Cost Difference of Adhesive between Solvent-Based and Solvent-Free Lamination

To calculate the amount of *adhesive usage* in the lamination process, a formula is used that combines several important parameters. First, the length of the film in meters is multiplied by the width of the film that has been reduced by 0.01 meters as the margin tolerance. This value is then multiplied by the fraction consisting of the result of multiplying the weight of the coating in grams per square meter with the percentage  $\text{g/m}^2$  of solid content(%), then divided by the total ratio of the material. The result of the calculation is then multiplied by the ratio of *adhesive* used in the lamination process.

Once the *usage value* is obtained, the next step is to calculate the adhesive cost. The calculation is done by multiplying the amount of usage by the adhesive price per kilogram. Thus, the total cost of *adhesive* required in a production process can be known directly based on the estimated actual use.

After the adhesive *calculation is carried out*, the next process is the calculation of the second component to determine the efficiency of production costs, namely the film material, with the following formula:

$$\text{Weight 1 Roll} \times \text{Price Per 1kg} = \text{Price Per 1 Roll}$$

Weight Calculation of Nylon Sample Roll 15mic (1000 meters)

$$\text{Sample Roll Length: Full Roll Length} \times \text{Full Roll Weight} = \text{Its Weight (kg)}$$

Price Calculation of 15mic Nylon Sample Roll (1000 meters)

$$\text{Sample roll weight} \times \text{Price/1kg}$$

**Table 2.** Cost of Film and Adhesive Materials Used

Proses Laminasi	Harga Film Material	Harga Adhesive	Total
Solvent Base	Rp 2.791.321	Rp 247.427	Rp 3.038.748
Solvent Free	Rp 2.791.321	Rp 116.011	Rp 2.907.332
		cost difference	Rp 131.416

Based on the table above, it is the total cost incurred for the combination of film and adhesive prices in each lamination method. For the *solvent base* lamination method, the total production cost reached Rp 3,038,748. As for the *solvent free* lamination method, the total cost is only IDR

2,907,332. From the difference between the two methods, it can be seen that there is a cost saving of Rp 131,416 if the *solvent free method is used*.

#### Average Reduction in Laminate Production Costs

$$\text{Percentage Decrease} = \text{Solvent Base Cost Ratio.} \times 100\%$$

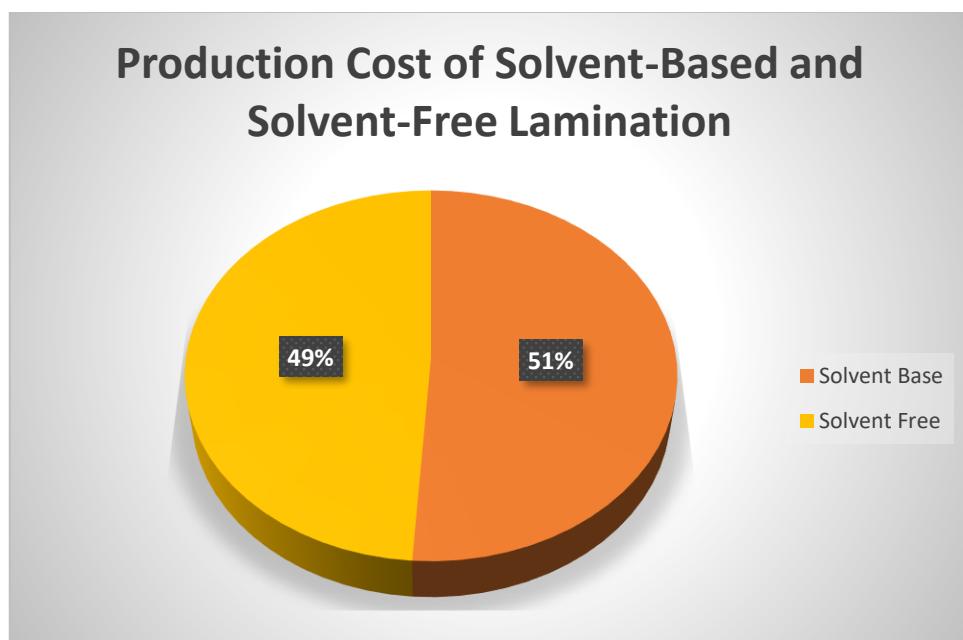
$$\text{Cost Comparison} = \text{Solvent Base Cost} - \text{Solvent Free Cost}$$

$$= \text{Rp. } 131,416 - \text{Rp. } 3,038,748, \times 100\%$$

$$= 0.043246758 \times 100\%$$

$$= 4.32\%$$

Based on the calculations made, the average value of the reduction in lamination production costs can be determined by comparing the cost difference used in the *Solvent Base* and *Solvent Free* lamination methods. The difference in costs is IDR 131,416 from the total *Solvent Base* cost of IDR 3,038,748. This comparison value is then multiplied by 100% to get a percentage reduction in costs. The calculation results show that the value of the cost reduction is 0.043246758 or equivalent to 4.32%. This figure indicates that the application of the *Solvent Free* lamination method can provide production cost efficiency of 4.32% compared to the *Solvent Base method*.



**Figure 2.** Production Cost of Solvent-Based and Solvent-Free Lamination

#### 4. CONCLUSION

The use of *solvent-free* lamination technology as a substitute for the *solvent base* method in the packaging production process has been proven to have a significant impact on cost efficiency and long-term operational sustainability. This substitution not only reduces chemical and energy consumption, but also cuts the need for adhesives by about 53%. With the amount of adhesive *solvent base* of 9.3 kg compared to adhesive *solvent free* of 2,046 kg, as well as the calculation of costs from the total production length of 1000 meters, a cost savings of Rp 131,416 or equivalent to 4.32% were obtained. This figure proves that *solvent-free* technology can be an effective strategy for companies to increase competitiveness by managing production costs more efficiently, while maintaining the quality of laminates according to the desired standards. Thus, the application of this method can be concluded not only as an environmentally friendly step, but also as a careful business choice and positive impact on long-term operational sustainability.

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